RUB

9TH INTERNATIONAL COGNITIVE LOAD THEORY CONFERENCE

JUNE 22ND TO 24TH, 2016

BOCHUM, GERMANY

ABSTRACTS

ICLTA International Cognitive Load Theory Association

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PROGRAM AT A GLANCE

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ABSTRACTS

Wednesday, June 22, 2016, 11:30 to 12:30

Keynote

Tina Seufert

(Ulm University)

Self-Regulation and Cognitive Load in Multimedia Learning

Computer based learning environments require learners to self-regulate their learning process. Learners set their goals based on individual conditions, they choose their strategies, they reflect on their progress and they may also try to optimize their affective state. In multimedia learning settings learners moreover can decide on which representation to focus first or at all. The nature of this regulation process is highly dynamic as learners adapt their goals and strategies during the learning process.

Until now, Cognitive Load Theory has particularly focused on how to design learning environments in order to optimize cognitive affordances of a task. The view of an optimal learning situation derives from a static perspective on learning and does not take into account that learners themselves might re-arrange the task and the goals. Hence, the cognitive requirements of a task will vary during learning and depends on learner's decision. Cognitive load might even be the reason to regulate and to change strategies in order to optimize the individual load level.

Moreover the regulation process itself can impose cognitive load. Metacognitive monitoring, choosing and conducting the adequate strategy, coping with negative affect, trying to suppress distraction or any other regulatory activities require cognitive resources. They must not be directly related to the task, but they are not necessarily extraneous.

In my talk I want to analyze the role of self-regulation for learning and its relation to cognitive load as a cause as well as an effect.

Wednesday, June 22, 2016, 13:30 to 15:10

Cognitive Load Theory and regulation

Jimmie Leppink, Tamara van Gog, Liesbeth Kester, Fred Paas, Paul Chandler, Jeroen van Merriënboer

(Maastricht University, Utrecht University, Utrecht University, Erasmus University Rotterdam, University of Wollongong, Maastricht University)

Effects of metacognitive checklists on self-regulated learning skills

Self-assessment and learning-task selection are key self-regulated learning (SRL) skills. However, high school and higher education students appear to hardly use SRL-skills and when they do engage in self-assessment they are often inaccurate (Bjork et al., 2013). Increased accuracy of self-assessment and task selection skills could help students to choose learning activities that in terms of complexity and instructional support are optimal given their current knowledge levels, thereby improving their learning (Kostons et al., 2012). Two earlier experiments (N = 41 and N = 57 high school students) on the facilitation of SRL skills using metacognitive checklists (Sibbald et al., 2013) showed results in line with Kostons et al. (2012), that is, students had difficulties selecting tasks that matched their current level of expertise. What these experiments had in common with Kostons et al. (2012) was that students were asked to self-assess their performance in all conditions and feedback on task performance or SRL accuracy was provided in none of the conditions. Therefore, with the expectation that prompting self-explanation and providing performance feedback might both increase SRL accuracy, we conducted an experiment in which N = 230 bachelor students were randomly assigned to the four combinations of self-assessment prompt (yes/no) and performance feedback (yes/no). Participants in all conditions performed two five-step probability calculus problems. After each problem, participants rated experienced intrinsic (complexity of topic, formulas, and steps) and extraneous (suboptimal instructions) cognitive load (Leppink et al., 2014). Next, they were asked what kind of task they would choose next in terms of complexity (-5 = much easier, +5 = much more complex, 0 = same) and instructional support (-5 = much less, +5 = much more, 0 = same). In the performance feedback conditions, students received 'correct'/'incorrect' feedback after each step. In the self-assessment prompt conditions, students were asked after the task to rate the expected number of steps performed correctly. We expected participants' complexity and support choices to become more accurate with self-assessment prompting and/or performance feedback (H1) and to be positively related to actual performance (H2: higher performance resulting in higher complexity and/or less support) and self-rated intrinsic and extraneous cognitive load (H3: higher load scores resulting in less complexity and/or more support). Multilevel modeling with participant and task as hierarchical levels (Leppink & Van Merriënboer, 2015) reveals that chosen complexity tends to increase with performance (H2), tends to decrease with intrinsic cognitive load (H3), and tends to become somewhat more in line with actual performance when learners are prompted to self-assess their performance (H1). Chosen support tends to decrease with performance (H2), tends to increase with intrinsic and extraneous cognitive load (H3), and tends to become somewhat more in line with performance feedback (H1). In other words, the findings are in line with H2 but provide mixed support for H1 and H3: performance feedback and extraneous cognitive load appear to influence chosen support but not complexity, whereas self-assessment prompting appears to influence chosen complexity but not support. Future studies on task-selection skills could consider different self-assessment prompts and different performance feedback cues.

Wednesday, June 22, 2016, 13:30 to 15:10

Cognitive Load Theory and regulation

Gertjan Rop, Peter Verkoeijen, Tamara van Gog

(Erasmus University Rotterdam, Erasmus University Rotterdam, Utrecht University)

The redundancy effect disappears because people learn to ignore the content of irrelevant information

The redundancy effect states that presenting irrelevant or unnecessary information should be avoided as it hinders rather than helps learning. At present, however, it is unclear to what extent the redundancy effect is influenced by task experience. The prevailing explanation for the occurrence of the redundancy effect is that learners spend valuable working memory resources on integrating relevant information with redundant information, which does not contribute to, or even hampers learning. However, eye-tracking studies indicate that, even after relatively little practice, learners are able to ignore task-redundant information. Our prior research inspired by these findings showed that a redundancy effect of irrelevant pictures also disappeared with increasing task experience. Because it is unclear whether participants started to ignore the irrelevant content, or the location of the screen were the irrelevant information was presented, the present experiment examined whether changing this location after participants gained task experience would reinstate the redundancy effect. If participants had truly learned to ignore the picture, then top down attention control processes should prevent learners from allocating attention to the pictures after the switch, even though the switch makes them more salient. We used a word learning task in which participants learned action word definitions accompanied by meaningful pictures (depicting the action to be learned) or irrelevant pictures (depicting another action). Participants (n = 327) first learned 10 words accompanied by meaningful or irrelevant pictures in two blocks of 5 words with the pictures always appearing at the same location. Crucially, in the third block of 5 words, after participants gained some task experience, the picture switched for half of the participants. There was an interaction between picture condition and switch, but not in the direction one would expect: For participants in the meaningful condition, the location switch hampered word learning in block 3 compared to block 2, whereas in absence of a switch, recall performance in block 2 and block 3 was equal. For participants in the irrelevant condition, we found no differences in recall performance between block 2 and block 3, irrespective of switch. Findings show that participants learned to ignore the content, and not the location, of irrelevant information. We assume that in the irrelevant condition, participants started to ignore the pictures in the first two blocks, as they did not aid in their learning. Then, in block 3, top down control overrode any effects of the salience of the irrelevant pictures appearing at a different location. In the meaningful condition, the pictures depicted the action to be learned, so participants presumably (as suggested by a prior study) allocated substantial attention to these pictures, and somehow the location switch must have interfered with attention and thereby with learning. We conclude that students in the irrelevant pictures condition learned to ignore the content, and not only the location of the irrelevant pictures, because chancing the location of these irrelevant pictures did not reinstate the redundancy effect. This is relevant for researchers in the field of educational psychology as well as instructional designers, as it sheds some light on conditions under which redundancy will or will not hamper learning.

Wednesday, June 22, 2016, 13:30 to 15:10

Cognitive Load Theory and regulation

Alexander Eitel, Katharina Scheiter

(University of Freiburg, Leibniz-Institute Tuebingen)

Implementation intentions to process pictures early foster comprehension – for those who follow them

When learning complex topics presented via written text and pictures, students often start processing text before taking a closer look at the picture. This may, however, lead to interference between one's self-generated mental picture of the text contents and the subsequently inspected picture (if they do not match). Such interference can be detrimental to comprehension; and can be avoided when the picture is processed early. Accordingly, previous research revealed that students who processed picture before text outperformed students who processed text before picture. These effects were found by using strong manipulations – that is, sequential presentation formats in which there was little opportunity to switch back-and-forth between representations. The present experiment used a more naturalistic way of presenting text and picture to students (i.e., together on one page) to test beneficial effects of early picture processing. Participants (N = 85 undergraduate students) learned about how polar lights develop in space and early picture or text processing was stimulated by means of implementation intentions. These are specific 'if-then' plans that link a specific situation ("If I have opened a new page") to the desired behavior ("…then I will carefully study the picture/text first"). Once internalized, they are assumed to work automatically, thereby not posing any extra load on the cognitive system. In the present experiment, participants should internalize the intention to study 'picture first' or 'text first' by writing it down two times prior to the learning phase. We additionally assessed a control condition, where no specific intention should be internalized. Results from the control condition revealed that without a specific intention, most of the early attention was indeed directed towards the text. However, this bias was overcome with the 'picture first' intention, as these participants fixated the picture much longer in the beginning of each page (in first six seconds) compared to participants in the 'text first' and control condition. These fixation patterns remained unchanged across the whole instruction supporting the idea of implementations intentions to elicit behavior automatically. Moreover, participants who followed 'picture first' intentions had better learning outcomes than participants who followed 'text first' intentions. In this analysis, however, data of seven 'picture first' participants had to be excluded because they fixated the picture for less than 20 percent of the time in the first six seconds (i.e., did not follow picture-first intention). Nonetheless, for most participants, implementation intentions as a more subtle manipulation effectively stimulated early picture processing which also proved to be successful for learning. Results thus confirm positive effects of picture-first processing also when the additional opportunity for frequent transitions between text and picture in a simultaneous presentation format is given.

Wednesday, June 22, 2016, 13:30 to 15:10

Cognitive Load Theory and regulation

Tim Kühl, Alexander Bertrams

(University of Mannheim, University of Bern)

The influence of ego depletion on learning with inference prompts vs. no prompts

According to Cognitive Load Theory (CLT), actively processing information and investing mental effort should foster learning. One promising instructional aid to engage learners in active processing might be inference prompts (e.g., Renkl, 2011), where learners are prompted to generate specific inferences that are crucial for understanding central aspects of a content. However, learners also need the resources available to be able to conduct these processes. In this connection, one potentially important factor, which is rather neglected within the context of CLT, is self-control. According to self-control theories (e.g., Baumeister, Vos, & Tice, 2007), active self-control is necessary to carry out such higher order processes. However, self-control seems to be a limited resource that can be depleted. Hence, under conditions of depleted self-regulatory resources (ego depletion), inference prompts might overwhelm learners. Thus, the potential benefits of inference prompts might particularly unfold under nondepleted conditions, but not under depleted conditions. To investigate this, 97 participants were assigned to one of four conditions resulting from a 2x2-Design with ego depletion (yes vs. no) and learning condition (inference prompts vs. no prompts) as independent variables. Ego depletion was manipulated with a writing task: Participants were instructed to transcribe a text on a blank sheet, but only participants in the depletion condition were instructed to omit the letters e and n wherever they would normally appear in their writing (depletion condition). All participants were stopped after 6 min. Thereafter they filled in questions how demanding this task was (manipulation check). Then they received the instructional material ("How airplanes achieve lift"). For the inference prompt condition, segments of the regular text were removed by questions asking for that particular information. Dependent variables were measures of cognitive load (effort and difficulty) as well as learning outcomes (retention and transfer). The manipulation check items revealed that participants in the depleted conditions stated that the task was more demanding than participants in the depleted conditions ($p < .01$), indicating that the manipulation worked. With respect to learning outcomes, there were no effects of ego depletion, no effects of learning condition and no interaction between ego depletion and learning condition – neither for retention nor for transfer. For mental effort, a 2x2-ANOVA revealed a main effect of learning condition, with learners in the inference prompts condition stating to have invested more mental effort than learners in the no prompts condition ($p < .05$). However, this did not translate into better learning outcomes. There was no effect of ego depletion and no interaction. For difficulty, a 2x2-ANOVA revealed no effect of learning condition and no interaction, but a main effect of ego depletion ($p < .05$): Surprisingly, learners in the depleted conditions found learning less difficult than learners in the nondepleted conditions. This may be interpreted as a kind of "contrast effect", in that the learning conditions were perceived as relatively easier when learners were exposed to the ego depletion task. It might be the case, that ego depletion would have an impact on learning (with inference prompts), when the intensity of the ego depletion task is boosted. Hence, its relevance for CLT should not be neglected prematurely.

Wednesday, June 22, 2016, 15:30 to 17:10

Worked examples

Matthias Schwaighofer, Markus Bühner, Frank Fischer

(Munich University, Munich University, Munich University)

Executive functions as moderators of the worked example effect: when shifting is more important than working memory capacity

Worked examples have proven to be effective for knowledge acquisition compared with problem solving, particularly when prior knowledge is low (e.g., Kalyuga, 2007). However, in addition to prior knowledge, executive functions and fluid intelligence might be potential moderators of the effectiveness of worked examples because these cognitive functions are important for cognitive achievements (e.g., Primi, Ferrão, & Almeida, 2010; Yeniad, Malda, Mesman, van Ijzendoorn, & Pieper, 2013; Yuan, Steedle, Shavelson, Alonzo, & Oppezzo, 2006). The present study examines the roles of the executive functions of working memory capacity and shifting, as well as the role of fluid intelligence for knowledge acquisition in the presence or absence of worked examples. Seventy-six university students learned to solve statistical problems either with worked examples or through problem solving (the absence of worked examples). Cognitive load was measured after each statistical problem. Results showed that shifting and fluid intelligence, but not prior knowledge and working memory capacity, moderated the effect of the presence of worked examples on knowledge acquisition. The higher the shifting ability and fluid intelligence were, the lower the benefit of worked examples was compared with problem solving. Learning environments did not differ with respect to cognitive load, and cognitive load was not correlated with working memory capacity, but it was correlated with fluid intelligence. These findings suggest that other important cognitive functions, such as shifting and fluid intelligence, might be more important than prior knowledge or working memory when worked examples are compared with problem solving. Future research can further examine whether the relative contribution of the different functions is likely to depend on the characteristics of the respective tasks—that is, whether a task puts a high or low demand on these cognitive functions. Results of a study probably starting at the end of February 2016 should also be presented at the conference. This study investigates the moderating role of prior knowledge, executive functions, perceptual speed and fluid intelligence for knowledge acquisition in a 2x2 design manipulating the presence of worked examples and time pressure (yes vs. no) in order to vary the demand on working memory.

Wednesday, June 22, 2016, 15:30 to 17:10

Worked examples

Bing Ngu, Huy Phan

(University of New England, University of New England)

Learning to solve trigonometry problems: A comparative study of the analogical problem-solving, worked example and problem-solving approaches

We hypothesized differential cognitive load associated with analogical problem- solving approach, worked example approach and problem-solving approach on learning how to solve trigonometry problems. A trigonometry problem (x/14 = tan63°) and an equation with a fraction (x/4 = 3) share a similar problem structure and therefore a similar solution procedure. The analogical problem-solving approach requires the learners to compare a trigonometry problem with an equation with a fraction, and then solve an equivalent trigonometry problem. The analogical comparison of structurally similar problems is expected to strengthen the learners' understanding of the underlying problem structure of trigonometry problems. The worked example approach requires the learners to study a worked example of a trigonometry problem and solve an equivalent trigonometry problem. The learners are expected to model the solution procedure in the worked example and transfer it to solve an equivalent trigonometry problem. The problem-solving approach requires the learners to solve trigonometry problems. Sixty three students were randomly assigned to one of the three instructional approaches. It was hypothesized that the analogical problem-solving group would outperform the worked example group, which in turn, would outperform the problem-solving group on post-test as well as the concept test. In line with previous worked examples research, it was hypothesized that the problem-solving approach would impose higher cognitive load than the worked example approach. Because students were expected to invest cognitive load when they compared two structurally similar problems, we predicted that the analogical problem-solving approach would incur higher cognitive load than the worked example approach. Test results indicated that all three groups had improved significantly from pre-test to post-test. However, the three groups neither differed on the post-test nor the concept test. In line with the hypothesis, the problem-solving group had significantly higher mental effort score than the worked example group. Contrary to the prediction, the analogical problem-solving group did not have higher mental effort score than the work example group. The worked example group did not perform better than the problem-solving group. This contradicts previous worked examples research. Furthermore, requiring the students to engage in analogical comparison of structurally similar problems as in the case of the analogical problem-solving approach did not appear to benefit learning of trigonometry problems more than either the worked example approach or the problem solving approach.

Wednesday, June 22, 2016, 15:30 to 17:10

Worked examples

Ouhao Chen, Yan She, Slava Kalyuga, Siqing Lian, John Sweller

(University of New South Wales, Capital Normal University, University of New South Wales, Capital Normal University, University of New South Wales)

The isolated-element effect, the worked example effect and the generation effect

Studying worked examples providing problem solutions to learners, usually leads to better test performance than solving the equivalent problems without guidance, demonstrating the worked example effect. The generation effect occurs when less guidance facilitates performance. The contradiction between these results can be hypothesized to be due to differences in the element interactivity of the learning tasks (Chen, Kalyuga & Sweller, 2015, Journal of Educational Psychology) Results such as these have been directly related to the expertise reversal effect (Chen, Kalyuga & Sweller, in press, Educational Psychology Review). Isolating elements can be used to reduce element interactivity compared with an integrated form incorporating all interactive elements. Accordingly, an interaction between guidance (high vs. low) and form (isolated vs. integrated) was hypothesised. A 2 (guidance: low vs. high) x 2 (format: isolated vs. integrated) factorial experimental design was used in the domain of algebra testing 82, approximately 13 year old, Year 7 students, from a secondary school in Beijing, China. They were novices in the task area. Students were randomly assigned to one of four groups with four different instructional booklets. For the isolated-integrated worked example group, isolated solutions were presented to teach students how to open a bracket in the first phase, whereas, in the second phase, integrated worked examples were provided to demonstrate connections between the isolated units presented in the first phase. For the isolated-integrated problem solving group, isolated units without solutions were presented for students to open the brackets themselves in the first phase, whereas, in the second phase, conventional, integrated problems were provided to be solved by the students. For the integrated-integrated worked example group, integrated worked examples were provided in both phases. For the integrated-integrated problem solving group, conventional problems were presented in both phases for solution by the students. Two steps were required for solving each problem: opening a bracket and calculating the final answer. For Step 1, one mark was allocated for each correctly opened bracket. For Step 2, one mark was allocated for a correct calculation, such as 3x5 = 15. No interaction was found on either the total score nor on the separate steps, but the effect of guidance on the first step, opening brackets, was significant, $F_{(1, 80)} = 5.22$, MSe = 31.62, p = .009, $\eta^2_{partial} = .085$. For Step 2, multiplying the two symbols, the worked example effect disappeared. These results indicate that the worked example effect was more likely on the higher element interactivity steps of opening brackets but not on the lower element interactivity steps of multiplying two symbols. Nevertheless, neither an isolated elements effect nor a generation effect was obtained.

Wednesday, June 22, 2016, 15:30 to 17:10

Worked examples

Milou van Harsel, Peter Verkoeijen, Tamara van Gog

(Utrecht University, Erasmus University Rotterdam, Utrecht University, Erasmus University Rotterdam)

Sequencing example study and practice problem solving in higher technical education

It is well established that, for novices, studying examples is a more effective and efficient instructional strategy compared to practice problem solving (Renkl, 2014; Van Gog & Rummel, 2010). This applies both to worked examples, in which learners study a written step by step demonstration of how to solve a problem, and to modeling examples, in which someone demonstrates how to solve a problem. Video modeling examples are increasingly being used in online learning environments. However, there are still open questions on how and when such examples should ideally be introduced, for example, how example study and practice problems should be sequenced to be most motivating and most effective and efficient for learning. Recent studies show that studying examples only (EE) or example-problem pairs (EP) is equally effective, and more effective and efficient for learning than studying problem-example pairs (PE) or problems only (PP) (e.g. Leppink et al., 2014; Van Gog et al., 2011). These results, however, have been mainly found in relatively short studies. When learning phases that are of longer duration are used, it is possible that effects would change. Moreover, prior studies did not take into account motivational aspects of learning, even though these might explain some of the findings. For instance, the finding that EE can be as effective as EP on both immediate and delayed tests (Leahy et al., 2015; Van Gog et al., 2015) might change when using learning phases that are of longer duration. It might be more motivating for learners to actively attempt to solve PP compared to continued EE. Moreover, regarding the EP versus PE comparison, it has been suggested that in short sequences, these results can be explained via affective/motivational variables, but this has not yet been tested. Furthermore, research has shown that this difference reverses for students with high prior knowledge (i.e., PE > EP; Reisslein et al., 2006), possibly because solving a problem first allows them to identify potential gaps in their knowledge, as a consequence of which they might find subsequent examples more useful. Therefore it could be hypothesized that, when using longer learning phases and more tasks, EP might become more effective than EE and PE might become more effective than EP when learners gain knowledge. The purpose of the present study is to replicate Van Gog et al. (2011) but with video examples, and to investigate 1) the effect of motivation when studying different sequences, and 2) whether the relative effectiveness and efficiency of different sequences are affected by using longer learning phases and more tasks. This study includes two experiments. In Experiment 1a (N = 120) and Experiment 1b (N = 120), first year higher education students, are randomly allocated to one of four conditions: 1) examples only, 2) example-problem pairs, 3) problem-example pairs, and 4) problems only. After completing a pre-test, participants in Experiment 1a study four learning tasks and participant in Experiment 1b study eight learning tasks. Subsequently four test problems will be solved. Topic interest and perceived competence are measured before and after the learning phase. Invested mental effort is measured after each task in the learning and test phases. Time on task is logged. Participants receive a delayed posttest one week later. The study is currently being conducted; results will be available at the conference.

Wednesday, June 22, 2016, 15:30 to 17:10

Worked examples

Katrin Schüßler, Jenna Koenen, Elke Sumfleth

(University of Duisburg-Essen, University Berlin, University of Duisburg-Essen)

Segmenting or self-explanation prompts – the impact on learning with non-algorithmic worked examples

Advantages of worked examples are well known from cognitive load research. However, Renkl (2014) points out three major limitations. 1) There is only little insight into learning with worked examples in the classroom. 2) The design principles are mainly proved for algorithmic examples. 3) The interrelations of the design principles are only partly examined. To focus on those aspects, worked examples to induce knowledge acquisition of chemistry concepts were developed and evaluated in an intervention study with a pre-post-design in a school setting. A first study examined the influence of different self-explanation prompts on learning outcome. Results indicate that the used worked examples are suitable to induce learning of chemistry concepts (e. g. acids) in classroom ($t_{(137)} = 15.44$, $p < .001$, $d = 1.23$; Schüßler, Koenen, & Sumfleth, in press), but no effect of the different self-explanation prompts on the learning outcome was found ($F_{(2,135)} = 0.15$, $p = .858$, $\eta^2_{partial} = .002$). One possible explanation might be that the effect of the self-explanation prompts is covered by the effects of the applied design principles. The developed worked examples (Schüßler, Emden, & Sumfleth, 2016) do not only rely on classic principles (e. g. multimedia principle, signaling principle) but also use 1) a cover story with authentic and likeable characters (model-observer-similarity principle), 2) dialogs frequently changing between experts' explanations (explanation-help principle) and novices' questions or summaries (studying-errors principle), and 3) division into units of meaning (segmenting principle). Among these design principles the segmenting principle is a very dominant one (e. g. 34 segments in comparison to 4 prompts). Therefore, the second study examines whether the increased learning outcome is due to the embedded self-explanation prompts or the induced segments (segmenting principle). To investigate the effect of segmenting and prompting on the learning outcome a 2 x 2 design is applied (N = 575; 9th grade; German secondary schools; randomly assigned). Content knowledge was surveyed one week before and after the intervention. Additionally, perceived item difficulty (Kalyuga, Chandler, Tuovinen, & Sweller, 2001), invested mental effort (Paas, 1992) and satisfaction with the learning environment were measured several times while students studied the worked examples (Schmeck, Opfermann, van Gog, Paas, & Leutner, 2015). Comparing pre- and post-test measures studying with the worked examples leads to a significant growth of content knowledge ($t_{(435)} = 16.59$, $p < .001$, $d = 0.847$). But a repeated-measures ANOVA with additional post-hoc analysis (LSD) exposes no differences in the learning achievement of content knowledge between the groups ($F_{(3,432)} = .30$, $p = .827$, $\eta^2_{partial} = .002$). However, groups do significantly differ concerning learning time ($F_{(3,397)} = 19.16$, $p < .001$, $\eta^2_{partial} = .126$). Additionally, self-explanation prompts lead to a higher perceived item difficulty during the intervention ($F_{(1,383)} = 6.84$, $p = .009$, $\eta^2_{partial} = .018$). Even though further research is needed these findings indicate that 1) worked examples are also effective in the classroom, 2) not all design principles developed for algorithmic examples seem to be valid for non-algorithmic examples, and 3) there seems to be an interrelation between segmenting and self-explanation prompts.

Wednesday, June 22, 2016, 17:10 to 18:00

Poster presentation 1

Martine Baars, Tamara van Gog, Anique de Bruin, Fred Paas

(Erasmus University Rotterdam, Utrecht University, Maastricht University, Erasmus University Rotterdam)

Self-regulated learning when solving problems and studying worked examples: the relationship between mental effort and judgements of learning

Making monitoring judgments about problem-solving tasks and whether an appropriate mental representation for future use is available, has proven to be difficult. According to the cue-utilization framework monitoring judgments, like Judgments of Learning (JOLs), are inferential by nature. One cue used to make JOLs is subjective rating of mental effort, which was found to be negatively related to JOLs when learning to solve problems in secondary education. Also, it was found that the students overestimated their learning when making immediate JOLs after studying worked-out examples of problem-solving tasks. Yet, at a delay one would expect that this overconfidence would diminish because students can no longer use information from their working memory and instead rely on their long-term memory. Furthermore, solving a practice problem after worked example study was found to improve JOL accuracy because performance on the practice problem can be used this as a cue to make a JOL. In this case, one would expect immediate JOLs after problem solving tasks to be more accurate because students are still able to use their task experience to make a JOL whereas at a delay most of the task experience might be forgotten. Experiment 1 Method Participants were 53 students (M_{age} =14.47, SD = .54). Directly after studying a worked example (4 in total), students rated their mental effort. Students provided a JOL either immediately after a worked example (immediate JOL, n = 25) or after all worked examples (delayed JOL, n = 28). Then the first test, restudy phase, and the second test were completed. Results Mental effort was significantly correlated to JOLs for both conditions (IMM: r = -.88, p < .001; DEL: r = -.73, p < .001), indicating that the higher the mental effort ratings, the lower JOLs were. Participants showed overconfidence in their JOLs. No difference in bias, absolute deviation, first test, and second test performance were found. Participants scored significantly higher on the second test than on the first test. Experiment 2 Method The method was similar to Experiment 1, however problem solving tasks instead of worked examples were used. Forty-four students (M_{age} =15.72, SD = .50) solved problems on troubleshooting electrical circuits. Results Again, the mean mental effort was significantly correlated to the mean JOLs for both conditions (IMM: r = -.74, p < .001; DEL: r = -.83, p < .001). No difference in bias, absolute deviation, first test, and second test performance were found. In Experiment 2, performance on the second test was not higher than on the first test. Conclusions Students seemed to use their mental effort as a cue to make JOLs. However, because students were not perfectly accurate in their JOLs, it would be interesting to investigate on what cues from task experience mental effort was based, and whether that makes mental effort a valid cue to make JOLs. Furthermore, students tended to overestimate their learning when they practiced solving problems or studied worked examples both conditions. Future research could investigate how monitoring accuracy when learning to solve problems can be supported to help student to learn in a self-regulated way. Finally, all students gained in performance between the first and the second test when studying worked examples but not when solving problems.

Wednesday, June 22, 2016, 17:10 to 18:00

Poster presentation 1

Roman Abel, Martin Haenze

(University of Kassel, University of Kassel)

Arranging solution steps and solving subtasks. Which kind of guidance do learners really need?

Learners exhibit no generation effect while performing learning tasks with high element interactivity, rather a worked example effect. We examined the effect of different types of generation activity on learning performance while studying complex learning tasks about probability calculation. The design of the task materials varied between the participants in two factors. 1. The amount of guidance in the arrangement of the solution steps – the order of solution steps was regular (high) vs. the order of steps was quasi randomized and had to be rearranged (low). 2. The amount of guidance within the solution steps – students only had to comprehend the steps (high) vs. to apply following instructions in order to solve the subtasks (low). One of the four conditions “high / high” corresponds to the classical worked out example. This group showed no superiority in learning performance. Particularly, we found an interaction between the previous knowledge and both difficulties.

Wednesday, June 22, 2016, 17:10 to 18:00

Poster presentation 1

Jaewon Jung, Dongsik Kim, Chungsoo Na

(Hanyang University, Hanyang University, Hanyang University)

Effects of WOE presentation types used in pre-training on the Cognitive Load and comprehension of content in animation-based learning environments

This study investigated the effectiveness of various types of worked-out example (WOE) used in pre-training to optimize cognitive load and enhance learners' comprehension of content in the animation-based environment. An animation-based environment was developed specifically for the study. The participants comprised 92 undergraduate students, who were divided into four groups. Each group was provided with a different type of WOE for pre-training, as follows: animation with narration; animation with concise narration; animation with narration and concise textual information; and animation with concise narration and verbal labels. After the pre-training sessions, the participants' cognitive load was measured in three dimensions (intrinsic, extraneous, and germane cognitive load), and their comprehension of the learning content was analyzed. Next, during the training session, the participants were asked to carry out a complete task using animation accompanied by narration and concise textual information. After the training session, the participants' cognitive load and comprehension of the learning content were analyzed again. To compare the mental effort and comprehension of content of the four groups, analysis of covariance was conducted using Predictive Analytics Software (PSAW) Statistics 18. The findings revealed that animation accompanied by concise textual information and animation accompanied by concise narration and verbal labels were both effective in controlling cognitive load and enhancing the learning experience. In addition, the results for the training session indicated that pre-training improves learners' control of their cognitive load and increases their comprehension of content. The findings of the study thus offered insights into the potential of various types of WOE-based pre-training to both control learners' cognitive load and make learning experiences more successful.

Wednesday, June 22, 2016, 17:10 to 18:00

Poster presentation 1

Brendan Bentley, Gregory C.R. Yates

(University of South Australia, University of South Australia)

Cognitive Load and calculators, a classroom study

We report on an experiment involving Australian year 7 (11 year old) students (n = 52), who worked on proportional reasoning problems within normal classroom periods of 50 minutes. The students were given workbooks on each of 4 separate periods: Pretest, treatment, immediate posttest, and delayed (1 week) posttest. On the second occasion, half the students were provided with booklets showing a series of 10 worked examples and were aided in solving the problem by the use of a calculator. The worked examples depicted a unitising strategy. The students exposed to worked example treatments produced (a) superior gains on test scores, (b) increases in self-efficacy ratings, and (c) reductions in self-reported load. In contrast, the respective control group students generally did not show any significant changes. Worked example instruction, along with the use of a calculator, suggests an effective methodology to assist in this area of the curriculum.

Wednesday, June 22, 2016, 17:10 to 18:00

Poster presentation 1

Vincent Hoogerheide, Margot van Wermeskerken, Sofie Loyens, Tamara van Gog

(Utrecht University, Utrecht University, University College Roosevelt, Utrecht University)

Testing the model-observer similarity hypothesis with video modeling examples

For novice learners, example-based learning is a very beneficial instructional strategy (Van Gog & Rummel, 2010) that can enhance learners' confidence in their own capabilities (i.e., self-efficacy and perceived competence; Hoogerheide et al., 2014). This holds true for worked examples that provide a written step-by-step demonstration for how to solve a problem and (video) modeling examples in which a model demonstrates how to solve a problem. The model-observer similarity hypothesis states that how similar to the model learners perceive themselves to be moderates the effectiveness of (video) modeling examples (Schunk, 1987). Findings have been mixed, however, possibly because manipulations of the similarity between learners and the model across conditions often also affected what the models said or did (e.g., Zimmerman & Kitsantas, 2002). Therefore, two experiments investigated whether, when the content of the examples is controlled for, learning outcomes, self-efficacy, and perceived competence are enhanced and effort investment decreased when learners study video modeling examples with a more similar model relative to a more dissimilar model. Experiment 1 used a 2 (Gender Model: Male vs. Female) x 2 (Gender Observer: Male vs. Female) between-subjects design. Adolescents (N = 167) studied a video modeling example in which a male or female model demonstrated how one would ideally solve a probability calculation problem. For male students, it was less effortful to study a male model than a female model, and a male model was more effortful to study for female than male students. A male model enhanced perceived competence more than a female model. No other main or interaction effects involving Gender Model were found. Experiment 2 used a 2 (Age Model: Adult vs. Peer) x 2 (Expertise Model: Low vs. High) between-subjects design. Adolescents (N = 157) observed a video in which an adult or peer model introduced herself as having low or high expertise in science, and then learned how to solve electrical circuit problems by observing two examples. Results showed that those who had observed adult models invested less effort in example study and learned more than those who observed peer models. Moreover, the low expertise and peer models' explanations were rated as being of less quality than the high expertise and adult models' explanations, respectively. No other effects were significant. An explanation for why a male model enhanced perceived competence more and why adults were more effective and efficient models, is that students might have perceived the math task as more appropriate for males than females and the physics task as more appropriate for adults than peers. This would explain why those who had observed peers evaluated their model's explanations to be of lower quality than students who had observed adults, even though all models provided the exact same explanations. Note that two additional experiments showed that manipulating who the model is in terms of Gender (N = 147) and Age/Expertise (N = 130) by means of pictures and a short story did not affect how much students benefited from worked examples, suggesting that who the model is only matters when ample social cues are available. Thus, model characteristics in video modeling examples can affect learning and motivational outcomes, even when the example content is controlled for. These effects seem shaped by views of task-appropriateness rather than model-observer similarity, however

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Poster presentation 1

Maria Wirzberger, Maik Beege, Sascha Schneider, Steve Nebel, Günter Daniel Rey

(Technical University Chemnitz, Technical University Chemnitz, Technical University Chemnitz, Technical University Chemnitz, Technical University Chemnitz)

CLT meets WMU: Simultaneous experimental manipulation of load factors in a basal working memory task

In multimedia learning settings, limitations in learners' mental resource capacity need to be considered to avoid impairing effects on learning performance. A prominent and influential theory that provides advice for the conducive design of media-transmitted instructional content from a cognitive perspective is the Cognitive Load Theory (CLT). Based on this theoretical framework, the current study investigates the potential of a single experimental approach to provide simultaneous and separate measures for the postulated structure of additive load-inducing factors, i.e. intrinsic, extraneous and germane cognitive load. Such approach allows to manipulate each facet in a selective, controllable way that directly relates behavioral outcomes to the process of learning. On this account, it aims to provide an advantage over collecting subjective responses via questionnaires or applying costly physiological measures. To further increase the internal validity and controllability of the inspected task setting, a basal letter-learning task operating on the concept of working memory updating (WMU) was used. Within each trial, it demanded participants to remember an initially presented letter set, perform a series of alphabetic updating transformations for each letter, and recall the final outcome for all letters afterwards. Such task setting respects the fact that learning involves to correctly represent changing working memory content over time. The resulting repeated-measures design comprised task complexity, split attention and schema presence as experimental factors, and additionally kept track of the individual levels of concentrated attention and working memory capacity. Whereas task complexity was determined by the amount of letters to remember within a trial, the necessity to split up attention resulted from changing the horizontal spatial distance within the letters. Schema presence was induced via repeating letter sets that had been shown earlier during the practice sequence of the task. On purposes of inspecting the performance of the tested student sample (N = 96), reaction times and errors were recorded in both updating and recall phases. Applying a multilevel-approach, the obtained results showed enhanced reaction times and errors with increasing complexity during both phases, as well as extended reaction times under the presence of split attention. The effect of schema presence presented itself in both phases in the case of errors, whereas a decrease in reaction times occurred only within updating steps. Additionally, interactions between two or all experimental factors showed up, i.e. for complexity and split attention in the case of updating reaction times, for complexity and schema presence in the case of recall reaction times, and for all factors in the case of updating errors. Results might be explainable with regard to underlying mental operations and aptitude variables, and relate well to recent reformulations of the theoretical framework. Overall, the study comprises a promising step within the empirical investigation of existing construction yards in cognitive load research.

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Poster presentation 1

Thilo Joachim Ketschau

(Göttingen University)

Cognitive Load as criterion for item difficulty in case of complex problem solving – a quantitative approach with standardized test items

The research on problem solving and problem solving competency has gained in importance in educational research in the last years (see for example Leutner et al., 2012; Abele et al., 2012). Furthermore, it must be assumed that problem solving competency is becoming more relevant in a work and social environment which is becoming increasingly complex (see for instance Dehnbostel, 2015; Sloane, 2000), because it is no longer possible to prepare the social and professional skills of pupils, trainees and students for all eventualities and situations of everyday life and work. This problem implies, in the perspective of pedagogical diagnosis, the need for effective and economical measurement of complex problem solving competency, which is needed especially for an evaluation of related learning processes and training interventions. The presented study addresses this need by offering a computer-based assessment to diagnose complex problem solving competency of students of economic and social sciences. Currently, the items of the assessment are constructed and a pre-test is planned for spring 2016. In order to construct complex items, an a priori prognosis of the expected level of the item's difficulty is necessary. Considering the considerable effort of the design and administration of computer-based complex items and assessments, the variance of test scores should be calculable prior to a pre-test to reduce measurement inaccuracy and therefore post-processing of the items. The Cognitive Load which is expected for the probands is assumed to be predictor and determinant for the ability to solve a complex item. It is represented as attribute of the extent of information contained in an item, no matter whether how much of it are attractors or distractors. This assumption is based on the premise that theories on Cognitive Load as a determinant of learning (see for instance Plass et al., 2010) can be adapted for contemplation of test conditions. Besides the discussion of this assumption, a format for standardized complex test items and a simple mathematical model for a priori estimation of item difficulty will be submitted in the presentation. With the data of the pre-test, this model should also be used for estimating the predictive possibilities of the criterion Cognitive Load for the difficulty of an item. The item difficulty itself may therefore be estimated as a parameter with probabilistic test models or by the frequencies of solutions manifested in response variables.

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Wednesday, June 22, 2016, 17:10 to 18:00

Poster presentation 1

Yuan Gao, Yuling Hsu, Tzu-Chien Liu, John Sweller

(Beijing University, Tzu Chi University, University Taiwan, University of New South Wales)

Effects of instructional guidance with varying details of representations and learning procedures on learning with computer simulations for novices

Computer simulations support for complex learning have become available for a wide range in formal or informal learning and instructional guidance is considered to be critical for successful learning in simulation-based learning environment (Kirschner, Sweller, & Clark, 2006; Mayer, 2004; Rutten, van Joolingen, & van der Veen, 2012). However, it is still yet to be clarified what the types and amounts of instructional guidance should provide for learners. Present study investigated the effects of different detail levels of instructional guidance for novice on learning about concepts of correlation in a simulation-based learning environment. Based on cognitive theory of multimedia learning and cognitive load theory, a between-subject experiment was conducted to investigate the two detail levels (higher- vs. lower-level) of instructional guidance on representation and learning procedure (two facets). Seventy-two Grade 10 students (36 male and 36 female) were randomly assigned into four conditions. 1. A High Detail Representation-High Detail Learning Procedure condition in which the learners explored the simulation-based learning environment with given values for setting the parameter representations and with given procedures. 2. A Low Detail Representation-High Detail Learning Procedure condition in which no exact value was provided for setting parameter representations and so the learners had to select appropriate values from a given range. However, the learners were still provided with given procedures to explore the simulation-based environment. 3. A High Detail Representation-Low Detail Learning Procedure condition in which the learners were provided with exact values for parameter representations, but they were not provided with detailed procedures for learning. 4. A Low Detail Representation-Low Detail Learning Procedure condition in which neither exact parameter values nor learning procedures were provided in detail. The understanding- and application- level test as well as a cognitive load self-rating scale was used to determine which detail level of condition could most benefit for novice. Furthermore, the log-file which recorded all manipulations of students' with the simulation-based learning environment during learning process was further analyzed to clarify what and how the different facets (representation and learning procedure) influenced the learning performance with varying detail. The results indicated that the High Detail Representation and High Detail Learning Procedure condition with highest detail instructional guidance provided most efficient support for learning with highest test performance and lowest cognitive load during learning process. In addition, analysis of log-file data revealed that most learners regardless of the experimental conditions could follow the instructional guidance during learning. Moreover, learners in the conditions with lower detail level on either/both representation or/and learning procedure experienced significantly more amounts of manipulations during learning than the High Detail Representation and High Detail Learning Procedure guidance condition with highest detail instructional guidance. These results in terms of cognitive load theory framework and their implications related to design the instructional guidance for learning with simulations were discussed.

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Poster presentation 1

Siti Nurma Hanim Hadie, Asma' Hassan, Saiful Bahri Talip, Zul Izhar Mohd Ismail, Ahmad Fuad Abdul Rahim

(University Sains Malaysia, University Sultan Zainal Abidin, University Malaysia Sarawak, University Sains Malaysia, University Sains Malaysia)

Evaluation of students' performance after a Cognitive Load Theory-based gross anatomy lecture

Gross anatomy is a dry content-driven subject that imposes high cognitive load to medical students. Despite formalization of student-centered learning in the modern medical curriculum, lecturing remains as the most feasible method of teaching anatomy to pre-clinical year students. To ensure effective lectures, it is crucial to find a way on how to convert the knowledge-transfer process of lecturing into actual learning. Therefore, we introduce a four-phase lecture guideline that utilizes the principles of cognitive load theory and explored for its effectiveness by measuring the students' cognitive load levels and test performance. A randomized controlled trial was conducted on 147 consented first-year medical students from three Malaysian medical schools that adopt similar medical curriculum. To eliminate sampling bias, stratified random allocation was performed by controlling the gender, entrance qualification and Malaysian University English Proficiency Test score. 'The gross anatomy of heart' topic was selected for the study as it was rated as the most difficult topic by eleven anatomy experts with mean difficulty index of 26.5. On Day-1, the control group attended a freestyle lecture on the topic, delivered by a qualified anatomy lecturer, who was trained to use the guideline one day after the lecture. The lecturer was given three weeks duration to prepare a cognitive load theory-based lecture of similar topic. The lecturer subsequently delivered the lecture to the Intervention group on Day-21. Prior to each lecture, the students answered 15 multiple true-false questions as their baseline knowledge measure. Immediately after the lecture, the students' cognitive load levels and self-perceived learning were measured using the validated cognitive load scale. The students also answered another set of multiple true-false questions as their post-lecture assessment. The Independent-t- and Mann-Whitney tests were performed to determine the difference of these variables scores between study groups. Our findings revealed the intervention group experienced significantly lower level of intrinsic load [t-stats (df) = 2.597 (145), p = 0.010] and extraneous load [Z-stats (IQR) = -2.481 (2.33), p = 0.013] compared to control group. The students in the intervention group also perceived better learning than the control group with significantly higher self-perceived learning score [Z-stats (IQR) = 7.500 (1.00), p = 0.001]. In addition, the post-lecture assessment score was higher in the intervention than in control group [t-stats (df) = -2.279 (145), p = 0.019] despite having similar level of baseline knowledge on the selected topic [t-stats (df) = 0.525 (145), p = 0.603]. From this notion, we posits that application of this theory could create a better learning environment in a lecture setting as proven by less mental burden and better understanding of the lecture content, experienced by the intervention group. Besides, this model provides a step-by-step approach on how a lecturer could apply the principles of cognitive load theory in their lecture. Hence, it is suitable for novice lecturers who are facing with difficulty when preparing their lectures. Nevertheless, to ensure the consequential validity of this guideline, other outcome variables such as knowledge acquisition, knowledge retention and learning behaviour change should be explored in the future.

Wednesday, June 22, 2016, 17:10 to 18:00

Poster presentation 1

Paul Blayney

(University of Sydney)

Improving adaptive instruction with a limited item speed test

Previous research has shown that the most effective instructional techniques are modified according to the level of learner expertise. However practical application of this finding requires a metric to determine the levels of expertise at which it is desirable to alter instructional procedures. This study investigates the effect of using a limited item speed test as such a metric can be used to guide the alteration of instructional techniques. We present the findings of an experimental study of 200 first year undergraduate accounting students split approximately evenly on gender, aged from 18 to 21 years. The majority of participants are studying for a Bachelor of Commerce degree and did not previously study accounting at a tertiary level. Experimental sessions are designed to be 75 minutes in duration beginning with a 5 minute pre-test and concluding with a 10 minute post-test. The main learning activity component of the session is 60 minutes in length. The experimental design assumes random assignment to either a control group or an adaptive instruction group. All participants are being provided with accounting problems to solve and learning assistance in the form of worked examples and instructional hints. A limited item speed test is being provided to all participants at ten minute intervals throughout the sixty minute learning stage of the experiment. The speed tests consist of base knowledge questions for the relevant accounting topic area. These questions require participants to provide correct answers as quickly as possible. The speed of response standard that participants are required to achieve is being developed by trialling the speed test questions using pilot participants. The questions are provided in multiple choice format with the use of drop-down menus. Adaptive instruction group participants who do poorly on the speed tests (incorrect responses or slow to answer) are being provided with additional instruction while good speed test results (correct and quick responses) allow adaptive instruction participants to progress to the next learning stage. In contrast, the learning assistance provided to control group participants are not being altered in accordance with the speed test results. The use of a time-based metric as a dynamic indicator of learning is easily generalised to all areas of instruction. The very basis of expertise in any domain is that the various elements of a task have been previously learned and are stored in long-term memory. Experts can access these schemas more quickly and accurately than novices. Learning can be assessed by how quickly accurate responses are provided. On the final test, we expect the means of the adaptive instruction group to be significantly higher than the means of the control group. Practical application of the expertise reversal effect requires real-time measures of learners' changing knowledge. This study is intended to devise a suitable metric.

Wednesday, June 22, 2016, 18:00 to 19:00

Issues in Cognitive Load research

Sébastien Puma, Nadine Matton, Pierre-Vincent Paubel, André Tricot

(University of Toulouse, Enac Toulouse, University of Toulouse, University of Toulouse)

Taking time into account for studying Cognitive Load Theory: using the time based resource sharing model

Cognitive load theory (CLT) allows describing cognitive resources involved during learning: working memory components and schemas in long-term memory. For example, when considering the modality effect (Ginns, 2005; Leahy & Sweller, 2011 for reviews) CLT relies on Baddeley's multi-component model. Here we argue that the use of a working memory model that takes time into account, the Time Based Resource Sharing model (TBRS, Barrouillet, Bernardin & Camos, 2004) should be useful for CLT, after Spanjers, van Gog and van Merriënboer (2010) and van Gog et al. (2009). This model allows describing working memory as an executive loop responsible for both maintenance and manipulation of information through the use of attentional focus. Because attentional focus can only be applied to one element at a given time, its use has to be shared among processes. In particular, maintaining item in working memory is described as refreshing memory traces trough attentional focus. This model provides valuable insights on laboratory experiments using meaningless materials (i.e. items that cannot be chunked). In particular, TBRS allows manipulating working memory span by varying the time available to refresh memory traces and the time needed to perform a processing task. TBRS model could be useful to cognitive load theory research by explaining dynamic changes of cognitive load during learning sessions. For example, this might help explaining why modality effect does not occur when information is self-paced but does when information is system-paced (Schmidt-Weigand, Kohnert & Glowalla, 2010). However, this model has never been used with meaningful information, which is a strong limit for its use in CLT framework. In two experiments, we used complex span tasks procedures to test assumptions allowed by TBRS, replacing meaningless items to be held in working memory by terms of mental calculus that could be chunked. Moreover, we contrasted two subgroups following their mental calculus skill in order to assess the impact of chunking on TBRS predictions. Experiment 1 reproduced a TBRS experiment while replacing the items to maintain by the terms of a mental calculus to perform. Sixty nine children (grade 7) were split in two subgroups based on their results during pretest. Higher performers showed no effect of the time needed to perform the interfering task ($p = .709$) while lower performers had significantly better results with the shorter interfering task than with the longer ($p = .019$). Experiment 2 extended previous results. Fifty nine other participants (grade 8) performed a complex span task using the same mental calculus and an interfering task, which varied between two conditions only by the time allowed to perform it (1 and 2 seconds). According to TBRS assumption, simply varying the time available for performing the interfering task would have a significant effect on mental calculus performance for both groups. However, higher performers showed no effect of the time available to perform the interfering task ($p = .154$) while lower performer did ($p = .032$). TBRS model appears to be promising alternative to other working memory models. In particular, it might help explaining modality effect inconsistencies or transience of information. However, especially in learning contexts, the question of chunking should be addressed.

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Issues in Cognitive Load research

Huei-min Wu, K.H. Lei, T.Y. Tso, H.C. Huang, C.J. Lin

(Fo Guang University, University Taiwan, University Taiwan, Fo Guang University, Fo Guang University)

Element interactivity: How many interacting elements are students able to handle?

It's a convention to estimate levels of task difficulty when constructing test instruments. The estimation is normally a three-level (easy, mediocre, and difficult) scale based on the judgement of domain experts, and then runs an item analysis to determine the level of item difficulty and item discrimination. The results may provide a valid test instrument, but it does not tell what students' problems are. Cognitive load theory (Sweller, 2010) suggests that element interactivity is the major source of working memory load and task difficulty. Analyzing task difficulty from the perspective of element interactivity may provide additional information regarding students' ability to cope with interacting elements and memory load as well as difficulties related to specific elements. The purpose of this study was to analyze item difficulty from the perspective of element interactivity and examine how students performed on different levels of element interactivity. In addition, this study also aimed to examine ability differences on test performance of different interacting elements. The test items and student performance were taken from our previous experiment on the learning of the area of parallelograms. The participants were 97 grade five students. Their ability levels (low, average, and high) were classified based on their midterm exam. The total number of test items was 38. Two researchers on math education analyzed the major elements (the intrinsic elements) and appended elements (additional elements due to the presentation or design of the test items) of the test items separately. A third person (a scholar of mathematics) was consulted when there was an inconsistency. The test results were then reanalyzed using element interactivity The major results were as followed: 1. The mean proportion of correct responses decreased as the number of elements increases. The student performance dropped below 60% correct when there were two, three, and four interacting elements for low, average and high ability students respectively. Overall, student performance dropped to about 50% correct when there were three interacting elements. 2. The mean time needed to solve the test items increased as the number of interacting elements increased, but to a certain level only. For low ability students, their problem solving time decreased after 4 interacting elements, indicating giving up trying; for the average and high ability students, after 5 interacting elements. The results also support Cowan (2001)'s suggestion of working memory capacity.

Key words: element interactivity, cognitive load, ability difference

Reference

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Wednesday, June 22, 2016, 18:00 to 19:00

Issues in Cognitive Load research

Tamara van Gog, Tim van Marlen, Margot van Wermeskerken

(Utrecht University, Utrecht University, Utrecht University)

Look at you! Natural and artificial gaze guidance in video modeling examples

In this talk we will present our recent studies on the effect of natural and artificial gaze guidance on learning. Natural Gaze Guidance Other people's faces, and especially their eyes, are real attention magnets. They quickly and automatically capture our attention, and this mechanism presumably evolved because eye gaze provides us with very powerful social cues. Insights into eye gaze as a social attention cue that have accumulated from research in evolutionary, social, cognitive, and developmental psychology, could potentially be very useful for educational psychology, for instance in the design of video modeling examples. After a short review of evidence that the eyes automatically capture attention and explanation of why this may be relevant for learning from modeling examples or multimedia instructions that include pedagogical agents, results from several experiments are briefly discussed. In these experiments, students observed video examples in which a human model can be seen demonstrating and explaining how to perform a task, either involving a demonstration with objects, with the model seated behind a table, or a "lecture style" setup, with the model standing next to a screen on which the various problem-solving steps are projected. It was manipulated whether or not students saw the face of the model in the video example and whether or not the model provided gaze cues. We investigated how this affected students' attention and whether it would help or hinder learning. Results show that even though seeing the face draws attention away from the task being demonstrated, this does not hinder learning. Gaze cues seem to foster timely integration of the verbal explanation with the visual materials. Artificial Gaze Guidance Gaze cues can also be provided even when the model is not visible in the video. This is done by superimposing the model's eye movements on a screen-recording of the model's task performance, with the eye movements being displayed, for instance, via a colored dot or circle. Such eye movement modeling examples (EMME) have proven effective for learning of classification tasks (e.g., Jarodzka et al., 2013) and text-picture integration strategies (e.g., Mason et al., 2015). However, for procedural problem-solving tasks we did not find beneficial effects of EMME (Van Gog et al., 2009; Van Marlen et al., submitted). We are currently investigating whether this lack of effect is due to the verbal explanation, which might be sufficient to guide attention to the right location at the right time (as the data by Van Marlen et al. suggested). A pilot study that is currently being replicated with a larger sample size, suggests that the gaze cues provided in EMME can be expected to be most helpful when the verbal explanation is ambiguous about which part of the task is being referred to.

Thursday, June 23, 2016, 09:00 to 10:40

Cognitive Load Theory in authentic learning / Gender

Klaus Stiller, Annamaria Köster

(University of Regensburg, University of Duisburg-Essen)

Cognitive Loads and training success in a video-based online training course

According to Cognitive Load Theory and associated studies the way of presenting information in an instructional environment is primarily essential to the success of learning. By avoiding unnecessary extraneous load rising from badly designed instructions and other sources learners are more likely to successfully construct knowledge. In addition it is known that learner characteristics like prior knowledge affect learning. Therefore, this study explores the effects of some learner characteristics (online learning experience, domain-specific prior knowledge, computer attitude and computer anxiety) on learning process (intrinsic, extraneous, and germane load) and success (subjective success of learning and number of passed modules) in a video-based online training about media design for employees of small and medium sized enterprises by using regression analyses (backward elimination). The training consists of 13 modules. The core element of each module was an instructional video lasting about 15 minutes. Learners were asked to deal with different tasks (one per module) in order to construct knowledge. According to action- as well as problem-oriented didactics the course was constructed around the following principles: learning situated in authentic problems; using multiple contexts for learning; using multiple perspectives for learning; learning in a social context; learning with instructional support. In addition the structure of each module was modeled on the Nine Events of Instruction (Gagné et al., 1992). We paid particular attention to providing a high level of self-instruction and an effective and efficient information presentation. Employees who worked through all modules and had successfully solved 11 of the 13 module tasks received a training completion certificate. A successful participation was suggested as possible with a workload of 20 to 25 hours. Fifty-eight employees participated seriously in the training and worked on at least one module task; twenty-eight of them provided full sets of data. Employees evaluated videos (domain-specific prior knowledge, difficulty of presentation and contents, and use of elaborative strategies) and answered questionnaires before starting the course (online learning experience, computer attitude and computer anxiety), four weeks after (usability), and at the end of the course (subjective success of learning). We also considered the number of passed modules. Ratings of difficulty of presentation and contents as well as use of elaborative strategies were used as measures for extraneous, intrinsic and germane load, respectively. Usability ratings were used as a measure of extraneous load coming from handling the learning environment. Usability experience, intrinsic, extraneous, and germane load as well as subjective success of learning and number of passed modules could not be modelled by the four learner characteristics under focus. Lastly, subjective success of learning could be modelled by usability and germane load (R = .68), the number of passed modules by usability and intrinsic load (R = .54). Summed up, perceived usability of the learning environment (extraneous load), difficulty of contents (intrinsic load) and elaborative processes (germane load) showed to be the important factors for learning, while learner characteristics played no role in this context. Overall, approaching authentic e-learning scenarios under a cognitive load perspective in a broader way was shown to be fruitful.

Thursday, June 23, 2016, 09:00 to 10:40

Cognitive Load Theory in authentic learning / Gender

Gerry Sozio, Shirley Agostinho, Sharon Tindall-Ford

(University of Wollongong, University of Wollongong, University of Wollongong)

Investigating product-oriented versus process-oriented worked examples to support understanding of quality teaching principles

Research has shown that students who learn by studying process-oriented worked examples, which present a step-by-step solution with accompanying rationale, leads to improved student performance in well-structured domains, such as mathematics and economics (Brooks, 2009). What is not well researched is whether similar patterns of results can be demonstrated in ill-structured domains, such as understanding the principles of quality teaching to improve teaching practice. This paper presents new research in investigating the use of process-oriented and product-oriented worked examples (Van Gog, Paas, & Van Merrienboer, 2008) to support first year Master of Teaching pre- service teachers (novices) and later year Master of Teaching pre-service teachers' (experts) understanding of the New South Wales Quality Teaching Model (QTM). The QTM is a research-based model that describes the elements of quality classroom pedagogy (Gore, Griffiths, & Ladwig, 2004). Gore et al., (2004) have devised a scoring mechanism that serves as a reflective tool to assist teachers in critiquing the elements of quality teaching. This research will investigate how process-oriented and product-oriented worked examples could be applied to this ill-structured domain as an instructional method to support pre-service teachers understanding of the reflective tool and how it can be applied. The research question guiding this investigation is: What form of Worked Example best supports novice and expert pre-service teachers' understanding and application of the NSW Quality Teaching Model when: • coding elements of a lesson during the observation of a teacher in practice against a description of element standards, • applying knowledge of the elements to provide strategies of how to enhance the quality of a selected element? The research is expected to contribute to our understanding of the application of worked examples within ill-structured content domains and in particular how worked examples may support novice and expert pre-service teachers' preparation for the teaching profession. This presentation will present the results from a 2015 pilot study and preliminary results from the first experiment conducted with first year Master of Teaching pre- service teachers during Semester One 2016.

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Thursday, June 23, 2016, 09:00 to 10:40

Cognitive Load Theory in authentic learning / Gender

Thomas Dickmann, Maria Opfermann, Stefan Rumann

(University of Duisburg-Essen, University of Duisburg-Essen, University of Duisburg-Essen)

It's all about visualizations: the relation between visual model comprehension, cognitive load and knowledge for learning chemistry at university.

Contemporary textbooks for university students include an abundance of different visualizations. This can be traced back to the general view that visualizations are important to understand scientific concepts. This view is supported by an own exploratory textbook analysis (Dickmann et al., 2015) which found that on average, 85% of contemporary university chemistry textbook pages contain visualizations of all different kinds. Against the background of high university drop-out rates (OECD, 2011), two conclusions can be drawn. First, despite the widely spread usage of visualizations in educational contexts, results on their effectiveness are highly diverse and domain-specific (e.g., Höffler et al., 2013). Second, to be able to provide a comprehensive approach to the usage of visualizations in chemistry, it is necessary to have a look at individual differences between learners and the way they process instructional materials. In this regard, the comprehension of (visual) models is seen as a crucial component for the development of conceptual knowledge and study success in natural sciences such as chemistry. Our project focuses on investigating, how visual model comprehension in chemistry is able to predict study success and which factors, in turn, have an impact on visual model comprehension. For instance, we assume that the higher the visual model comprehension of a student, the less cognitive load she or he will experience during learning or problem solving, which should result in higher performance accordingly In a first step of the project, a visual model comprehension test was developed based on extensive textbook analyses and an according classification of visual models that can be found within current university materials for chemistry courses. The final instrument comprises 45 items on three scales and was validated in a pilot study. An overall of 145 university chemistry students took part in this study and answered the visual model comprehension test as well as standardized achievement tests on general, organic and physical chemistry. Mental effort and perceived difficulty were assessed for each of the test subscales as well as once after all items had been answered. First results show that students with higher visual model comprehension indicated less mental effort ($r = -.197$; $p = .023$), perceived less difficulty ($r = -.379$; $p < .001$) and had higher achievements in general, organic as well as physical chemistry (all $p < .001$). Furthermore, both mental effort ($p = .009$) and perceived difficulty ($p = .001$) significantly predicted achievement in general chemistry. Mental effort also predicted achievement in organic chemistry ($p = .034$), while the results for physical chemistry slightly missed statistical significance ($p = .059$). Perceived difficulty significantly predicted achievement in physical chemistry ($p = .006$), while the results for organic chemistry slightly missed statistical significance ($p = .057$). To sum up, and in line with our expectations, visual model comprehension appears to be an important prerequisite for successful chemistry study achievement as students with this ability experience less cognitive load and show higher performance. In a next step, we will try to shed more light on this construct and investigate, which individual prerequisites (e.g., cognitive, mathematical or spatial abilities) are able to predict visual model comprehension. These results will be presented at the ICLTC 2016.

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Cognitive Load Theory in authentic learning / Gender

Andy Bevilacqua, Fred Paas, Genomary Krigbaum

(Grand Canyon University, Erasmus University Rotterdam, Grand Canyon University)

Effect of motion in the far peripheral visual field on cognitive test performance and Cognitive Load

Cognitive load theory posits that limited attention is in actuality a limitation in working memory resources. The load theory of selective attention and cognitive control sees the interplay between attention and awareness as separate modifying functions that act on working memory. Reconciling the theoretical differences in these two theories has important implications for learning. To begin to resolve this dichotomy the authors investigated whether continuous non-biological movement in the far peripheral visual field (i.e., 80-90 degrees) would be automatically processed by the brain outside of attention and if so, whether it would induce a measureable cognitive load. Thirty-nine participants (17 males and 22 females) were recruited to perform a cognitively demanding test on a central computer display, while continuous movement was displayed in the far peripheral field on both sides (experimental group), or without movement in the peripheral field (control group). In contrast to our main hypothesis, the group with movement in the peripheral visual field needed less time to complete the cognitive test than the control group that accomplished the task with no movement. Further analysis revealed a significant gender difference, indicating that males performed the cognitive task faster with continuous movement in their peripheral view than without this movement. We found no such advantage for females. The implications of these results and recommendations for future research that extends the present study are presented.

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Cognitive Load Theory in authentic learning / Gender

Mona Wong, Juan Cristobal Castro-Alonso, Paul Ayres, Fred Paas

(University of New South Wales, Chile University, University of New South Wales, Erasmus University Rotterdam)

Solving the gender difference in instructional animation researches

Research has found that animations can foster females' learning and close the gender gap (e.g. Jacek, 1997; Sánchez & Wiley, 2010; Wong, Castro-Alonso, Ayres, & Paas, 2015; Yezierski & Birk, 2006). It often argued that animations help students with lower spatial ability (i.e. females). However, in many cases the conclusion was drawn based on the assumption that females generally have lower spatial ability rather than directly measuring it in the studies (e.g. Jacek, 1997; Yezierski & Birk, 2006). In addition, Falvo and Suits (2009) found females outperformed males even though females had lower-spatial ability. Wong et al. (2015) also found that animations gave an advantage to females regardless of individual spatial ability differences – females performed better and had lower cognitive load in animation conditions. The mixed result leaves the relationship between gender and spatial ability still debatable (Bors & Vigneau, 2011). The present study presented an analysis investigating the relationship amongst gender, spatial ability and performance on learning with animations. Regression analyses were conducted separately on males and females based on four sets of experimental data. Potential predictors included objective spatial ability scores (CRT and MRT), measurement of spatial location (Corsi), self-reported mental rotation rating, self-reported spatial ability rating, and learning conditions (animations vs. static pictures). The dependent variable was performance scores on LEGO object manipulation tasks. The result showed that objective measures (i.e. CRT and MRT) were good predictors for males but not females, whereas subjective measure (i.e. self-rated spatial ability) and the Corsi were good predictors for females but not males. One possible explanation is that the CRT and MRT tests both measure mental rotation ability, failing to capture spatial location memory which females are better at. Such discrepancies may be traced to evolutionary differences. Nevertheless, the overall results suggest that different measures of spatial ability are required for males and females in such research domains.

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Thursday, June 23, 2016, 11:00 to 12:00

Poster presentation 2

Dayu Jiang, Slava Kalyuga, John Sweller

(University of New South Wales, University of New South Wales, University of New South Wales)

Studies in the expertise reversal effect in teaching foreign language listening skills

The expertise reversal effect suggests that instructional methods should accommodate learners' individual differences because pedagogies that are effective for novice learners may turn out to be ineffective or even counterproductive to expert learners (Kalyuga, Ayres, Chandler, & Sweller, 2003; Sweller, Ayres, & Kalyuga, 2011). This study reports a series of four experiments which were designed and conducted to explore the expertise reversal effect in the field of foreign language listening teaching and learning. Three instructional formats (read-only, listen-only, and read-listen) were designed to teach students English/French listening skills. Experiment 1 was done to explore whether there is an interaction between levels of learners expertise and instructional formats in teaching listening skills in English as a foreign language. Two-way ANOVAs indicated a significant interaction between the instructional approaches and levels of learner listening expertise, $F_{(2, 184)} = 7.30$, MSE = 33.09, $p < .01$, = 0.07. Significant main effects of listening instructional approaches for measures of extraneous cognitive load were found, $F_{(2, 187)} = 3.29$, MSE = 4.41, $p < .05$, = 0.03 (M = 3.30, SD = 2.06 for the read-only group; M = 3.86, SD = 1.92 for the listen-only group; and M = 4.26, SD = 2.29 for the read + listen group). A significant simple effect was found for learners with higher levels of listening expertise favouring the read-only approach, $F_{(2, 184)} = 7.30$, MSE = 33.09, $p < .01$, = 0.07. For learners with lower listening expertise, no significant simple effect was found, $F_{(2, 184)} = 0.85$, MSE = 33.09. Experiment 2 aimed to test the hypothesis that lower expertise learners would be more benefited from the read-listen teaching condition. Ninety-six Year 1 undergraduate students were randomly assigned to three groups respectively. A one-way ANOVA revealed significant differences in listening comprehension performance across the three groups, $F_{(2, 93)} = 3.19$, $p < .05$. Experiment 3 was carried out to test the hypothesis that novice learners need access to both reading and listening materials in order to facilitate the form-meaning pairing. One hundred and five Grade 1 high school students were randomly assigned into three groups. An analysis of variance showed that the effect of instructional formats on participants' listening performance was significant, $F_{(2, 102)} = 4.77$. $p = .01$. Experiment 4 was designed to explore the effect further by employing beginner-level learners of French as a foreign language (FFL). Ninety-six Year 2 French-major university students were randomly allocated into three groups. An analysis of variance showed a significant difference in terms of French listening performance, $F_{(2, 93)} = 8.04$, $p < .01$.

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Poster presentation 2

Charly Eielts, Tamara van Gog, Fred Paas

(Erasmus University Rotterdam, Erasmus University Rotterdam, Erasmus University Rotterdam)

The effect of finger tracing on chinese character learning

The present study investigated the effectiveness of finger tracing and observing finger tracing on Chinese character learning and how this relationship is moderated by visual working memory capacity. Thirty-six participants studied Chinese symbols and their meaning in three instructional conditions: 1) by actively tracing the Chinese symbol 2) by observing a model tracing the Chinese symbol, 3) or by observing the static image of the Chinese symbol. We predicted that symbols studied in the tracing condition and observation condition would be recalled and recognized better on an immediate and two week delayed post-test compared to the control condition. Furthermore, we predicted that especially participants with lower visual working memory capacity would benefit from finger tracing Chinese symbols. Opposite to the hypothesis, the results showed that finger tracing and observing finger tracing negatively impacted learning outcomes, but only for participants with low visual working memory capacity. It appears that observing or tracing instructions added extraneous cognitive load for learners and thus hampered learning. These results suggest caution in implementing finger tracing instructions in Chinese symbol learning.

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Poster presentation 2

Daniel Choi, Kim Ouwehand, Fred Paas

(Erasmus University Rotterdam, Erasmus University Rotterdam, University Rotterdam)

Effects of eliciting gestures during task performance on Cognitive Load.

Cognitive load theorists (e.g., Paas & Sweller, 2012) have embraced the concept of embodied cognition (also called grounded cognition, for a review see Barsalou, 2008) together with the concepts of primary and secondary knowledge from Geary (2008, 2012). From an embodied cognition perspective, cognition is grounded through interaction with the world (i.e., action and perception). From an evolutionary educational psychology perspective, primary knowledge is knowledge humans have evolved to learn and therefore, acquiring this knowledge puts low demands on working memory. Secondary knowledge however, is knowledge that has cultural value and has to be taught explicitly. Paas and Sweller (2012) argue that this primary knowledge can be used in instruction to enhance the learning of secondary knowledge. The present study proposes that gesturing as a form of action and primary knowledge might be a promising tool to enhance learning of secondary knowledge. Indeed gesture research has shown that gesturing can enhance learning (Goldin-Meadow & Wagner, 2005) and memory (Cook, Yip, & Goldin-Meadow, 2010; Ouwehand, Van Gog, & Paas 2015). De Nooijer, Van Gog, Paas, and Zwaan (2013) found that especially gesturing during retrieval has a positive effect on learning novel verbs. Spontaneous gesturing of a learner during a task is often followed by better retention of that task (Cook & Goldin-Meadow, 2006; Cook et al., 2010). However, other research has shown that in some cases, explicitly prompting learners to gesture can also have reverse effects on learning (De Nooijer, Van Gog, Paas, & Zwaan, 2014; Post, Van Gog, Paas, & Zwaan, 2013). A possible explanation is that the instruction to gesture increases extraneous load which hinders learning. Indeed, the studies of De Nooijer et al. (2014) and Post et al. (2013), who studied language learning showed that specifically the learning of students with low language proficiency suffered from the instruction to gesture. In sum, on the one hand, spontaneously gesturing has been found to improve learning, but on the other hand, explicitly instructing learners to gesture can have the opposite effect. The present study addresses this problem by investigating a possible way to implicitly encourage learners to gesture, namely, by manipulating the physical learning environment. This idea is based on the revised model of cognitive load theory construct, proposed by Choi, Van Merriënboer, and Paas (2014) who claim that the physical learning environment can have an impact on learning by its influence on cognitive load. In this model, physical learning environment incorporates all physical aspects of the learning environment, such as physical properties of the learning materials and the space in which the learning takes place. The aspect that is manipulated in the present study is the physical size of the instruction. Gestures occupy space and from an embodied cognition perspective, we hypothesize that learning from a text on a large piece of paper will elicit more gestures than learning from the same sized text on a smaller piece of paper. In addition, we hypothesize that gesture rate is related to better test performance. Finally, we hypothesize that cognitive load is negatively related to gesture rate, that is learners who gesture more, will experience less cognitive load during task performance. Methods Participants, design and procedure Forty healthy young participants will learn about photography te

Thursday, June 23, 2016, 11:00 to 12:00

Poster presentation 2

Alexandra Stümmler, Matthias Wilde

(Bielefeld University, Bielefeld University)

Effects of scaffolds on motivation and learning success in experimental tasks in biology lessons

Developing experimental competency is an anchored goal in the school curriculum. According to Hammann and Prenzel (2008) German students have significant weaknesses in working on experimental tasks. To ensure a growth in competence, it is necessary to take the different learning conditions which cause heterogeneity in class into account. Within-class grouping is considered as a core strategy for adaptive instruction (Lipowsky, 2015). According to the Self-Determination Theory, motivation is a crucial factor for meaningful learning. The quality of motivation depends on the fulfillment of the basic psychological needs, autonomy, perceived competence and social relatedness (Deci & Ryan, 2000). Though, too much freedom and insufficient guidance can overwhelm learners, especially those with little prior knowledge (Kirschner, Sweller, & Clark, 2006). To avoid a cognitive overload, students need instructional guidance (Kirschner, Sweller, & Clark, 2006; Mayer, 2004). The strong presence of step-by-step experimental guides in school books support that assumption. According to the Cognitive-Load-Theory (Sweller, van Merrienboer, & Paas, 1994), instructional designs and procedures determine the extraneous load. Consequently, an appropriate instructional task design is supposed to reduce the extraneous load (Paas, Renkl & Sweller, 2003; Schmidt-Weigand, Franke-Braun, & Hänze, 2008) and to ensure better learning success. Hänze, Schmidt-Weigand and Blum (2007) developed incremental scaffolds, which consist of consecutive hints and the associated partial solution. These scaffolds allow instructional guidance without thwarting the students' autonomy in complex tasks. Several studies point positive effects of incremental scaffolds in complex science tasks on learning success and motivation out (Schmidt-Weigand et al., 2008). Hence, incremental scaffolds for experimental tasks are expected to reduce students' cognitive load and to contribute to better learning experience and success in biology classes. Within the project the effects of the extent of instructional guidance on motivation and learning success in the context of experimental tasks in biology classes will be investigated. The treatments are derived from Schmidt-Borcherding, Hänze, Wodzinski and Rincke (2013) and modified for biological experimental tasks. The study follows a three-group-design over a period of four lessons with different learning treatments in each group. In treatment one students' do not receive any scaffolds. It is assumed that cognitive load is high in this treatment. In treatment two the learning process is highly structured by step-by-step examples, whereas treatment three holds incremental scaffolds in order to reduce students' cognitive load. The growth in knowledge will be measured by a pre-posttest design consisting of multiple choice and open-end items. To examine the quality of motivation, the short-scales of intrinsic motivation (KIM; Wilde, Bätz, Kovaleva, & Urhahne, 2009) and flow experience (Rheinberg, Vollmeyer, & Engeser, 2003) will be applied. Students' cognitive load will be measured by a scale from Kepsch (2012). Results of this study are assumed to give further directions for the research field of scaffolds in context of experimental lessons in biology, especially for inclusive settings.

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Poster presentation 2

Julia Ollesch, Markus Vogel, Tobias Dörfler

(Heidelberg University, Heidelberg University, Heidelberg University)

Multimedia-based teaching of mathematics - also a question of Cognitive Load

Nowadays mathematical processes can be embedded in multimedia learning environments in a way that is not possible with the traditional paper and pencil-formats. On the one hand, using multimedia in mathematics lessons offers new possibilities, for example active linking between different forms of representations which could foster learning and understanding. On the other hand, there are also disadvantages involved: Using media may lead to more complexity in classroom learning. And from a cognitive perspective, (simultaneous) processing of multiple representations could extend extraneous cognitive load and thus diminish understanding or learning outcome. This is particularly important if representations are less mutual supplementary than negatively interfering with each other due to, for example, split-attention effects or redundancies. Accordingly, the knowledge about properties of (dynamic) representations as well as cognitive load theory is essential in multimedia learning. This is why mathematics teachers have to gain the competencies to evaluate if a representation is appropriate for their students to support understanding and reduce the risk of cognitive overload. Furthermore, pedagogical content knowledge with respect to multimedia use should develop according to education at university and should be connected with mathematical and psychological content knowledge as well. Within the presented project we developed a test in order to assess the competencies of prospective mathematics teachers regarding two major domains in multimedia learning: cognitive load and mutual supplement of representations. The assessment consists of ten video-vignettes showing various scenes during mathematics lessons using multimedia-based representations. To assure the validity, the instrument was reviewed in a multistage expert rating, both qualitative (9 experts) and quantitative (104 experts). The ten vignettes were then applied in a pilot study with 77 students to proof validity, so that we continued with the main study. Aims of the current study are twofold: First, we examine the factorial structure of the test instrument and second, we want to verify construct validity. Until now 261 prospective teachers for mathematics took part in the assessment between June and July 2015. Structural equation modeling reveals that the two theoretically expected facets could be proven. Preliminary results also show that the validity of the test is given by the expected correlations between the pedagogical content knowledge test score and self-reported “duration of studies” ($r = .14$, $p = .03$) and the “number of attended courses” addressing “computers in mathematics lessons” ($r = .17$, $p = .03$). As assumed, there is also a interplay amongst the three knowledge categories of Shulman (1987): pedagogical content knowledge test score correlates with the content knowledge test score ($r = .29$, $p = .00$) as well as pedagogical content knowledge and the pedagogical-psychological knowledge test score ($r = .17$, $p = .01$), while content knowledge and pedagogical-psychological knowledge correlate in a similar way ($r = .28$, $p = .00$). Preliminary results are promising and we expect to get even more insights with the final data. At the moment we analyze data from 402 students and evaluate the most suitable structural equation model with respect to statistical and theoretical assumptions. Final results will be discussed with regard to education of student teachers.

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Poster presentation 2

Huy Phan, Bing Ngu, Alexander Yeung

(University of New England, University of New England, Australian Catholic University)

Achieving optimal best: The use of Cognitive Load Theory in mathematical problem solving

Optimal best is a recently developed well-being concept. Individuals achieve personal outcomes that reflect their maximum capabilities. Realistic best, in contrast, is a personal functioning that may show moderate capability without any aspiration, motivation, and/or effort expenditure. Drawing from existing evidence and theorizations, it is known that there are psychosocial and motivational components that optimize individuals' achievements for optimal best. The indication of optimization, therefore, entails positive psychosocial and motivational elements together with appropriate instructional designs for effective learning. We contend that cognitive load imposition plays a central role in the structure of instructional designs for learning, which may then influence individuals' achievements of optimal best. This article, theoretical in nature, explores varying efficiencies of different instructional approaches, taking into consideration the potency of cognitive load imposition. Focusing on mathematical problem solving, we discuss the potentials for instructional approaches to influence individuals' striving of optimal best from realistic best.

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Poster presentation 2

Margina Ruiter, Fred Paas, Sofie Loyens

(Erasmus University Rotterdam, Erasmus University Rotterdam, University College Roosevelt)

Effect of cycling action on lecture retention, attention and mood

Lectures, live or video, are one of the primary means of knowledge transmission in universities (e.g., Bligh, 2000). Unfortunately, it is not possible to stay focused the whole time on the lectures content. Indeed, it is found that students' attention decreases over time. In addition, it has been demonstrated that this mind wandering impairs memory for lecture material (Farley et al., 2013). Thus, it seems important to discover strategies that could be used to reduce mind wandering in lectures to improve educational outcomes. An interesting method to keep students concentrated on the task-at-hand is to add a concurrent non-interfering task, which is less detrimental to memory than mind wandering (Andrade, 2009). In the present study we investigated whether cycling on a desk bike would attenuate time on task effects on retention, self-reported attention, mental effort and mood in a lecture-setting. In order to test this, four experimental conditions were set up and 130 first-year psychology students were tested. In the first experimental cycle condition students had to cycle while watching the second half of a video lecture. Afterwards their memory of lecture material was being assessed by a retention test. In order to control for state-dependent memory, half of the cycle participants had to cycle during the test as well. Students in the sit still condition had to sit still during the entire lecture. Yet, half of the sit still participants had to cycle during the retention test. Considering the literature on sustained attention and physical activity, two hypotheses were derived. First, it was hypothesized that retention of lecture material, attention and mood would decline with time on task. Secondly, we hypothesized that cycling during the second part of the lecture would attenuate these time on task effects. In line with our first hypothesis, the results showed that time on task negatively influenced self-reported attention, $F_{(1, 118)} = 23.81$, $p < .001$, $\eta^2_{partial} = .17$, mood, $F_{(2, 117)} = 13.87$, $p < .001$, $\eta^2_{partial} = .20$, and mental effort, $F_{(1, 118)} = 19.90$, $p < .001$, $\eta^2_{partial} = .14$. Furthermore, cycling during the second part of the lecture attenuated the decrease in mood, $F_{(2, 117)} = 24.39$, $p < .001$. There was, however, no significant effect of time on task on performance on the retention test $F_{(1, 118)} = 1.53$, $p = .219$, $\eta^2_{partial} = .01$. Additionally, there was no statistically significant interaction between the effects of condition and time on retention of the lecture material $F_{(1, 118)} = 1.05$, $p = .374$, $\eta^2_{partial} = .03$. These findings have important implications for workplaces and educational facilities that are seeking to implement active workstations with desk bikes. The results of this study suggest that students can utilize desk bikes without an acute change in retention performance, and gain besides a better mood state, the demonstrated physical health benefits associated with them.

Thursday, June 23, 2016, 11:00 to 12:00

Poster presentation 2

Alexander F. Koch

(Switzerland University)

Why cognitive load may indicate you teach competently: new ideas in Cognitive Load Theory research.

In this presentation we want to present two core concepts of learning (cognitive load theory and flow theory) and integrate them into a novel psycho-physiological research design that goes beyond sheer learning and introduces a new idea of competence measurement in school teaching. As a baseline we draw on ACT* theory. ACT* (Anderson, 1996, 2002) says procedural knowledge is activated through situation recognition and therefore lets people act upon implicit, proceduarlized knowledge, i.e. competence. According to flow theory (Csikszentmihalyi, 1990, 2008) pure action comes along with total cognitive absorption. That means cognitive load is at its highest level. As is commonly known cognitive load assumes that learning is possible via germaine load and the lower extraneous and intrinsic load are the better it is for problem solving and learning respectively. Yet, teaching is said to be chaotic. From a teacher's perspective, teaching means solving a series of ill-structured problems. This denies reflection in action and makes teaching automated. Knowing this automaticity may be considered an indicator of knowledge utilization which is using procedural knowledge and is manifest in the appearance of flow experience. In order to make this theory empirically testable we suggest psycho-physiological instruments and video analyses. With reference to Haapalainen, Kim, Forlizzi und Dey (2010) cognitive load can be measured via heart-rate variability. Other research also indicates that there are psycho-physiological correlates of flow-experience (de Manzano, Theorell, Harmat, & Ullen, 2010; Keller, Bless, Blomann, & Kleinböhl, 2011; Kivikangas, 2006; Pfeifer, 2012). Similar research was conducted on teacher experience (Stück, Rigotti, & Balzer, 2005). Also Stoeckli (1992) pioneered measuring stress via heart rate. Yet, Stoeckli showed videos to teachers and measured their heart rate in situ. We inted to take a step further and measure in actu. We suggest to combine heart rate tracking with video-taping classroom instruction and ex-post teacher interviews on empirical heart-rate peaks in relation to visualized video sequences. Current sports equipment allows to follow heart-rates easily on a long term basis, i.e. 24 hours (e.g. Fitbit wristbands). Videos of the classroom interaction will help teachers remember and explicate "peak" situations in question. At first we want to aply commonly used video cameras, but – in view of scaling up – one could consider more modern approaches as reasonable prized surveillance equipment for example. In the presentation we want to address theoretical connections between cognitive load, flow and ACT* theory and relate them to teacher professional competences. Building upon this, we want to creatively discuss empirical approaches and hope to trigger new ideas in cognitive load research.

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Poster presentation 2

Tugce Durgut, Bianca Böhm, Svenja Schmidt, Yonca Kaya, Kübra Kenger

(University Bochum, University Bochum, University Bochum, University Bochum, University Bochum)

Shorter learning time and better performance through predetermined learning time

Research has shown that learners can profit from multimedia learning opportunities (Mayer, 1999). But most studies on multimedia learning keep time on learning constant across experimental groups. Thus, only little is known about the effect of learning time on learning outcome in multimedia learning. According to Caroll, the invested learning time and the required learning time determine learning outcome (Hess & Hermann-Günter, 1994). According to Schmeck (2014) it can be assumed that also in multimedia learning a predetermined learning time can have an effect on the active learning time and on learning outcome.

This study investigates how predetermined learning time with multimedia contents (text and picture) influences learning (active learning time and performance). Eighty-three students were randomly assigned in four groups (Solomon-Four-Groups-Design: two control groups and two experimental groups). The two experimental groups received a predetermined learning time and the two control groups were allowed to determine the learning time by themselves (pre- and self-determined time as conditions). During the predetermined and self-determined learning time the students were given the task to learn the emergence of lightning. Afterwards, they had to take a quiz on lightning (in form of multiple-choice questions). In experimental group one and control group one we additionally assessed current motivation before learning.

Students with a predetermined learning time (experimental groups one and two) learned the same as the students with self-determined learning time (control groups one and two), but they needed less time than the students with self-determined time. It became clear that the pre-determined learning time led to a shorter learning time and these students were not cognitively overloaded. Thus, giving learners the opportunity to determine their time in multimedia learning enhanced learning efficiency without increasing cognitive load. Furthermore, comparing groups with current motivation assessment with groups without current motivation assessment revealed an additional significant effect on learning efficiency.

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Poster presentation 2

Christian Kißler, Meryem Göcer, Nurgül Emlikli

(University Bochum, University Bochum, University Bochum)

How does a test announcement affect the learning performance and cognitive load of students mediated by test anxiety and motivation?

This study focuses on the research question: How does a test announcement affect the learning performance and cognitive load of students mediated by test anxiety and motivation? It was hypothesized that a) the test announcement increases test anxiety and b) test anxiety decreases the capacity for germane load. Furthermore, as a low capacity for germane load decreases learning performance it was hypothesized that c) the test announcement also decreases learning performance. It was also hypothesized that motivation will be influenced by the test announcement and will also impact the capacity for germane load, but it was not possible to determine whether the motivation would be influenced in a positive or a negative way because of different information found in the literature.

This study was conducted with four school classes with an amount of 87 students (44 girls, 41 boys, 2 students with unknown gender) of the ninth grade (M = 15.01 years old, SD = 0.77) of two school types (grammar school and middle school) in a quasi-experimental design. There were no significant results concerning most research questions, e.g. that test announcement decreases learning performance. However, descriptive results showed always the expected effects. An analysis of variance with the factors gender and announcement has shown significant results concerning the variable test anxiety and the factor gender. To measure test anxiety a new instrument (a scale with eight items) was developed. The instrument was tested for reliability (α=0,807) and correlated with other instruments as expected (hint at high validity). Furthermore there were significant results concerning the factor announcement and the variable cognitive load. Most students did not speak German as their first language (the performance test was conducted in German). It can be hypothesized that this influenced the learning performance and was a reason for missing the level of significance concerning the main research questions; it may be that the sample was not big enough and the influence is too small to be significant for the tested group.

Thursday, June 23, 2016, 12:00 to 13:00

Junior Researchers' Keynote

Jimmie Leppink

(Maastricht University)

Current trends and future directions in research inspired by Cognitive Load Theory

Research inspired by cognitive load theory has resulted in at least four different types of developments. Firstly, it has resulted in a wide variety of instructional design principles and guidelines (Sweller, Ayres, & Kalyuga, 2011; Van Merriënboer & Kirschner, 2012; Van Merriënboer & Sweller, 2010). Secondly, measures of different types of cognitive load have been developed (Leppink, Paas, Van der Vleuten, Van Gog, & Van Merriënboer, 2013; Leppink, Paas, Van Gog, Van der Vleuten, & Van Merriënboer, 2014; Naismith, Cheung, Ringsted, & Cavalcanti, 2015). Thirdly, we have gained some understanding of how emotion may influence cognitive load and learning (Fraser, Huffman, Ma, Sobczak, McIlwrick, Wright, & McLaughlin, 2014; Fraser, Ma, Teteris, Paxter, Wright, & McLaughlin, 2012). Fourthly, research on so-called pre-assessment learning effects has demonstrated that learners' beliefs about the assessment of learning tend to influence their engagement in learning (Lafleur, Côté, & Leppink, 2015). Especially when taken together, these different types of developments have many implications for the design of education and future research (Leppink & Duvivier, 2016; Leppink & Van den Heuvel, 2015). This keynote will discuss some of the implications for future research from a theoretical perspective (Leppink, Van Gog, Paas, & Sweller, 2015) as well as from a methodological perspective (Leppink & Van Merriënboer, 2015). In particular, methods that aim to help learners engage in learning activities that match their current knowledge or proficiency level will be discussed. These methods include self-testing through quizzes in blended learning environments (Spanjers, Könings, Leppink, Verstegen, De Jong, Czabanowska, & Van Merriënboer, 2015) and questions on self-assessment and learning task selection (Kostons, Van Gog, & Paas, 2012; Sibbald, De Bruin, & Van Merriënboer, 2013).

Thursday, June 23, 2016, 14:00 to 15:40

Measuring Cognitive Load

Carmen Candel, Raquel Cerdán, Cristina Candel

(University of Valencia, University of Valencia, University of Valencia)

Cognitive Load when reading from different sources, a matter of interactivity.

According to Paas, Renkl and Sweller (2003) cognitive load refered to a multidimensional construct that encompasses both, the load and the interactivity that the task learning requirements imposes on the learner's cognitive system classically defined by three dimensions (1) Extrinsic Load (EL), (2) Instrinsic Load (IL) and (3) Germaine Load (GL). Unfortunately, very little is known about how the three types of cognitive load (i.e. CL) influence multiple documents processing. The main purpose of this study was to replicate a potential three factor solution similar to that one developed by recent research in Cognitive Load Theory (Leppink, Paas, Van der Vleuten, Van Gog, & Van Merriënboer, 2013; Leppink, Paas, Van Gog, Van der Vleuten, Merriënboer, 2014) and to analyze the psychometric properties of a scale for measuring cognitive load in multiple documents reading situations. A first 24 item-pilot test consisting of a three factor structure was administered to a sample of 66 university students of Education (M_{age} = 19. 8, SD = 1. 62). The scale was administered during the transfer phase of a pilot study, right after the execution of a multiple document reading task where students were required to read a set of documents and answer comprehension questions. The items were elaborated so that they referred to perceived difficulty regarding specific demands of reading multiple documents and solving associated tasks, but without concrete references to the topics dealt with in the experimental situation. An exploratory factor analysis (EFA) was performed and the internal consistency was assessed. Total internal consistency was 0.945. The factor analysis supported a 24-items solution consisting of 2 factors that explained 49,82 % of total variance. The questionnaire has proved to be reliable at least in a two-factor solution, Perceived Difficulty (IL – EL) and Germaine Load (GL), nevertheless its adaptation into a potential two factor structure, limitations, future applications and further considerations regarding a Germaine Load dimension are discussed.

Thursday, June 23, 2016, 14:00 to 15:40

Measuring Cognitive Load

Babette Park, Andreas Korbach, Roland Brünken

(Saarland University, Saarland University, Saarland University)

Differentiating measurement of Cognitive Load factors in multimedia learning: a comparison of different measures

Recent studies about learning and instruction use cognitive load (CL) measurement to pay attention to the human cognitive resources and the consumption of these resources during the learning process. In order to validate diverse measures of CL for different CL factors, the present study compares different methods for measuring CL. An experimental three-group design (N = 78) was used with exposure to seductive details (extraneous CL induction) or mental animation tasks (intrinsic/germane CL induction) or no additional information (control group) during learning with multimedia. CL was measured by the rhythm method (Park & Brünken, 2015), the index of cognitive activity (ICA; Marshall, 2007), and subjective ratings (Paas, 1992). Moreover, eye-tracking was used to analyze the attention allocation and as an indicator for cognitive activity. Results of a MANOVA for all dependent variables showed an overall effect for learning instruction, $F_{(24,124)} = 3.377$, $p < .01$, $\eta^2_{partial} = .395$. Univariate testing showed effects on retention, $F_{(2,72)} = 4.372$, $p < .05$, $\eta^2_{partial} = .108$, and comprehension, $F_{(2,72)} = 3.856$, $p < .05$, $\eta^2_{partial} = .097$, the task difficulty rating, $F_{(2,72)} = 3.673$, $p < .05$, $\eta^2_{partial} = .093$, the total fixation duration on picture Areas Of Interest (AOIs), $F_{(2,72)} = 6.804$, $p < .01$, $\eta^2_{partial} = .159$, text AOIs, $F_{(2,72)} = 8.257$, $p < .01$, $\eta^2_{partial} = .187$, and the total number of transitions, $F_{(2,72)} = 4.534$, $p < .05$, $\eta^2_{partial} = .112$. Detailed analyses showed higher transfer in the mental animation group in contrast to the control group, $\Delta M = -1.04$, $p = .032$ and higher comprehension in the mental animation group in contrast to the seductive details group, $\Delta M = -1.79$, $p = .017$. The rhythm method, $\Delta M = -38.352$,$p = .025$, the subjective ratings of task difficulty, $\Delta M = -.730$, $p = .011$, and mental effort, $\Delta M = -.629$, $p = .030$ indicated higher CL in the mental animation group in contrast to the control group. The rating of task difficulty, $\Delta M = -.572$, $p = .042$ and mental effort, $\Delta M = -.776$, $p = .018$, indicated higher CL in the mental animation group in contrast to the seductive details group. Eye-movement analyses showed an increase in total fixation duration on picture information in the mental animation group in contrast to the seductive details group, $\Delta M = -37.782$, $p = .001$, and an increase in integrative transitions between related text and picture AOIs in the mental animation group in contrast to the control, $\Delta M = -15.907$, $p = .004$, as well as the seductive details group, $\Delta M = -10.578$, $p = .048$. The ICA showed no significant differences between the groups. Results suggest that specifically the rhythm method in combination with eye tracking is appropriate to show the extraneous CL manipulation. However, for the intrinsic/germane CL manipulation the interpretation is not as clear as the identifying correlations for the different measures are missing. In sum, the results provide evidence for the benefits of combining eye-tracking analyses with other methods of CL measurement for a direct and continuous CL assessment and for a differentiating access to the single CL factors.

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Thursday, June 23, 2016, 14:00 to 15:40

Measuring Cognitive Load

Muhamad Saiful Bahri Yusoff, Siti Nurma Hanim Hadie

(University Sains Malaysia, University Sains Malaysia)

Assessing validity of Cognitive Load scale in a problem-based learning setting

Cognitive load scale (CLS) has been validated to measure different types of cognitive loads in non-PBL setting so far. This study was conducted to assess validity of CLS in a PBL setting. This study assessed construct validity, convergent validity, discriminant validity and internal consistency of CLS. A cross sectional study was conducted on 100 first year medical students during a PBL session. CLS was administered to the medical students immediately after the PBL session ended. The confirmatory factor analysis was performed to examine its construct, convergent, and discriminant validity. The reliability analysis was performed to determine its internal consistency. Confirmatory factor analysis was performed by Analysis of Moment Structure software and reliability analysis was performed by Statistical Package for Social Sciences software. A total of 93 medical students completely responded to the scale. The goodness of fit indices showed the three-factor CLS had a good construct (χ^2 = 36.88, p = 0.25, χ^2/df = 1.15, RMSEA = 0.041, GFI = 0.93, CFI = 0.99, NFI = 0.95, TLI = 0.99). The Cronbach's alpha values of the three factors (i.e., intrinsic load, extraneous load and self-perceived learning constructs) ranged from 0.82 to 0.95, indicating a high level of internal consistency. Average variance extracted and composite reliability analysis suggested the 10 items of CLS have good convergent and discriminant validity. This study showed that the psychometric properties of CLS were good. CLS is a valid and reliable measurement tool to assess cognitive loads of medical students during PBL. Further research is required to verify credentials of the scale in other PBL setting.

Thursday, June 23, 2016, 14:00 to 15:40

Measuring Cognitive Load

Sabrina Navratil, Tim Kühl, Ferdinand Stebner, Benedict Fehringer, Stefan Münzer

(University of Mannheim, University of Mannheim, University Bochum, University of Mannheim, University of Mannheim)

The index of cognitive activity – a promising objective measure of Cognitive Load when learning with different visualization formats

Animations can possess instructional advantages over static pictures. This is particularly true when potential drawbacks (visual complexity and transience) are diminished and, moreover, animations depict dynamic features. In such a case (as for the current study), the information can directly be read-off in animations, thereby freeing cognitive resources that can be invested for elaborative processes. However, the question aroused whether this lack of information about dynamic features in static pictures can be compensated by presenting this information in the text. Moreover, it was examined how the associated differences in cognitive load might be best assessed. 198 participants were assigned to one of six conditions resulting from a 2x3-Design with the independent variables text information (with vs. without dynamic information) and visualization format (no visualization vs. static picture vs. animation). The instructional material dealt with Kepler's second law (a planet's change in velocity when orbiting the sun). Dependent variables were subjective measures of cognitive load (difficulty, effort, concentration, demands) and learning outcomes (retention and transfer). Moreover, gaze behavior was assessed (Tobii TX 300). Areas of interest (AOI) were defined separately for visualization and text. Based upon that, the Index of Cognitive Activity (ICA; Bartels & Marshall, 2012; Marshall, 2002) was calculated separately for the different AOIs and standardized for each participant. The ICA is supposed to be an objective indicator of cognitive workload – it is computed by an algorithm that accounts for the high-frequency changes of pupil size due to cognitive activity (while low-frequency changes such as changes of light are minimized). For all different subjective measure of cognitive load, results of a 2x3-ANOVA revealed no effects of text information, no effects of visualization format and no interactions. With respect to retention, there was a main effect of text information, with learners receiving more information performing better. There was no effect of visualization format and no interaction. For transfer, results revealed again a main effect of text information (learners receiving more information performing better) and also a main effect of visualization format, with learners receiving animations outperforming learners with static pictures (or no visualization). However, there was no interaction of text information and visualization format. Concerning the ICA-score while watching the visualizations, results showed a main effect of visualization format, with participants in the animation conditions having higher scores than participants in the static picture condition. There was no influence of the factor text information and no interaction. A mediation analysis was conducted with visualization format as independent variable, the ICA-score as mediator and transfer as dependent variable. This mediation analysis was significant. Summing up, the results of the current study showed that while the assessed subjective measures of cognitive load failed to detect any differences between conditions, the objective ICA-sore not only partly mirrored the results of the transfer test, but was also able to explain the observed differences. Hence, the ICA-score may be a promising candidate for measuring cognitive load while learning with visualizations. Further research should be conducted to validate its stability and generalizability.

Thursday, June 23, 2016, 16:00 to 17:40

Gestures and Motion

Nadine Marcus, Paul Ayres, Niloufar Lajevardi

(University of New South Wales, University of New South Wales, University of New South Wales)

Does gesturing improve the learning of human motor skills for children, when learning from instructional animation and statics?

Previous research found animated instructions can lead to better learning of a human movement task when compared to equivalent statics (Ayres et al 2009), due to our innate ability to learn by observing movements. Moreover, De Koning & Tabbers' (2011) review found gestures, also forms of human movement, can facilitate learning. A previous study (Marcus et al, CLT2013) that focussed on adults learning Mandarin characters, found gestures improved learning from statics significantly more than animations. In this study we consider whether gestures can improve learning of a motor task for children, if there is a difference for static versus animated instructions, and tasks of different difficulty levels. We focus on primary school children learning Persian characters. We hypothesize that including human movement into an instructional format will benefit learning as it taps into our movement processor. Thus the first hypothesis is that animations will lead to better performance than statics. Our second is that including gesture will lead to better learning than no gesture. Lastly we predict an interaction effect, and hypothesize that gesture will facilitate learning more for statics than animation. Gesturing may become redundant for more difficult animations when cognitive load is higher. Four groups of 11 grade 1 and 2 students, were given a series of 9 Persian characters to learn to write, ranging in difficulty level from easy to medium to difficult. Two groups received animated instructional materials, with one group asked to gesture while learning. The other two groups received equivalent static graphics, with one group gesturing. All groups had equal learning times. The students were then tested on ability to reproduce the characters including correct strokes and dots, drawing order, and positioning relative to a guide line. Results from a MANOVA supported our hypothesis with a significant overall interaction between gesture and instructional format ($F_{(3, 38)} = 7.42$, $p < .001$) as well as significant main effects for presentation format ($F = 28.0$, $p < .001$), with animations outperforming statics, and gesturing ($F = 16.5$, $p < .001$), with gesturing outperforming non-gesturing. Univariate tests indicated a significant interaction for both easy and medium tasks, but not the difficult task. Simple effects tests showed that for the static presentation, all three tasks found gesturing superior to non-gesturing. For the animated presentation, only the easy task produced a gesturing advantage. Our results provide support for the existence of a human movement processor that when invoked can support learning, particularly for human movement tasks. Gesturing supported learning for young children, particularly for easier tasks (when less cognitively loaded) and when learning from statics (movement is not inherent to this instructional format). As expected, animations led to better learning than statics. Gesturing was redundant for the more difficult animated tasks when children were cognitively challenged, and movement was inherent.

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Thursday, June 23, 2016, 16:00 to 17:40

Gestures and Motion

Paul Ayres, Ruth Mierowsky, Nadine Marcus

(University of New South Wales, University of New South Wales, University of New South Wales)

The impact of gesturing when learning to play piano clips from animations

This study aimed to investigate the impact of gesturing when learning from instructional animations. Theoretical considerations derived from embodied cognition (Glenberg, 2008) and cognitive load theory (Sweller, Ayres, & Kalyuga, 2011) underpinned the study. A second aim of the study was to investigate whether the expected positive effects of gesturing were subject to the expertise reversal effect (see Sweller et al., 2003). A musical task (playing the piano) was chosen because it met two important criteria. Playing the piano is a form of human movement that requires the use of hands, and therefore was expected to be particularly suited to learning from animated presentations. Playing the piano can be mimicked using the hands and therefore was expected to particularly suited to gesturing. Two hypotheses were tested: 1: Gesturing would lead to greater learning than non-gesturing 2: There would be an interaction between gesturing and expertise Method and procedure Fifty university students from an Australian University were assigned randomly to one of two gesturing conditions in a 2 (gesturing vs. non-gesturing) x 2 (novice vs. more experience) factorial design. The learning materials consisted of a series of four piano clips of increasing difficulty. Each clip showed the hands of a musician playing the musical extracts, and in perfect synchronization the sounds made by the piano were heard. Participants viewed each animation clip individually twice and after each clip were asked to play the musical piece on a piano. The gesturing group were required to make gestures when viewing the animations, and the non-gesturing group were not. Results For clips 2 ($p < .001$) and 3 ($p < .01$) the gesturing group had significantly higher scores than the non-gesturing group. Furthermore, the gesturing group experienced significantly less difficulty than the non-gesturing group on for clips 1 ($p < .01$), 2($p < .001$), and 3($p < .001$). These results provide support for Hypothesis 1, as when gesturing participants scored higher and experienced less difficulty. For clip1 only, a significant interaction was found ($p < .05$). Simple effects tests indicated that for the novice group, gesturing led to significant higher scores than non-gesturing ($p < .05$). However, for the more experienced group no significant difference was found. Hence, the only support for hypothesis 2 was found on clip 1. However, for the novice group a significant advantage for gesturing was found on clips 1 ($p < .05$) and 2 ($p < .01$), but not for clips 3 and 4. For the more experienced group, there was a significant gesturing advantage for clips 2 ($p < .01$) and 3 ($p < .05$) but not for clips 1 and 4. These results suggest that as the tasks got more difficult gesturing lost its advantage. Conclusion It can be concluded that the effectiveness of the gestures was moderated by both task complexity, where gestures were most useful for tasks that were of a moderate level of difficulty, and expertise, where more expert piano players found gestures to be redundant for the easier clips, and more useful for the harder clips, while novices found the gestures to be useful for the easier clips, but not for the more difficult ones.

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Thursday, June 23, 2016, 16:00 to 17:40

Gestures and Motion

Steffi Zander, Stefanie Wetzel, Sven Bertel

(University of Weimar, University of Weimar, University of Weimar)

Effects of using touch-gestures on mobile devices on elementary school children`s solving of spatial tasks

Touch-based mobile devices are increasingly used in educational settings. It is often argued that pragmatic advantages are seen in increased mobility during computer-based learning phases, due to a high portability of devices, internet connectivity and high availability of learning applications. From an educational psychology perspective, it is of special interest to examine how the touch-based modes of interaction with learning materials (e.g. apps) affect performance, cognitive load and motivation. It has been argued that touch screens afford more natural gestures and embodied interaction while learning. The use of gestures to interact with information sources, such as with 2-D and 3-D visualizations, has been shown to support the processes of solving spatial tasks. Subsequently, it is of interest whether using touch-gestures can also improve learning from dynamic visual information presented and interacted with on touch-based devices. We present results of first studies in which we addressed the question of whether, for elementary and secondary school students (aged 9-10 and 13-14 years), solving spatial tasks can be enhanced by using touch-gestures on mobile devices. In the first study two conditions of 3D-spatial tasks – an interactive touch-based app allowing to physically rotate objects and a paper-based static version – were compared using a within-and between subject design. Elementary school children (N = 64) worked either with paper- or touch-based learning material in two trials. Findings suggest that the touch-based, dynamic version improves task solving significantly with regard to success rate and mental efficiency. Results indicate an additive, enhancing effect of the touch-based, dynamic app especially for children who had already completed the paper-based trial and were therefore relatively capable of solving the tasks by using mental rotation processes. In the second study, a mixed between-within subject design was used that was extended by three parameters: (1) both the static and the dynamic versions of the spatial tasks were presented on tablets, (2) participants were older and therefore relatively capable of solving the tasks without pre-training, and (3) two further experimental conditions were established, namely static/static and dynamic/dynamic to control for the specific influence of gestures. 56 students took part in the study. Data analyses of experiment 2 are ongoing. Results of experiment 1 and 2 will be presented and discussed at the conference.

Thursday, June 23, 2016, 16:00 to 17:40

Gestures and Motion

Alexander Skulmowski, Günter Daniel Rey

(Technical University Chemnitz, Technical University Chemnitz)

Embodied Cognitive Load Theory: costs, benefits and resources determine embodied learning outcomes

Harnessing the potentials of embodied interactions in multimedia learning is a difficult task, as interactivity has been shown to elicit both positive and negative effects on learning and cognitive load. In spite of the “less is more” stance usually inferred from the tenets of cognitive load theory, some attempts at integrating the results of embodied cognition research, in particular regarding motor activity and interactivity, have shown promising results. In order to bridge cognitive load theory and embodiment theory, we developed a cost-benefit model named embodied cognitive load theory. The building blocks of the model are (cognitive) benefits and costs attributed to interactive features; according to the model, an interactive feature will only enhance learning if the benefits (decreases in cognitive load) exceed the costs (increases in cognitive load). This model has been confirmed by a study on the design of tangible user interfaces which revealed increases in learning performance when a 3D visualization was controlled using a tangible user interface compared with a mouse interface, thereby utilizing the haptic feedback of the tangible. However, tangible user interfaces requiring too much motor coordination (costs) lead to lower learning performance than less interactive designs. In a follow-up study in which participants used a mouse-controlled 3D visualization, we varied the available learning time (1 minute vs. 6 minutes) and label display mode (interactive selection vs. permanent display of all labels). The experiment revealed an interaction between time and label display mode; cognitive load was increased by an interactive selection feature when only a short learning time was provided. Conversely, the interactive feature lowered cognitive load with long learning times. These two experiments provide evidence for the cost-benefit model of embodied cognitive load theory. In addition, the second experiment suggests that the effects of interactivity in embodied learning depend on the available task resources, such as time, thereby extending embodied cognitive load theory. Future research directions in cognitive load theory and embodiment are discussed.

Thursday, June 23, 2016, 16:00 to 17:40

Gestures and Motion

Andreas Korbach, Paul Ginns, Roland Brünken, Babette Park

(Saarland University, University of Sydney, Saarland University, Saarland University)

Effects of tracing gestures: an eye-tracking study

The present studies were designed according to the study of Hu, Ginns, and Bobis (2015) that showed beneficial effects of finger tracing on learning success and the study of Macken, and Ginns (2014) that showed beneficial effects of tracing gestures on anatomy and physiological learning about the human heart. Cognitive load theory and theories of embodied cognition provide explanations for the beneficial effects of tracing gestures. One explanation is that the finger functions like a cue to focus attention for visual processing, similar to the effects of hand gestures and position on attention direction (Cosman & Vecera, 2010). The goal of a pilot study was to combine eye tracking and finger tracing within one experimental setup and to analyse eye movements as an indicator for changes to visual information processing. The original paper-based learning instruction about the human heart (Macken & Ginns, 2014) was converted to a digital version and adapted for eye tracking on a 1280x1024 screen presentation. In addition, the instruction was shortened from 12 to 7 pages that focused on the anatomical structures and cut off the information about function and blood flow. The multiple-choice tests for prior knowledge and learning success were adapted, too. Participants (N = 13) were randomly assigned to one of two groups. The tracing group was instructed to use finger tracing while learning whereas the control group was instructed not to use their hands while learning. Preliminary results do not confirm the beneficial effect of tracing on learning success, however there was a significant increase in transitions between textual and related pictorial areas of interest for the tracing group ($M = 99.0$, $SD = 27.87$) in contrast to the control group ($M = 59.0$, $SD = 19.30$), $t(11) = -2.89$, $p < .05$. The present pilot study was conducted in order to solve several technological problems concerning the combination of eye tracking with tracing behaviour. These first results indicate that tracing has an effect on eye movements and information processing, as a recent study by Park, Korbach, and Brünken (2015) found the text-picture transitions to be positively correlated to learning success. The missing effect in the present pilot study on learning success may be due to the shortening of the learning instruction and the changes concerning the tests for prior knowledge and learning success. The main study is already running with the original learning instruction and focuses on eye-tracking analyses in combination with cognitive load measurement to investigate cognitive load explanations for the effects of tracing and pointing gestures. First results of the main study will be presented and discussed on the conference.

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Thursday, June 23, 2016, 18:00 to 19:00

Cognitive Load Theory and testing

Tino Endres, Shana Carpenter, Alf Martin, Alexander Renkl

(University of Freiburg, Iowa State University, University of Freiburg, University of Freiburg)

Constructive retrieval by prompted recall

The testing effect has been shown to be a quite robust effect in memory research. When applying this effect in educational settings, it is an important question under which conditions learning by testing works best. Several studies have shown that learning by testing is best when the retrieval process is difficult and, therefore, effortful but successful. Finding the right balance between retrieval effort and retrieval success is a challenging problem. A promising approach is to enrich a retrieval task with elaboration demands. The enriched free-recall task should lead to more mental effort without lowering retrieval success, which should enhance higher learning outcomes. In this study, we enriched a recall task (i.e., retrieval task) with an elaborative prompt that was taken from studies on writing learning journals. In a between-subject design, we compared an elaboration-enriched free-recall condition with a free-recall conditions without elaboration prompt. Fifty-six undergraduate students took part in the study. Participants learned from a video-recorded lecture on cognitive load theory. Learning outcomes were assessed one week later by a posttest composed of a factual-knowledge and a comprehension sub-scale. The enriched free-recall increased the comprehension of the learning contents. Against expectation the effect was not mediated by increased mental effort. Instead, the effect on comprehension was mediated by the learners' use of elaboration strategies in response to the recall task. The enriched recall-task had no effect on the acquisition of factual knowledge. Overall, our findings support the constructive retrieval account of the testing effect. They also encourage to use tasks in classroom teaching that combine elaboration and retrieval.

Thursday, June 23, 2016, 18:00 to 19:00

Cognitive Load Theory and testing

Julian Roelle, Kirsten Berthold

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Test-based learning: Inconsistent effects between higher and lower level test questions

Providing learners with test questions subsequent to an initial study phase is a common instructional technique. However, test-based learning is not always equally effective. Rather, its effectiveness depends on various factors. One of these factors is the level of the cognitive processing required to answer the test questions. In general, the evidence concerning this factor is consistent with generative learning theory; high level test questions (e.g., application questions) are usually more beneficial than low level test questions (e.g., summarization questions). Nevertheless, the evidence includes some inconsistencies. One inconsistency refers to effects between high and low level test questions regarding the performance on low level posttest questions. In some studies high level test questions were beneficial, whereas in other studies they were even detrimental regarding the performance on low level posttest questions. This could be due in part to the fact that low level test question questions often focus learners on a higher share of the information that is provided in the initial study phase than high level test questions. Thus, it can be predicted that effects between high and low level test questions regarding the performance on low level posttest questions depend on the scoring of the low level posttest questions. If solely responses are scored that relate to information at which both high and low level test questions are focused, then high level test questions should not be inferior and potentially even superior to low level test questions. By contrast, if also responses are scored that relate to information at which high level test questions are not focused, then low level test questions might be superior. A second inconsistency is that although high level test questions consistently fostered performance on high level posttest questions, the effect sizes substantially vary between studies. This might partly be due to the fact that learners performed different activities in the initial study phase. Specifically, it can be predicted that the superiority of high level test questions is higher if learners merely perform low level activities such as summarizing in the initial study phase than if learners perform high level activities such as applying in this phase. We tested these predictions in a 2×2 experiment (N = 81 students) with the factors (a) activity in the initial study phase (summarizing vs. applying) and (b) level of subsequent test questions (low level/summarization test questions vs. high level/application test questions). Regarding the performance on low level posttest questions, there was no significant effect between high and low level test questions if solely responses were scored that related to information at which both types of test questions were focused, $F_{(1, 70)} = 2.27$, $p = .14$, $\eta^2_{partial} = .03$. However, if also responses were scored that related to information at which the high level test questions were not focused, the learners who received low level test questions reached higher scores, $F_{(1, 70)} = 13.34$, $p < .01$, $\eta^2_{partial} = .16$. Regarding the performance on high level posttest questions, we found that the learners' activities in the initial study phase mattered. The high level test questions were superior to the low level test questions only if the learners' engaged in low level activities, $F_{(1, 34)} = 4.94$, $p = .03$, $\eta^2_{partial} = .13$, but not if learners engaged in high level activities in the initial study phase, $F < 1$.

Thursday, June 23, 2016, 18:00 to 19:00

Cognitive Load Theory and testing

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The effect of testing for complex cognitive skill retention in a fixed sequence task, a dual task and a decision making task

Testing has been found to be more effective than recurrent practice for cognitive skill retention (Messineo, Gentile, & Allegra, 2015; Roediger & Karpicke, 2006). The testing-effect is explained by (1) the intense retrieval effort that learners have to invest in the testing situation to retrieve information from long-term memory, and (2) a transfer enhancing processing of information which is identical inthe testing situation and the later retention assessment situation (Bjork & Bjork, 1992; Roediger & Karpicke, 2006). In a testing situation the participants remember and recall only the relevant information which induces germane load (Sweller, 1994). Cognitive tasks have been topic of many testing effect studies (e.g. Carpenter, Pashler, Wixted, & Vul, 2008; Wheeler, Ewers, & Buonanno, 2003). However the advantage of the testing effect has been investigated rarely for complex cognitive skills required for dynamic tasks (e.g. Kluge & Frank, 2014), e.g. in process control, air traffic control, steering an airplane or computer programming (Van Merriënboer, 1997). The present study analyses the testing effect for complex cognitive skill retention required in the following three tasks-types: a fixed sequence task, a decision-making contingent task and a dual task. It is assumed that testing as a refresher intervention supports skill retention better than practice or no intervention for all three task-types. The testing effect was analysed in three studies: Study 1 used a simulated fixed sequence process control task (N = 60), Study 2 used a simulated decision-making process control task (N = 60) and Study 3 used a simulated dual process control task (N = 60). The decision-making task and the dual task were extensions of the fixed tasks. In each of the studies, participants learned how to operate the relevant simulated process control task (week 1) and after one week the testing-intervention and the practice intervention took place (week 2; experimental group). The week after, the tasks had to be executed without any support (week 3). The control group in each study received no refresher intervention. For all three studies, the testing effect was not supported: Testing showed similar results to practice (decision-making task) or practice was superior to testing (fixed sequence and dual task). The comparison of testing and control groups indicated that testing supports a higher performance in the dual task and the decision-making task. The results indicate also that testing shows a comparable but not superior potential to practice for complex cognitive skill retention in the analysed tasks types.

Friday, June 24, 2016, 09:00 to 10:40

Cognitive Load Theory in languange learning

Stéphanie Roussel, André Tricot, John Sweller

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Is learning content and a second language simultaneously a good idea?

"Content and Language Integrated Learning is a dual-focused educational approach in which an additional language is used for the learning and teaching of both content and language (…)". (Coyle, Hood & Marsh, 2010). This approach assumes that learning a foreign language is a biologically primary task that can be accomplished in the same way as learning a native language, by simple immersion in the foreign language. In contrast, we argue that such an approach can overwhelm working memory because it involves learning two categories of biologically secondary knowledge (foreign language and domain-specific content knowledge) simultaneously. Cognitive load theory research suggests that simultaneously acquiring new biologically secondary knowledge such as content knowledge and second language learning is demanding and is not acquired by immersion (Sweller, 2015). However, this approach has been identified by the European Commission as an effective opportunity for pupils to use their new language skills now, rather than learning them now for later use. The current experiment investigated learning domain-specific content knowledge when the learning material is presented in a foreign language (the "immersion" hypothesis) or if it is more efficient to provide a translation of the foreign language into the native language as a form of explicit instruction. 102 participants (French law students learning German as a foreign language) were divided into three equivalent groups. Each group had to read an informative text about the European Court of Justice in French, German, or German with a translation into French. In the translation condition, the sentences were alternated between the two languages and some critical words and phrases were underlined, highlighted in bold or linked with corresponding translations by arrows. The posttest consisted of a translation of some of the identical German words and phrases from the learning materials into French; content questions asked in French; and a translation transfer test from German to French of similar words and phrases to those found in the learning context but from a different context. Preliminary results (75 participants) indicated a significant effect of the experimental conditions on the language posttest ($F_{(2;72)} = 11.1$; $p < .001$). Performance was better for German with translation ($M = 17.4$; $SD = 7.07$) compared to French only ($M = 12.1$; $SD = 6.26$) or German only ($M = 9.21$; $SD = 5.21$): $LSD = 5.26$ ($p < .004$) and 8.19 ($p < .001$) respectively. There was also a significant effect of the experimental conditions on the content posttest ($F_{(2;72)} = 20.20$; $p < .001$). Performance was better for French only ($M = 16.96$; $SD = 3.79$) compared to German only ($M = 10.04$; $SD = 3.53$) and to German with translation ($M = 12.65$; $SD = 4.18$): $LSD = 6.91$ ($p < .001$) and 4.30 ($p < .001$) respectively. German with translation was better than German only ($LSD = 2.61$; $p < .05$). These results suggest that learning a second language is facilitated by explicitly teaching that language rather than solely via immersion. Furthermore, as expected, learning a second language interferes with simultaneous content learning irrespective of the method used to teach the second language.

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Friday, June 24, 2016, 09:00 to 10:40

Cognitive Load Theory in languange learning

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Cognitive Load Theory in the context of bilingual education: exploring unchartered territory

Bilingual education, also known as content and language integrated learning (CLIL), has been established on all levels of education in the majority of European countries as it is praised as "effective means of improving language learning provision" (Council of the European Union, 2008, p. 22). Lorenzo (2007, p. 35) confidently stated that "CLIL is bilingual education at a time when teaching through one single language is seen as second rate education." But, despite a general confidence in the effectiveness of CLIL, empirical research in general and large-scale studies in particular that prove its superiority over more traditional language education are scarce (e.g., Pérez-Cañado, 2012). This is also true for cognitive load theory (CLT; Sweller, 2010), which has so far not been considered in the context of (research on) bilingual education. From a theoretical point of view, one could imagine perceived difficulty and mental effort to be positively influenced by bilingual education, so that CLIL students have advantages over non-CLIL students in their regular language classes – this is also relevant due to the fact that CLIL and non-CLIL groups are usually taught on the basis of the same English book in their regular language classes. In the context of a quasi-experimental study on general EFL proficiency, secondary education learners (N = 702, M_{age} = 13.9 years) from English CLIL and non-CLIL tracks at German Gymnasiums and regular tracks from schools without CLIL rated the perceived difficulty (Kalyuga, Chandler, & Sweller, 1999) and their invested mental effort (Paas, 1992) on a scale from 1 (very little) to 9 (very high) retrospectively after they worked on five language production tasks. Overall, CLIL students' values on both variables were lower across all tasks. Effect sizes of group mean differences range from Cohen's d = 0.54 to d = 0.03, with the majority exhibiting statistically significant differences between CLIL and non-CLIL learners. A sum score encompassing all five tasks indicates statistically significant differences between CLIL and non-CLIL students on both variables ($F_{effort(2, 697)} = 9.58$, $p<.001$; $F_{difficulty(2, 698)} = 21.24$, $p<.001$) and produces substantial effect sizes ($0.31 \leq$ Cohen's $d \leq 0.50$). In line with theoretical considerations, the results suggest that CLIL students' perceive task difficulty as being lower and report investing less mental effort in language production tasks in comparison to students from regular and non-CLIL tracks. This study can be seen as a first approach to explore effects of CLIL with the CLT framework.

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Friday, June 24, 2016, 09:00 to 10:40

Cognitive Load Theory in languange learning

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Seductive details in foreign language learning

Seductive details are defined as interesting but irrelevant words or pictures that are added to learning material in order to spice it up (Garner et al, 1989). Studies have shown that adding seductive details resulted in poorer learning performance compared to presenting learning material without seductive details (Mayer, 2009; Rey, 2012). One explanation for this effect is that adding seductive details increases cognitive load because learners have to process unnecessary material (Park et al., 2015). Effects, however, vary according to the type of task and the type of learning performance measures (Garner et al, 1991; Mayer et al., 2008; Park et al., 2011). The goal of this study was to examine the seductive details effect in foreign language (L2) comprehension. This perspective is noteworthy because reading a text in L2 creates extraneous load as learners lack sufficiently trained schemata on how to process lexical and syntactical information (Lee & Mayer, 2015). Therefore fewer resources are available for engaging in high level cognitive processing We expected that seductive details should have a detrimental effect in L2 learning and that this effect should vary with regard to the level of students' vocabulary knowledge. 49 German students (age 15-19) learning French at school (L2) were asked to read an instructional text about geographical and political characteristics of the French oversea departments. Afterwards they answered retention and transfer questions. Students were randomly assigned to two groups within their classes: Half of the students received the text with (seductive details condition) and the other half without seductive details (base text condition). Students were further asked to rate the text in terms of emotional and cognitive interest. Results showed no differences in prior knowledge, vocabulary knowledge, verbal ability, age and years of French language teaching, and their grades in French. As expected we found that students in the base text condition showed better performance in the transfer test than students in the seductive details condition, $F_{(1, 45)} = 5.13$, $p = .028$, $d = .67$. Vocabulary knowledge and French grade were used as covariates. Vocabulary knowledge was a significant covariate, $F_{(1,45)} = 18.15$, $p < .001$, but not French grade, $F < 1$. We did not found a significant interaction between vocabulary knowledge and transfer test results, $F < 1$. In the recall test no differences between groups were observed, $F < 1$, except for the influence of vocabulary knowledge. This result is in line with Reys (2012) meta-analysis showing stronger effects in transfer than in retention tasks. Furthermore, students estimated the text including seductive details as more interesting but less helpful than the base text. The main result is that the seductive details effect was demonstrated in L2 language learning. However, the level of vocabulary knowledge did not interact with transfer performance. Thus, the detrimental effect of seductive details was similar for learners with higher and lower vocabulary knowledge. This result does not support the idea that seductive details particularly affect low vocabulary knowledge learners who are exposed to higher levels of cognitive load than high vocabulary knowledge learners. Rather, these results point to alternative explanations such as motivational and emotional factors for explaining seductive details effects in foreign language learning.

Friday, June 24, 2016, 09:00 to 10:40

Cognitive Load Theory in languange learning

Olga Ignatova, Slava Kalyuga, John Sweller

(University of New South Wales, University of New South Wales, University of New South Wales)

The imagination effect when learning auditory linguistic material

This study explores the role of imagination in language learning and investigates if mental practice can be beneficial for the acquisition of concrete and abstract concepts and expressions presented in an auditory format under conditions of low and high element interactivity. Previous research on the imagination effect has focused on visual rather than auditory information. The purpose of this study was to examine if Imagination instructions are superior to study instructions with auditory linguistic material and to compare the results of using imagination instructions for concrete and abstract linguistic material. One hundred and twenty novice students were randomly assigned to two experimental groups corresponding to the method of learning (Imagine/Study). The instructional material included 28 pairs of Italian sentences, paired with their English equivalents, including 14 abstract and 14 concrete sentences, presented randomly. A 2 (study vs. imagine) x 2 (concrete vs. abstract) x 2 (low vs. high element interactivity) factorial ANOVA with repeated measures on Degree of Abstractness and Levels of Element Interactivity was conducted and demonstrated the following main effects and interactions: 1. a significant main effect of the Instructional method, $F_{(1, 118)} = 7.86$, MSe = 10.50, $p = .006$, $\eta^2_{partial} = .062$, indicating that overall, imagination instructions produced higher results than study instructions; 2. a significant main effect of the Level of Element Interactivity $F_{(1, 118)} = 16.17$, MSe = 22.10, $p < 0.001$, $\eta^2_{partial} = 0.121$, indicating that overall, low element interactivity instructional material produced higher results than high element interactivity material; 3. a significant interaction effect of the Degree of Abstractness * Element Interactivity * Instructional Method, $F_{(1, 118)} = 6.61$, MSe= 6.77, $p = .011$, $\eta^2_{partial} = .053$. The Imagine group outperformed the Study group. The “study versus imagine” paradigm showed that imagination instructions were effective when using auditory information and so the imagination effect is not restricted to visual information. Furthermore, the results also demonstrated that the imagination instructions were superior to study instructions for abstract linguistic material under the high element interactivity condition.

Friday, June 24, 2016, 09:00 to 10:40

Cognitive Load Theory in languange learning

You-Hsuan Chang, Tzu-Chien Liu, Yi-Chun Lin

(University Taiwan, University Taiwan, University Taiwan)

Effects of computer-mediated dictionaries assisted learning with checking-meaning function on vocabulary learning and reading comprehension

The study investigated the effects of checking meaning function (Lin, Fan, Liu, & Paas, 2015) of computer-mediated dictionaries on incidental vocabulary acquisition and reading comprehension. According to the cognitive load theory (Paas & Sweller, 2012; Sweller, 2010), this function would increase germane cognitive load, which helped them to be more concentrated on the vocabulary. The checking process would also be expected to let learners make a deeper impression on the vocabulary, which might benefit their incidental vocabulary acquisition. On the other hand, due to the limited cognitive resources (Paas & Sweller, 2012), using more cognitive resources on vocabulary searching would cause less cognitive resources to be used on the reading comprehension. Therefore, the checking meaning function might increase extraneous cognitive load for reading comprehension and result in worse inference comprehension performance. Sixty-six undergraduates with different majors from a Taiwanese university were randomly assigned to the Click On group or the Checking Meanings group. There was no difference of the foreign language ability between the two groups. Reading materials, dictionary material, and computerized environment of the two groups were identical. The only difference between the two groups was the checking-meaning function was provided or not. The Click On group was instructed to click with the mouse on an unknown word to receive its definition (Liu, Fan, & Paas, 2014). The Check Meanings group was instructed to click on an unknown word as Click On group, but after that, learners have to select one meaning from a list of several meanings that fits best to the reading context (Lin et al., 2015). Participants' vocabulary learning and reading comprehension performances were measured after learning. Planned comparisons were used to detect any significant differences. The results indicated that the Checking Meanings group outperformed the Click On group on the vocabulary test, which suggested that the checking meaning function of computer-mediated dictionaries can enhance incidental vocabulary acquisition. In addition, Checking Meanings group was also found to look up less vocabularies again than the Click On group, which supported the hypothesis that checking meaning function would let learners make a deeper impression on the vocabulary they searched. However, the Checking Meanings group had worse inference comprehension than the Click On group. The results would be explained by the use of checking meaning function cost more cognitive resources on searching meaning of vocabulary, then no more cognitive resources were used on inference comprehension.

Friday, June 24, 2016, 12:00 to 13:00

Keynote

Ralf Rummer

(University of Erfurt)

Text modality, cognitive load, and desirable difficulties

Many principles for the design of multimedia learning materials share the recommendation to reduce learners' cognitive load. One prominent example is the modality principle, according to which pictures should be presented with auditory rather than visual texts. I will discuss this principle in the light of current data that question both the theoretical explanation of the modality effect and its generality. In this context, I will further focus on research on desirable difficulties, which provides a fundamentally different perspective on cognitive load, namely that (sometimes) long-term learning benefits when processing is cognitively more demanding and therefore more effortful. Based on this idea it is important to investigate the modality effect (as well as other influential multimedia effects) with delayed tests. I will report a number of studies suggesting that the modality effect is restricted to immediate tests whereas in delayed testing, written texts appear to be more effective. In other words, written (rather than auditory) text that accompanies pictures or animations can be interpreted as a desirable difficulty. I will conclude with discussing the fundamental question of how one can determine in advance when it is desirable to reduce cognitive load and when it is desirable to introduce (which kind of) processing difficulties.

AUTHORS