Multimedia design in chemistry teacher training

A new teaching concept on evaluating one's own teaching material through eye-tracking

Justus-Liebig-University Giessen, Institute of Chemistry Education


axel.langner@dc.jlug.de
@AxelLangner

marietta.nied@la.jlug.de



nicole.graulich@dc.jlug.de
@nik_kola82

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

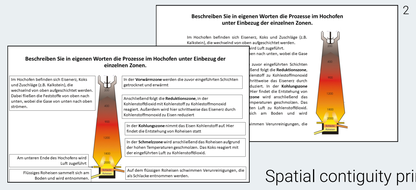
Teaching Concept

Design principles from well-established theories, such as the *Cognitive Theory of Multimedia Learning*[1], are often taught as guidelines to design instructional materials in student teacher training courses. However, they can only rarely be verified in terms of effectiveness of guiding learners attention by student teachers themselves.

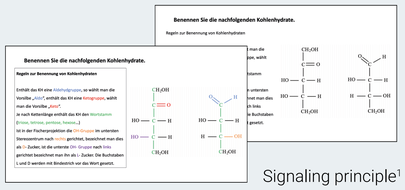
Therefore, in our newly designed course, students (N=19) were put in the position to test their own teaching materials with an eye-tracker in a small empirical investigation to determine the effects of differently designed materials on how learners perceive these learning materials.

Design Principles

Students designed teaching materials with and without respecting multimedia design principles, e.g.:



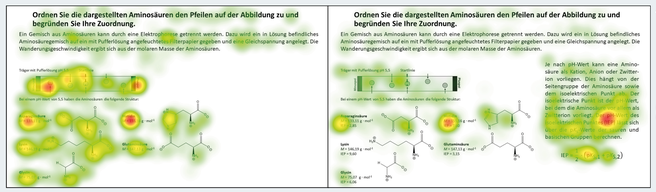
Spatial contiguity principle[1]



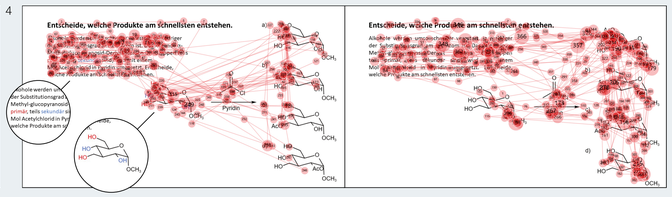
Signaling principle[1]

Empirical Investigation

Students tested their own teaching materials by presenting their materials to learners and determined the effects of different designs on learners' attention, perception, and strategy via eye-tracking and subjective cognitive load assessment (via likert-scale questionnaire[3]).



1 | Attention distribution (heat maps) of two learners while solving a task with (left) and without (right) the application of the coherence principle[1]. The learner on the left was able to solve the task successfully. In contrast, the irrelevant elements on the right resulted in an unsuccessful problem solving.



2 | Scan paths (gaze plots) of two learners while solving a task with the application of the signaling principle[1]. The highlighted primary and secondary hydroxyl groups in the reactant in the left example lead to increased fixations of the hydroxyl groups in the products.

Eye-Tracking metrics used, e.g.:

- Scan path
- Gaze proportion
- Area of interest visits
- Transitions between Area of interests
- Time to first fixation
- Reaction or response time

Student's Perspective

Overall, students reflected on the design principles and the usability of the designed teaching materials. This raised their awareness of perceptual processes and thus of digital (and analogue) multimedia that promote or hinder learning.

Students reported that the design of teaching materials is crucial for learning success. Furthermore, they stated that they could improve their ability to critically review or design teaching materials in terms of design, educational purpose, and learning promotion (evaluated via open-ended questionnaire).


"From now on, I think I can improve learning materials according to the task or the goal."

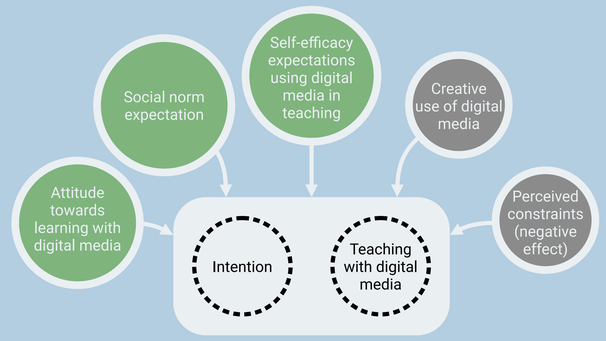

"I have become more aware that the design of the materials has a crucial impact on the successful completion of a task."


"Learning resources should consider learning theories. And design principles should be used purposefully."

Results

The course significantly increased student teachers' *attitude towards learning with digital media* (T=121, p=0.035, r=0.48), social norm expectation (T=119, p=0.008, r=0.61) and *self-efficacy expectations using digital media in teaching* (T=141.5, p=0.015, r=0.56) with a medium to large effect size. Creative use of digital media and perceived constraints did not change significantly (data collected via likert-scale questionnaire[5]).

Based on the *Theory of Planned Behavior*[6], it may be assumed that the course positively influenced students' intention for future applications of digital media in teaching.



3 | Adapted and simplified model of the *Theory of Planned Behavior*, which states that the intention to perform a behaviour can be predicted by various factors.[6] Factors, such as *attitude towards learning with digital media*, *social norm expectation*, *self-efficacy expectations using digital media in teaching*, *creative use of digital media* and *perceived constraints*, influence the *intention* and *behavior to teach with digital media*.[5]

[1] Mayer R. E., (2009), Multimedia Learning, Cambridge University Press. [2] illustration from Schmidt A. P., (1993), CC BY-SA 3.0 [3] Leppink, J. et al., (2013), Development of an instrument for measuring different types of cognitive load, Behav. Res. Methods, 45(4), 1058-1072. [4] illustration reprinted with permission from StudyHelp, (2018), Aminosäuren. https://www.studyhelp.de/online-lernen/chemie/aminosaeuren/. Copyright 2018 StudyHelp GmbH [5] Vogelsang, C. et al., (2019), Experience, Attitudes and Motivational Orientations as Potential Factors Influencing the Use of Digital Tools in Science Teaching, Zeitschrift für Didaktik der Naturwissenschaften, 25(1), 115-129. [6] Ajzen, I., (1991), The theory of planned behavior, Organ. Behav. Hum. Decis. Process., 50(2), 179-211. Icons from Bruce D., (2015), CC BY-SA 4.0

Students gave their consent to use their images.

Eye-Tracking Research
CER Graulich Group

Supported by
FCI FONDS DER CHEMISCHEN INDUSTRIE