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ANIMATED ILLUSTRATIONS - FINDING CRITICAL FACTORS FOR AN EFFECTIVE INFORMATION PROCESSING

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Abstract
What are important settings for making learners benefit from animated visuals and illustrations? One interesting method is to use pictures and animations to illustrate phenomena that are not visible with naked eyes. In addition, multimedia can make visualizations interactive and provide possibilities also for combinations with acoustic information.
This paper reports about a study with 99 students who worked with a multimedia learning environment. Explained is how infrared motion detectors and infrared thermometers work, and Planck's law and infrared radiation are made more familiar. Illustrated graphs, animations and thermal imaging were employed. Their information value was assessed. It was distinguished between knowledge that was primarily based on pictorial information or on text based information. The best results provided animations with spoken explanatory text where pictorial imagination is important for understanding. This was significant for all students, but especially fruitful for the not so capable students. Concerning abstract, text based information students with higher abilities profited from written text, while students with lower abilities (median split) gained better results with spoken text.

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; Bogacz & Trafton, 2002; 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 explaining further details and / or giving hints for information processing.

One challenging but probably a fruitful employment for illustrations and animations is to explain 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 to students. Illustrated graphs, animations and thermal imaging are employed and their information value will be discussed. Results from a study with 9th graders will be presented in this paper.

Overview
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.

The study is part of a project about multimedia learning. Research is done in three steps.
The first is to make sure that handling of the software is problem-free.
The second deals with processing of information, especially still and animated visuals. (This is discussed here.)
The third will look at learners' working with the material and their learning processes.

1 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 of the applied learning environment can shortly be described with the following key words:

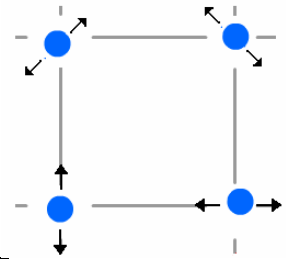
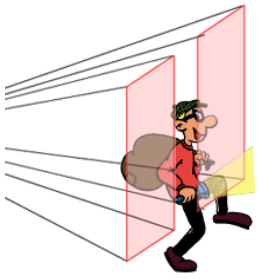
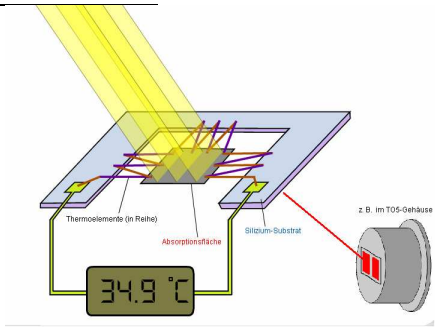
- ***Multicodal* learning:** Especially animated visuals are used to illustrate physical concepts.
- ***Multimodal* learning:** Oral information is given to support processing of visual information. (It is distinguish between knowledge information and hints for an effective information processing.)
- 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 illustrated by media, to show the use these methods and make them more familiar. 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.

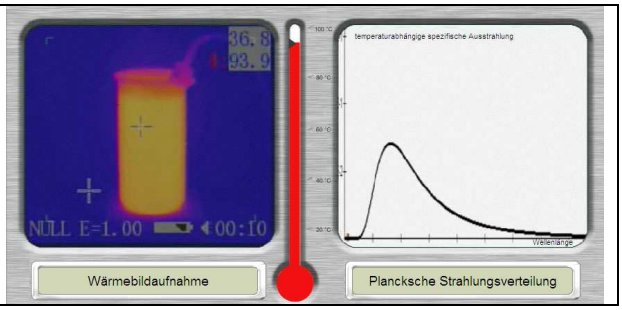
2 Learning subjects

The topic is everyday physics in general - 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:

▫ The movement of (charged) particles as a reason for electromagnetic radiation is considered.	
▫ The functioning of an infrared motion detector is analyzed. (It is shown, how a "thief" is detected if he moves through the supervised area.)	
▫ The operating mode of a non contact infrared thermometer is explained: IR radiation heats up a plate, what is measured by thermo couples.	

▪ Different perspectives for looking at the heating of a cup of water are offered: Combinations of realistic pictures, heat images and Planck's diagram can be examined.	

3 Research questions – and methods

This paper focuses on the multimodality aspect and the comparison between animations and still pictures. Questions are especially:

- What are relevant factors to improve goal directed perception of information by combining animations with spoken text?
- Is the understanding of abstract concepts and relations made easier by applying the supplantation principle?
- What about the attractiveness of the embedding of visuals into a track of information?

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 working with different program versions. The programs had 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 assessed the learning program as a whole.

The learning environment and four selected items or the questionnaire can be seen at: http://www.physikonline.net/programme/indexprogr.html.

4 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 the correlation between students' assessments and their test performance were inspected.

The first inspection is on students' assessments.

A) Students assessed attractiveness and the informational value of illustrations and text.

A questionnaire was used with a scale from 1 to 5. Results are shown in Tab. 1

Tab. 1: Result from students' assessments.

	N	mean	standard-deviation
Text – information value	93	3,4	,78
Illustrations – informational value	95	3,9	,72
Visuals – attractiveness	95	4,2	,68

- 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.

B) Animations and still pictures in combination with explanatory text.

In figure 1 you see the results of the post knowledge test of the four different subgroups, working with:

a) animations with spoken explanations
b) still pictures with spoken explanations
c) animations with written text
d) still pictures with written text.

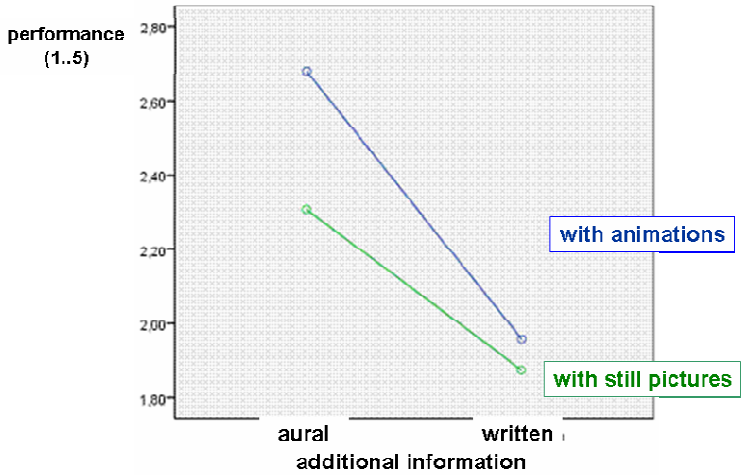


Fig. 1: Test performance for pictorial based information depending on the kind of visualization and modality.

The diagram shows that aural information is helpful for learning, and especially, this has a positive effect in combination with animations. (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.)

C) 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 students with higher and lower abilities (see below).

D) 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 of information.

E) Were there differences between students with higher and lower abilities?

According to their prior school grades in science we distinguished between students with higher and with lower abilities. We used a median split for statistics and looked at the following two different kinds of information.

a) Processing of visual information

We compared the results of students with higher and lower abilities when they got spoken or written information in combination with illustrations.

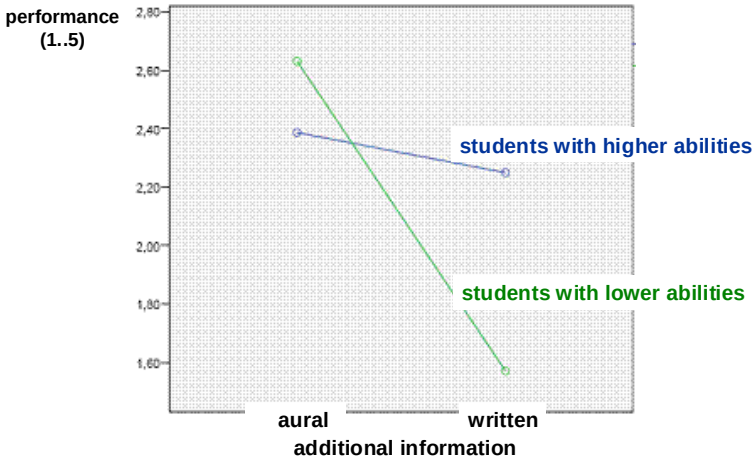


Fig. 2: Test performance for pictorial based information depending on students' abilities and modalities of information.

- There was a significant interaction effect between students' abilities and modality of information: Especially not so gifted students could profit from spoken text in combination with visual information.

b) Text based information processing

Also the results of students with higher and lower abilities concerning the use of spoken or written information in combination with text based knowledge were compared (see fig. 3).

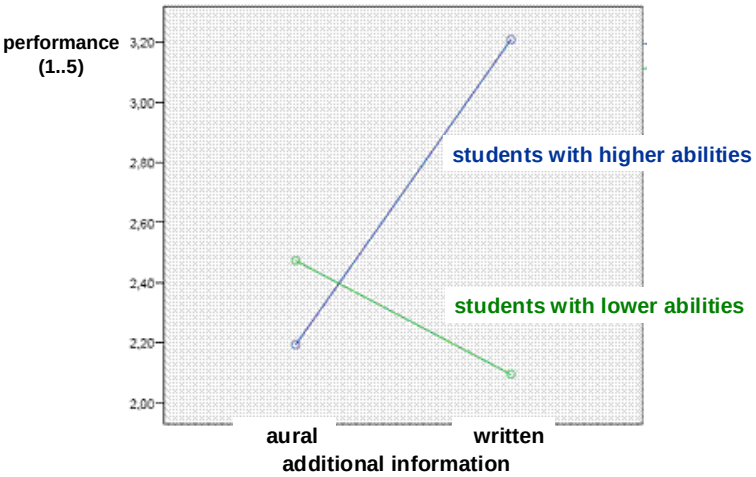


Fig. 3: Test performance for text based information depending on students' abilities and modalities of information.

Regarding the processing of text based information we found:

- Students with better abilities performed better if they could read the text by their own (a repeated use is possible).

- Some of them even reported that the speech was not good for their workflow and their concentration. So this may be the reason that this group even performed not as good as the group with lower abilities when additional aural information was given. (However, the difference was not significant.)
- For students with lower abilities, aural information was better in any case.

F) The assessments of students and their learning results

We expected a correlation between the students' assessments of the learning material and their own test performance. However, this could only be found for text based knowledge. There was no significant 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 high scores, in general.
b) There is a lack of experience with illustration, and as students are not so familiar with pictorial information also their evaluations are more or less vague.

5 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 it was good for our students to offer them animations, especially in combination with spoken text. This modality effect is in line with the findings of Mayer (2001). The fact that especially students with lower abilities profited from spoken text can be seen in conformity with the cognitive load theory. As the learning material is complex, and therefore the germane cognitive load is certainly not 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 students with higher abilities it is more convenient for them to work with written text in those cases where primarily text based information is relevant. Also reportings from these 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:

- For illustrating time dependent processes animations were helpful in this learning environment.
- Especially for students with lower abilities, spoken information combined with animations was better (than animations with written text).
- For text based information (numbers, facts) written text was better, especially students with higher abilities, offering them a more flexible and enduring access to information (compared to the "fugitiveness" of spoken text).

Finally, a last impression should also be mentioned: Visual information is more and more given in learning material. However, processing of visual information 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.
The learning environment can be seen at: http://www.physikonline.net/programme/indexprogr.html.

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