Can Text Compensate Differences in Types of Graphics?

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Abstract. The effectiveness of dynamic and static visualizations as opposed to only text was investigated for the understanding of a dynamic domain. Forty-six students were assigned to one of three conditions: a text-only, a text with dynamic or a text with static visualizations condition. Learning outcomes were measured by means of a verbal factual knowledge, a transfer and a pictorial factual knowledge test. Results revealed that the two visualization conditions outperformed the text-only condition solely for pictorial tasks, but not for verbal factual knowledge or transfer tasks. No differences were observable between the two visualization conditions for any learning outcome measure. As the text was described in detail and was sufficient to solve the transfer test, it also might have overshadowed potential differences between the two visualization conditions. Thus, in a follow-up study, the effectiveness of dynamic and static visualizations which are accompanied by a stripped-down text will be investigated.

Keywords: Multimedia principle; dynamic visualizations; static visualizations; animation

Introduction

Instructional Advantages of Text and Visualizations

There is strong empirical evidence that people learn better with text and visualizations than with text alone (e.g., Anglin, Vaez, & Cunningham, 2004), which is also referred to as the Multimedia Principle of instructional design. The Multimedia Principle has been shown to be more pronounced for transfer tasks rather than (verbal) factual knowledge tasks (Mayer, 2001). Moreover, with respect to factual knowledge tasks, the superiority of text and visualizations over text alone has been shown to be especially accentuated for pictorial tasks, but less accentuated and sometimes even diminished for verbal tasks (cf. Baker & Dwyer, 2000).

Instructional Advantages of Dynamic and Static Visualizations

When comparing the effects of static to dynamic visualizations (e.g., videos or animations), the current state of the literature remains somewhat unclear (Höffler & Leutner, 2007; Tversky, Bauer-Morrison, & Bétrancourt, 2002). This is why it is suggested to take a closer look at the conditions when and why dynamic visualizations might be best suited for instructional purposes (e.g., Schnotz & Lowe, 2008). A crucial difference in the processing of dynamic compared to static visualizations might lie in the property of dynamic visualizations to directly depict dynamic features, so that this dynamic information can be directly read-off. In contrast, in static visualizations these dynamic features have to be inferred, which might be a resource-intensive process (cf. Schnotz & Lowe, 2008).

The domain at hand (Kepler's second law) dealt with changes in the velocity of the planetary motion around the sun. For this instructional material, the direct depiction of dynamic features is basically the sole important dimension in which static and dynamic visualizations differ. Hence, we expected dynamic visualizations to be more apt to convey theses dynamics than static visualizations.

Hypotheses

To summarize, we expected that learners who were receiving text with dynamic or static visualizations to outperform learners receiving only text. This superiority should be more pronounced for pictorial tasks as well as transfer tasks as opposed to verbal factual knowledge tasks. Moreover, for the

dynamic domain of the study at hand, we expected dynamic visualizations to be superior to static visualizations with respect to learning outcomes, particularly transfer tasks.

Method

Participants and Design

Forty-six students of the University of Tübingen were randomly assigned to one of three conditions: a text-only, a text with dynamic visualizations, and a text with static visualizations condition.

Instructional Material

Kepler's second law deals with the planetary motion around the sun. The complete text of this instructional material, which was used in the current study (and which was equal among all conditions) is as follows: "Planets are orbiting the sun on an ellipse, not on a circle. On an ellipse, the distance between the planet and the sun is changing continuously. Kepler's second law states that the line joining a planet and the sun sweeps out equal areas during equal intervals of time. When the distance between sun and planet is getting shorter, a planet has to cover a greater distance so that the line joining a planet and the sun sweeps out equal areas during equal intervals of time. Therefore, to coincide with Kepler's second law, a planet has to move faster, the shorter its distance is to the sun, and to move slower, the larger its distance is to the sun."

The text of the instructional material was presented in written form. The visualizations were placed above the text in the visualizations conditions. The whole instructional material fitted on the screen.

Knowledge Test

The knowledge test comprised a verbal factual knowledge test, a transfer test and a pictorial factual knowledge test. The verbal factual knowledge test consisted of four multiple-choice questions posed in a verbal format. The correct answer of each question was explicitly stated in the text of the instructional material. For the three transfer tasks, learners had to apply what was learned to new situations. The three transfer tasks consisted of a cloze text, an open question and a drawing task. The three pictorial tasks consisted of one drawing task, in which learners had to draw Kepler's second law, one multiple-choice question in which learners had to choose the right static visualization of Kepler's second law among four alternatives and one multiple-choice question in which learners had to choose the right dynamic visualization of Kepler's second law among four alternatives. Learners in the text-only condition had to infer the correct solution, based on the instructional text. While the first two pictorial tasks were explicitly depicted in both visualization conditions, the third pictorial tasks was only explicitly depicted in the dynamic visualization condition, but had to be inferred by the static visualization condition on basis of the instructional material.

Results

Learning time and performance on the three knowledge tests served as dependent variables. Means and SD are depicted in Table 1. A one-factorial ANOVA revealed no differences among the three instructional conditions with respect to learning time ($F < 1$, *ns*). Also, one-factorial ANOVAs did not reveal any differences with respect to verbal factual knowledge ($F(2, 43) = 1.00$, $p = .38$) or transfer ($F < 1$, *ns*), but for pictorial tasks ($F(2, 43) = 8.95$, $p = .001$). Bonferroni post-hoc tests revealed that the dynamic and the static visualization conditions outperformed the text-only condition ($p < .001$ and p

=.02, respectively), whereas there were no differences between these two visualization conditions (p = .60). The same pattern of results occurred when considering learning time as a covariate.

Table 1. Means (and SD) for learning time and learning outcomes.

	Text-only (N = 15)	Dynamic (N = 15)	Static (N = 16)
Learning time (sec.)	90.40 (47.33)	104.56 (38.44)	95.56 (65.67)
Verbal Test (%)	55.00 (36.84)	70.00 (21.55)	64.06 (27.34)
Transfer Test (%)	52.50 (25.58)	58.33 (19.16)	61.46 (25.98)
Pictorial Test (%)	55.00 (23.53)	85.56 (18.76)	76.04 (18.23)

Discussion

Opposed to our hypotheses, we did not observe learners receiving text and visualizations to outperform learners receiving only text for transfer tasks (or verbal factual knowledge tasks), but solely for pictorial tasks. The latter might be interpreted as learners receiving only text might have difficulties in building an adequate pictorial mental model of the topic. A closer examination of the transfer tasks, on the other hand, revealed that these tasks were basically solvable by applying three rules, which were explicitly described in the text. Keeping three text-based rules in mind might not overburden a learners working memory capacity, so that this lack of complexity of the instructional material might account for the findings on transfer tasks, as well verbal factual knowledge tasks.

Considering the instructional equality of dynamic and static visualizations, it is reasonable that no differences for transfer and verbal factual knowledge tasks occurred between the two visualization conditions, since there were already no differences for these two conditions compared to a text-only condition. From a principle-based point of view, one might ask if the text, which explicitly described the dynamics of the content, might have overshadowed differences in learning from dynamic and static visualizations. Hence, it might be the case that when presenting a shortened text, where the dynamics of the content are not explicitly described, but have to be inferred, the benefits of dynamic over static visualizations (i.e., the depiction of dynamic information) might shine through. This issue will be investigated in a follow-up study. The results of this planned study are intended to be presented at the conference.

References

Anglin, G. J., Vaez, H., & Cunningham, K. L. (2004). Visual representations and learning: The role of static and animated graphics. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (2nd ed., pp. 865–916): Mahwah, NJ, Erlbaum.

Baker, R., & Dwyer, F. (2000). A meta-analytic assessment of the effect of visualized instruction. *International Journal of Instructional Media, 27*, 417-426.

Höffler, T. N., & Leutner, D. (2007). Instructional animation versus static pictures: A meta-analysis. *Learning and Instruction, 17,* 722-738.

Mayer, R. E. (2001). *Multimedia learning*. Cambridge: Cambridge University Press.

Schnotz, W., & Lowe, R. K. (2008). A unified view of learning from animated and static graphics. In R. K. Lowe & W. Schnotz (Eds.), *Learning with animation: Research and design implications.* New York: Cambridge University Press.

Tversky, B., Bauer-Morrison, J., & Bétrancourt, M. (2002). Animation: Can it facilitate? *International Journal of Human-Computer Studies, 57,* 247–262.