Animated Illustrations - Finding critical factors for an effective information processing

Raimund Girwidz, Michael Lippstreu, Anja Winterlin, University of Education Ludwigsburg, Germany

Abstract
One interesting application multimedia is to illustrate phenomena that are not visible with naked eyes. Also combinations with acoustic information can be provided. This paper reports about a study with 99 students who worked with a multimedia learning environment, explaining how motion detectors and infrared thermometers work. Illustrated graphs, animations and thermal imaging were employed. The best results brought animations with spoken explanatory text for areas where pictorial imagination is important. Concerning abstract, text based information the more gifted students profited from written text, while not so good students gained better results with spoken text.

1. Introduction
The statement that learners benefit from animated visuals can not be generalized. Different effects were found in several studies (e.g. Park, O.-C. & Hopkins, R 1993; Mayer, R. E. & Moreno, R. (2002); Dahlquist, 2000; Lewalter, 2003; Betrancourt & Tversky, 2000). Conscientious considerations and deeper inspections are necessary to uncover hidden parameters that might be relevant. Especially, visualizations are not isolated means for learning. How should additional information be designed? Our study focused on spoken or written text that gives hints for processing and / or explains further details. One challenging and probably a fruitful employment for illustrations and animations are phenomena that are not visible with naked eyes. These are characteristics for the kind of learning content regarded in this paper. The focus is laid on visuals that are used to explain, how infrared motion detectors and infrared thermometers work, as well as to make Planck's law and infrared radiation more familiar. Illustrated graphs, animations and thermal imaging are employed and their information value will be discussed. Results from a study with students (9th graders) will be presented.

We designed a learning environment to find out some rules about using animations and illustrations, and this paper will give a survey over:
1. Instructional design features
2. Subject area with examples
3. Research questions and methods
4. Results
5. Conclusions

2. Instructional design features
The theoretical background is based on the work of Mayer (2001), Weidenmann (2002), Schnotz & Bannert (2003), Girwidz et al. (2006). Important design features for the used learning environment can shortly be described with the following key words:
• Multicodal learning: Especially animated visuals are used to illustrate physical concepts.
• Multimodal learning: Oral information is given to support processing of visual information.

• Techniques like the supplantation principle (Salomon, 1979, 1994) are used to explain and illustrate abstract concepts. Processes and procedures that learners cannot perform by their own are realized and shown by media, with the intention that they will be adopted. In this context, seeing connections between pictures, illustrations and diagrams is meant.
• Interactivity is implemented to enhance active learning. Navigation tools are provided to adapt the flow of information to the learners' abilities and to avoid cognitive overload.
• Illustrations are embedded into a track of information that builds up a knowledge structure and integrates it into a sense making context. The intention is also to work against inert knowledge.
3. Learning subjects

The topic in general is everyday physics - here especially the infrared motion detector and the infrared thermometer. General characteristics of the learning subjects are:

- Fundamental but complex concepts are examined (here infrared radiation).
- The topics are not visible in nature. (Imagination is important.)
- Dynamic process components are essential.

Four examples from the learning environment are:

<table>
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<tr>
<th>Example</th>
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<td>The movement of (charged) particles as a reason for electromagnetic radiation is considered.</td>
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<td>The functioning of an infrared motion detector is analyzed. (It is shown, how a “thief” is detected if he moves through the supervised area.)</td>
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<td>The operating mode of a non contact infrared thermometer is explained: IR radiation heats up a plate, which is measured by thermo couples.</td>
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<td>Different perspectives for looking at the heating of a cup of water are offered: Combinations of realistic pictures, heat images, Planck’s diagram can be closer examined.</td>
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4. Research questions – and methods

This paper focuses on the multimodality aspect and the comparison between animations and still pictures. To find out more, four classes of 9th graders (together 99 students) were taught with four different program versions. Each class was divided into four subgroups, and they got learning programs with the following specifications:

1. animations with additional aural information
2. animations with written information
3. still pictures and aural information
4. still pictures and written information.

Three subtests / questionnaires were applied:

- A knowledge test (also with tree subdivisions) was administered. Each of the three parts referred to knowledge that could only be drawn from a specific coding: (5 questions only referred to illustrations; 5 questions only referred to text; 6 questions referred to combinations of text and visuals).
- Students assessed the visualizations, the attractiveness and their benefits for learning.
- Students assessment the learning program.

5. Results

The influences of several aspects were inspected. Differences in learning results and students’ assessments were examined with t-tests, and interferences tested with analysis of variance. Also
correlations between different variables were analyzed. Here only the correlation between students’ assessments and their test performance is regarded. The first inspection is on students’ assessments.

5.1. **Students assessed the attractiveness and the value of illustrations and text.**
A questionnaire was used with a range from 1 to 5. Results are shown in Tab. 1

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<th>Tab. 1: Result from students’ assessments.</th>
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<tr>
<td>Text – information value</td>
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<tr>
<td>Illustrations – information value</td>
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<td>Visuals – attractiveness</td>
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</table>

- Text was assessed not to be as good for learning as visual information. (The difference was highly significant).
- The attractiveness of visuals was assessed to be very good (4.2 out of 5) and much higher than text information.

5.2. **Animations compared to still pictures and explanatory text.**
In an ANOVA interaction plot (Fig. 1) you see the results for the different subgroups that got:
- a) animation with spoken explanations
- b) still pictures with spoken explanations
- c) animations with written text
- d) still pictures with written text.

![Fig. 1: Test performance for pictorial based information depending on the kind of visualization and modality.](image)

The mean values are 2.68, 2.31, 1.96 and 1.88 (F = 2.9, p = 0.038).
-Animations with spoken text led to the best results. However this was the case only for visual based knowledge.

5.3. **The next issue was whether spoken or written text was more effective.**
We found significant differences between visual based information and text based information:
- In combination with illustrations spoken text was more effective.
- For text based knowledge, however more detailed inspection revealed that there is to distinguish between more capable and less capable students (see below).

5.4. **Were there differences between types of learners?**
We asked the students whether they preferred aural or written information for learning. 35 percent preferred aural, 65 percent written text.
- However, we could not see significant differences in learning results if the students got their preferred mode.
5.5. **Were there differences between good and not so good students?**

According to their prior school grades in science higher and lower achievers were distinguished. We used a median split for statistics.

**a) Processing of visual information**

We compared the results of high and low achievers when they got spoken or written information in combination with illustrations.

**Fig. 2: Test performance for pictorial based information depending on students’ capability and modality.**

- There was a significant interaction effect between prior knowledge / initial abilities and modality of information: Especially not so gifted students could profit from spoken text in combination with visual information.
- Regarding pure text information, spoken text was not so good for gifted students. They performed netter, when they could read text on their own.

**b) Text based information processing**

Also the results of high and low achievers were compared concerning the use of spoken or written information in combination with text based knowledge (see fig. 3).

**Fig. 3: Test performance for text based information depending on students’ capability and modality.**

Regarding the text based information processing we found:
- Gifted students could process better written text, that they could read by their own (a repeated use is possible).
- For not so good students, aural information was better (also) for textual information.
5.6. The assessments of students and their learning results
We expected a correlation between the students' assessment of the learning material and their own test performance. However, this could only be found for text based knowledge. There was no correlation between the students' assessments of the material and their performance in the visual based knowledge test.
Two possible reasons might be:
  a) A ceiling effect, because the illustrations had very good values, in general.
  b) There is a lack of experience with illustration and students are not able to estimate the relevant factors correctly.

6. Discussion and Conclusions
The study concentrated on a special kind of learning material, namely process oriented phenomena that are not directly visible, and where imagination is important for understanding. For time dependent aspects animations appeared to be good for our students especially using the modality effect. This is consistent to the findings of Mayer (2001). The fact, that especially not so good students profited from spoken text can be seen in conformity with cognitive load theory. As the learning material is complex and therefore the germane cognitive load is certainly not very low, it should be helpful to use two modes for information.
However, additional spoken text information is not always better. We suppose that this is because of a more longwinded access to repeat spoken information. As a consequence for the more capable students it is more convenient for them to process written text in the case that primarily text based information is relevant. Also reporting from better students confirms this hypothesis. At least the results showed that capabilities of students have to be taken into account.
To sum up the findings from this study, four final remarks can be made:
  • To illustrate time dependent processes animations were helpful in this learning environment.
  • Especially for not so gifted students, spoken information combined with animations was better (instead of written text).
  • For text based information (numbers, facts) written text was better, especially for more gifted students, offering them a more flexible and lasting access to information (compared to "fluctuation" of spoken text).

A last impression should also be mentioned: Visual information is more and more given in learning material. However, processing of visual information also has to be trained. We think that more research is necessary to clear up the best way to teach, also taking into account the capabilities of students.

References