EARLI SIG 6/7 CONFERENCE 2010 PROGRAM BOOK

Conference coordinators

Tina Seufert
University of Ulm, Germany
tina.seufert@uni-ulm.de

Gemma Corbalan
Open University of the Netherlands
g.corbala@slo.nl

Jörg Zumbach
University of Salzburg, Austria
joerg.zumbach@sbg.ac.at

Beatrice Ligorio
University of Bari, Italy
b.ligorio@psico.uniba.it

Local committee

Tina Seufert (tina.seufert@un-ulm.de)

Gerda Glaeske (gerda.glaeske@uni-ulm.de)

Cornelia Gutmann (cornelia.gutmann@uni-ulm.de)

Felix Wagner (felix.wagner@uni-ulm.de)

Katja Hartig (katja.hartig@uni-ulm.de)

Silja-Susann Taxis (silja-susann.taxis@uni-ulm.de)

Program Book Editors

Manuel Hopp (manuel.hopp@uni-ulm.de)

Felix Wagner (felix.wagner@uni-ulm.de)

Keynote speakers

Keynote I **Monday, August 30, 11.00-12.00**

Paul Kirschner
Open University oft he Netherlands, Heerlen, Netherlands
Center for Learning Sciences and Technology, CELSTEC

Educational Urban Legends: Busting Persistent Myths in Education, Educational Innovation and ICT in Education

Mark Twain once said that "In religion and politics, people's beliefs and convictions are in almost every case gotten at second hand and without examination". Unfortunately this appears also to be true in present day education, educational innovation and use of ICT in education. Educational technologists, educational reformers, instructional designers, local and federal politicians, school managers, and advisory groups are all jockeying to show how innovative and up to date they can be, based not upon good science but upon commonly held but often either unproven or untrue beliefs. As a result of this, we now find teachers, parents and students revolting against many of these so called innovations and students becoming the dupes of it all. And what is the root of all of this? The reforms that we often see are most often not based on good science (and specifically the cognitive sciences) and/or good scientific research, but rather upon beliefs, plausible sounding rationale and/or arguments, poorly designed research and the strange idea that 'stagnation means decline'. The reaction to these reforms - though it uses the word evidence - is also based upon beliefs about how education and educational research is and should be carried out. Paul Kirschner will look at a number of these urban legends from the perspective of what cognitive science and good research in the field has to say about them.

Keynote II **Tuesday, August 31, 11.30-12.30**

Shaaron Ainsworth
University of Nottingham
Learning Science Research Institute

Exploring the Roles of Psychology in Technology Enhanced Learning: A Chronological Perspective

Psychologists are often drawn to the area of Technology Enhanced Learning (TEL) as it offers a way to test and refine their theories of learning; I know I was! However, over the last two decades the theories, technologies, methods, and contexts in which I research have all changed, often fairly dramatically. In this talk, I want explore how the field is changing by exploring how my own research has changed: from its beginnings in cognitively inspired individualised learning environments tested in the artificial contexts to today where I work with a plethora of technologies from handhelds to large screen displays, in contexts which range far from the laboratory and explore theories which take into account social, emotional, motivational, personality factors as well as cognitive ones. I want to end by reflecting on how we can manage these complex inter-relating factors (theoretically and methodologically) so that the symbiotic relationship between psychology and TEL can continue to be a relevant and fruitful one.

Keynote III **Tuesday, August 31, 16.30-17.30**

Peter Gerejets
University of Tübingen
Knowledge Media Research Center

Bridge over troubled water: From Cognitive Science to designing digital instruction

In recent years, research on designing digital instruction (e.g., materials to be used in multimedia or hypermedia environments) has been dominated by theories like the Cognitive Load Theory (Sweller, 1999) or the Cognitive Theory of Multimedia Learning (Mayer, 2002). These theories can be characterized as "framework & principles" approaches as they compile theoretical building blocks from research on memory and mental representation into comprehensive frameworks that are used to derive general and simple instructional-design principles recommended as practical guidelines. Based on examples from our own research program, I will argue that this "framework & principles" approach to designing digital instruction has its limitations and needs theoretical and methodological augmentations at three different levels of explanation in order to be theoretically and practically satisfactory: (1) Augmentations at the "framework level": Causal chains that are specified within the frameworks to explain instructional-design effects need to be substantiated more thoroughly by measuring the postulated processes and mediators and by directly testing the hypothesized relations. (2) Augmentations at the "foundational level": When theoretical or empirical inconsistencies occur that can not be resolved at the framework level, structures and processes at a more fundamental level of explanation than the one used by the framework itself have to be addressed for clarification. (3) Augmentations at the "representations in context level": When realistic materials for authentic instructional contexts are to be designed, the roles of external representations with regard to domain contents and learning objectives need to be specified by means of task analyses at a level of explanation that can be considered "above" the framework level. Based on the structuralist view of theories, a methodological perspective for future research on designing digital instruction will be proposed that allows to integrate these three levels of explanation into a comprehensive approach.

Program overview

Monday, August 30	
09.00-11.00	PhD Workshop
09.00-10.30	Work in Progress I and II
10.30-11.00	Coffee Break
11.00-11.15	Remembrance for Roxana Moreno
11.15-12.00	Keynote I (Paul Kirschner)
12.00-13.00	Lunch
13.00-14.00	Paper Session 1a (Self-regulated Learning)
14.00-14.15	Short Break
14.15-15.15	Paper Session 1b (Teacher Education)
15.15-15.40	Coffee Break
15.40-17.00	Paper Session 2 (Learning with new Technologies)
17.00-19.30	Posters and Reception
Tuesday, August 31	
09.00-10.00	Paper Session 3a (Learning with Multiple Representations I)
10.00-10.20	Coffee Break
10.20-11.20	Paper Session 3b (Learning with Multiple Representations II)
11.20-11.30	Short Break
11.30-12.30	Keynote II
12.30-13.30	Lunch
13.30-14.50	Paper Session 4a (Cogntive load I)
14.50-15.10	Short break
15.10-16.10	Paper Session 4b (Cognitive load II)
16.10-16.30	Short break
16.30-17.30	Keynote III
17.30-18.15	Business Meeting
19.30-	Evening Event / Barbecue
Wednesday, September 1	
09.00-11.00	Paper Session 5(Emotion and Motivation)
11.00-11.10	Best Paper Award
11.10-11.30	Short Break
11.30-13.30	Paper Session 6 (Cooperation, Explanation, Examples)
13.30	End of Conference

Monday August 30		
09.00-11.00	**Ph.D. Workshop (**Chair: Uwe Fischer)	
09.00-10.30	**Work in Progress Session I** (Chair: Stefanie Panke)	
	Computer based Learning and Instruction	
	Elena Svirko	14
	Approach to Learning and Enjoyment as Factors in Learning from an Online Course	
	Nicolae Nistor	17
	Verifying the Unified Theory of Acceptance and Use of Technology: The Influence of Culture, Computer Literacy, Age and Sex on the Acceptance Mechanisms	
	Steven Bruneel	20
	Study and Non-Study Related ICT Use of Flemish Students in Higher Education	
	Shannon Kennedy-Clark	23
	MUVEing Slowly -Inquiry Learning in a Scenario-Based Multi-User Virtual Environment	
	Work in Progress Session II (Carola Modica)	
	Instructional Design	
	Anna Escofet	26
	Uses of ICT among University Students: An Academic and Social Perspective of Technology-Mediated Learning Pocesses	
	Griet Lust	29
	Tool Use in Content Management Systems: Analysis of Blackboard Log Files	
	Maria Opfermann	32
	Can Representational Fading Enhance Multimedia Learning?	
	Wendy Kicken	35
	Effects of a Mobile Performance Support System on Students' Learning Outcomes	
10.30-11.00	**Coffee Break**	
11.00-11.15	**Remembrance for Roxana Moreno**	
11.15-12.00	**Keynote I (**Chair: Gemma Corbalan)	
	Paul Kirschner	4
	Educational Urban Legends: Busting Persistent Myths in Education, Educational Innovation and ICT in Education	
12.00-13.00	**Lunch**	
13.00-14.00	**Paper Session 1a (**Chair: Jörg Zumbach)	
	Self-regulated Learning	
	Martine Baars	38
	Accuracy of Immediate and Delayed Judgments of Learning during Problem Solving and Worked Example Study	
	Inga Glogger	41
	Inventing Prepares Learning not only Cognitively, but also Motivationally	
	Silja-Susann Taxis & Cornelia Gutmann	44
	Effects of a Learning Strategy Training for Children	

	Joerg Zumbach	167
	When Non-Linearity Contributes to Germane Cognitive Load: Effects of Content and Task Complexity	
14.50-15.10	**Short Break**	
15.10-16.10	**Paper Session 4b (**Chair: Tina Seufert)	
	Cognitive load – Research on Worked Examples	
	Tamara van Gog	170
	Effects of Worked Examples, Example-Problem Pairs, and Problem-Example Pairs Compared to Problem Solving	
	Ingrid A. E. Spanjers	173
	Segmentation of Worked Examples: Effects on Cognitive Load and Learning	
	Rolf Schwonke	176
	How Different Ratios of Giving and Withholding Guidance in Computer-Supported Learning Affect Cognitive Load and Learning Outcomes	
16.10-16.30	**Short Break**	
16.30-17.30	**Keynote III (**Chair: Jörg Zumbach)	
	Peter Gerjet	6
	Bridge over troubled water: From Cognitive Science to designing digital instruction	
17.30-18.15	**Business Meeting**	
19.30	**Evening Event / Barbecue**	

Wednesday September 1		
09.00-11.00	**Paper Session 5 (**Chair: Carola Modica)	
	Emotional and motivational Aspects of Learning	
	Christine Otieno	179
	Leaflets about Climate Change and Invasive Species: The Effects of How Information is Presented on Emotions and Learning	
	Maria Tulis	182
	Computer-Based Practice in School: Students' State-and Trait Emotions and the Impact of Solving Word Problems on Mathematics Performance	
	Cornelia Schoor	185
	Are Pictures more Motivating than Text? Effects of Presentation Codality on Interest	
	Kim Stalbovs	188
	Implementation Intentions on Support Strategy Use in Multimedia Learning	
	Lai Jiang	191
	The Impact of Motivation-Related Variables on Scaffold Use	
	Maria Cristina Matteucci	194
	Motivated (E)-Learning: Results of a European Project as Starting Point	
11.00-11.10	**Best Paper Award (**Chair: Tina Seufert)	
11.10-11.30	**Short Break**	

Approach to Learning and Enjoyment as Factors in Learning from an Online Course

Elena Svirko
Jane Mellanby
Department of Experimental Psychology, University of Oxford
Department of Experimental Psychology, South Parks Road, Oxford, UK, OX1 3UD
elena.svirko@psy.ox.ac.uk
jane.mellanby@psy.ox.ac.uk

Abstract. The introduction of online-teaching in university courses poses the challenge of designing software that will encourage deep approach to learning. Using 254 medical students, we compared their approach to learning, as measured by Biggs et al. (2001) 2F-SPQ-R, for a Neuroanatomy computer-aided learning (CAL) course with that for their neuroanatomy studies in general. The students reported a significantly less deep and more surface approach to learning for the CAL course. However, their approach for the course was not related to results on a neuroanatomy assessment based on it. We have also examined the factor of study enjoyment. Students reported significantly lower enjoyment of the CAL course than their neuroanatomy studies in general. Enjoyment of the CAL course was associated with a deeper approach towards it and with better performance on the neuroanatomy assessment based on it. The current findings were also compared to those obtained before changes were made to the CAL course aimed at encouraging a deeper learning approach.

Keywords: Computer-aided learning; E-learning; Approach to learning; Study enjoyment; Medical students; Higher education

Students are not passive receivers of information and the approach to learning that they adopt is important for the learning outcome. There is reasonable consensus in research about two approaches: deep and surface (e.g. Biggs et al, 2001; Entwistle & Kozeki, 1985; Marton & Saljo, 1976). The factors that have been included into the deep approach concept include searching for meaning, relating concepts, relating different representations of information, incorporating information into existing knowledge. On the other hand the surface approach to learning has been proposed to involve rote-learning, focusing on discrete elements of the studied material without integration and never going beyond course requirements.

Research has demonstrated that approach to learning is not a fixed personality trait, but that the learning context and the nature of the desired outcome can determine the approach adopted (e.g. McManus et al, 1999; Newble & Clarke, 1986; Trigwell et al, 1999). Both conceptually and from research relating approach to learning outcome a deep approach is desirable for university students (e.g. Duff, 2003; McManus et al, 1998; Trigwell & Ashwin, 2003; Watkins & Hattie, 1981).

The introduction of online-teaching in university courses poses the challenge of designing software that will encourage a deep approach to learning. Just like the other teaching methods such as lectures and laboratory work, online courses might or might not be successful at this.

Svirko and Mellanby (2008)

In 2008 we reported the results of a study which examined some of the issues concerning using the use of online courses in higher education, using as an example the Neuroanatomy Computer-Aided Learning (CAL) course that is undertaken by second year pre-clinical medical students at Oxford University.

The key findings of that study were that enjoyment of the CAL course, assessment of the amount of information in it as appropriate, and ease of understanding the course were all associated with a deeper approach towards it. The majority of the students did find the course easy to follow and thought it contained the right amount of information. However, only 26% said they enjoyed the course. Also the students reported using a significantly less deep approach to learning for the CAL course than for their studies in general. This was a disappointing finding. Interestingly, the pages of the CAL course which included detailed patient case studies were unanimously judged by 18 independent assessors to be encouraging deep approach to learning. Furthermore, medical students' assessment marks for questions referring to these pages were higher than for the rest of the assessment.

Based on our findings and other research in the area we made a number of recommendations to the CAL course developers, which have been implemented. The key ones were:

- Increase the use of clinical relevance and of interactive materials (in order to encourage the use of the deeper approach);
- Insert links between the different pages of the course where relevant and between this course and other web-based resources (in order to encourage forming of connections and integration of information);
- Keep the same general amount of information in the course while making improvements.

These suggestions were implemented and we are in the process of conducting a study investigating whether this has had any effect on the factors of approach to learning and course enjoyment. We are also examining how these factors interact with academic performance. Most data collection has been completed.

Method

The participants were 119 male and 135 female second year pre-clinical medical students.

Their learning approach was assessed using Revised Two-Factor Study Process Questionnaire (R-SPQ-2F; Biggs et al., 2001). Participants were asked to answer each R-SPQ-2F question twice at the same sitting, once in relation to the neuroanatomy CAL course and once in relation to their studies in neuroanatomy in general (the order of administration was counter-balanced).

After R-SPQ-2F, participants were asked to rate on a 10-point scale their enjoyment of the neauroanatomy CAL course, their neuroanatomy studies in general and the pre-clinical medical course as a whole and their level of anxiety in the previous 3 months. They were also asked how many hours they spent on the CAL course and how many online revision quizzes, which accompany the course, they had completed.

The Neuroanatomy Computer-Aided Learning (CAL) course is described in detail in Svirko and Mellanby (2008). Following the research reported, several important improvements were made to the CAL course, which include: addition of more videos showing dissections and clinical examination; addition of a few links to relevant external online resources; increase in the number of self-test exercises and patient case studies.

The measure of academic achievement used so far was a formative assessment in neuroanatomy, which is a computer-based assessment of the information contained in the CAL course. The question format is multiple-choice. The assessment is completed in the CAL lab under exam conditions.

Procedure

The neuroanatomy CAL course for the medical students ran for the 8 consecutive weeks of the Autumn Term. R-SPQ-2F and the questions about enjoyment, anxiety and CAL course use were administered at the start of the eighth (and last) week of term. The Formative Neuroanatomy Assessment was administered seven weeks later, at the start of the Spring Term, before any further teaching had taken place. This was done for two consecutive academic years (2008/2009 and 2009/2010).

Results

Approach to learning and neuroanatomy CAL course

The students reported significantly lower Deep Approach ($M=25.48$ vs. $M=31.58$, $t=-17.40$, $df=254$, $p<0.001$) and higher Surface Approach scores ($M=27.30$ vs. $M=23.57$, $t=12.13$, $df=254$, $p<0.001$) for the CAL course than for their neuroanatomy studies in general.

This is the same pattern of results as had been observed by us in the previous study, therefore, the improvements to the CAL course have not succeeded in getting the students to adopt as deep approach for it as for the other teaching methods in the same subject.

Enjoyment of the neuroanatomy CAL course

The enjoyment ratings of the CAL course made by the current cohort were significantly higher than those made by the cohort of 2005/2006 and 2006/2007 academic years (using Mann-Whitney U test,

z=-2.75, N=459, p=0.006). This suggests that the improvements done to the CAL course did make it more enjoyable.

On the other hand, the current cohort reported significantly less enjoyment of the CAL course than their neuroanatomy studies in general (Median=5.5 vs. 8, z=-10.56, N=254, p<0.001) or of the pre-clinical medical course in general (Median=5.5 vs. 8, z=-12.00, N=254, p<0.001). The scale on which the students rated their enjoyment ranged from 1=Not At All to 10=Very High. Thus the medians indicate that on average the students did enjoy their neuroanatomy studies and the pre-clinical medical course as a whole, but were neutral towards the CAL course.

Enjoyment of the CAL course was significantly positively correlated with the performance on the Formative Neuroanatomy Assessment based on the course (Spearman's r=0.20, N=254, p=0.001). It was also significantly positively correlated with Deep Approach (Spearman's r=0.53, N=254, p<0.001) and negatively with Surface Approach scores (Spearman's r=-0.40, N=254, p<0.001) towards the CAL course. However, the approach to learning did not predict the assessment scores.

Preliminary Conclusions

Student enjoyment of an online course is an important factor for both academic achievement and adopting the more desirable deep approach to learning.

We argue that the neuroanatomy assessment used so far is too simple a measure to detect the qualitative differences in the learning outcome produced by deep and surface approaches. Because of the nature of the assessment (short, multiple-choice questions), we believe that high scores on it could be achieved equally well by knowing the required information from the deep study of it or by memorizing some diagrams and answers to quizzes, etc. just before the assessment. In order to determine whether the learning approach adopted has an impact on the learning outcome, an assessment targeting students' understanding of the material (not just their memory for it) is needed.

It seems the changes that we have previously suggested are not enough to make the online course as enjoyable or to get the students to adopt an approach that it as deep as for the other aspects of teaching currently employed in the same subject. It seems more substantial changes are needed.

References

Biggs, J., Kember, D. & Leung, D.Y.P. (2001). The revised Two-Factor Study Process Questionnaire: R-SPQ-2F, *British Journal of Educational Psychology, 71,* 133–149.

Duff, A. (2003). Quality of learning on an MBA programme: The impact of approaches to learning on academic performance, *Educational Psychology, 23,* 123–139.

Entwistle, N.J., & Kozeki, B. (1985). Relationships between school motivation, approaches to studying and attainment among British and Hungarian adolescents, *British Journal of Educational Psychology, 55,* 124–138.

Marton, F. & Säljö, R. (1976). On qualitative differences in learning – I: Outcome and process, *British Journal of Educational Psychology, 46,* 4–11.

McManus, I.C., Richards, P. & Winder, B.C. (1999). Intercalated degrees, learning styles, and career preferences: Prospective longitudinal study of UK medical students. *British Medical Journal, 319,* 542-546.

McManus, I.C., Richards, P, Winder, B.C. & Sproston, K.A. (1998). Clinical experience, performance in final examinations, and learning style in medical students: Prospective study, *British Medical Journal, 316,* 345–350.

Newble, D. & Clarke, R.M. (1986). The approaches to learning of students in a traditional and in a problem-based medical school, *Medical Education, 20,* 267–273.

Svirko, E., & Mellanby, J. (2008). Attitudes to e-learning, learning style and achievement in learning neuroanatomy by medical students. *Medical Teacher, 30,* e219 - e227.

Trigwell, K. & Ashwin, P. (2003). *Undergraduate Students' Experience of Learning at the University of Oxford* (Oxford, University of Oxford).

Trigwell, K., Prosser, M. & Waterhouse, F. (1999). Relations between teachers' approaches to teaching and students' approaches to learning, *Higher Education, 37,* 57–70.

Watkins, D. & Hattie, J. (1981). The learning processes of Australian university students: Investigations of contextual and personological factors, *British Journal of Educational Psychology, 51,* 384–393.

Verifying the Unified Theory of Acceptance and Use of Technology: The influence of culture, computer literacy, age and sex on the acceptance mechanisms (Paper proposal)

Nicolae Nistor[1],
Tina Busche[1],
Jan Oliver Heymann[1], *and*
Marius Ciprian Ceobanu[2]
[1]*Ludwig-Maximilians-Universität, Leopoldstr. 13, D-80802 München, Germany*
[2]*Universitatea "Alexandru Ioan Cuza", str. Toma Cozma 3, RO-700554 Iaşi, Romania*
nic.nistor@uni-muenchen.de; tinabusche@gmx.de; oliver.heymann@psy.lmu.de; ciprian@uaic.ro

Abstract. Technology acceptance is an important prerequisite of successful learning in technology-enhanced environments. The Unified Theory of Acceptance and Use of Technology (UTAUT) synthesizes previous acceptance models; however it is not yet sufficiently validated. Moreover, there is insufficient empirical evidence on the influence of the acceptance mediators: culture, computer literacy, age and sex; these are increasingly significant in the actual European context. We verify the UTAUT model using a bi-cultural sample of N = 1891. As a first result, we supply empirical evidence for UTAUT, extending the model by the predictor computer anxiety and the moderator culture. Second, the acceptance mechanisms appear to be different in the sub-samples determined by culture, computer literacy, age and sex. Third, a cluster analysis confirms the differences in the technology acceptance mechanisms. In conclusion we discuss some consequences of these findings for the acceptance model and for the practice of e-learning in the actual European context.

Keywords: Technology acceptance; UTAUT; culture; age; sex; e-learning

Introduction

Technology acceptance is an important prerequisite of successful learning in technology-enhanced environments. The Unified Theory of Acceptance and Use of Technology (UTAUT) synthesizes several prominent acceptance models; however it has not yet been sufficiently validated. A deeper understanding of the technology acceptance mechanisms requires not only larger samples, but also a wider diversity of the sample population. Moreover, the moderating influence of the variables culture, computer literacy, age and sex, which are increasingly important for the continuing education in the European context, require more attention.

The present work aims at verifying the UTAUT on a larger basis, i.e. a relatively large sample, balanced in terms of culture, computer literacy, age and sex. First, we give a brief overview of the theoretical background of the technology acceptance theories. Second, we describe the actual stage and results of an ongoing technology acceptance study conducted in different regions of Germany and Romania. Third, we discuss the consequences of our findings for the theory and practice of e-learning.

Theoretical background

Technology acceptance models are mostly based the view of acceptance as an attitude, as well as the theory of reasoned action and its expanded version, the theory of planed behavior (Ajzen & Fishbein, 2000). The Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh, Moris, Davis, & Davis, 2003) synthesizes its predecessors and describes the technology use as a consequence of the use intention, which is further determined by the predictors performance expectancy, effort expectancy and social influence. Additionally, the predictor facilitating conditions directly determines the use of technology. All the influences stated by the UTAUT model are moderated by users' sex, age, experience with technology, and voluntariness of use. Straub (2009) discusses the UTAUT and concludes that it is still a relatively new model with limited use in the research literature, calling for further validation. The present research aims at validating the UTAUT; preliminary results (Nistor, Wagner, Istvanffy, & Dragotă, in press) are consistent with the findings of Venkatesh et al. (2003).

The moderating influence of culture on technology acceptance has been studied in few contexts (e.g. Li & Kirkup, 2007), however not yet with the UTAUT. Most of the intercultural acceptance studies compare countries from Europe or North America with Eastern Asian countries; obviously, the differences are considerable. Within the European Union, the differences in culture may be rather moderate; the differences in economic conditions during the last three decades are probably a better explanation than the differences of beliefs and values.

As for the influence of users' sex and age, Venkatesh and colleagues (2003) assume that these may be not necessarily significant per se, but possibly in interaction with each other. For example, the influence of the facilitating conditions may be stronger for older women than for younger men.

Methodology

In order to verify the influence of the acceptance predictors on the intention to use and technology usage, as well as the moderating influences of culture, computer literacy, age and sex, we studied a sample of N = 1891 persons who studied or had completed a university study, aged between 19 and 65 years, and located in Southern Germany (N = 875) and in various regions of Romania (N = 1016). The sample was balanced in terms of sex, age and profession. The research instrument consisted of a German and a Romanian translation of the questionnaire proposed by Venkatesh et al. (2003, p. 460) with variable values from 1 = very low, to 5 = very high acceptance. Aimed at surveying students' general intention towards technology use, the questions were generally related to "the computer as a learning tool", not to a more specific technology. The survey was partially conducted online, partially using pen-and-paper forms; the participation was voluntary.

Results

The analysis of the pooled data (N = 1891) confirmed the UTAUT model. The intention to use was generally high (M = 3.82, SD = 1.12); the technology usage was very high and with a limited variance (M = 4.20, SD = .71). The five predictors could explain approx. 40% of the variance of the intention to use, and 30% of the variance of the technology usage. The strongest predictors were the performance expectancy (ß = .56, $p < .001$ for the influence on the intention to use), the social influence (ß = .51, $p < .001$ for the influence on the intention to use), the computer anxiety (ß = - .44, $p < .001$ for the influence on the technology usage), and the facilitating conditions (ß = .28, $p < .001$ for the influence on technology usage). About 5% of the variance of the technology usage was explained by the intention to use; however 26% of the residual variance was explained by the other predictors, therefore according to our data the intention to use cannot be seen as a mediator between the predictors performance/effort expectancy and social influence, and the dependent variable technology usage. The three predictors also have a direct influence on the technology usage, with significant regression factors up to ß = .30.

The effects of the moderators were first verified by means of variance and multiple regression analysis in the sub samples determined by different values of the observed moderators; the results were then confirmed by a moderator analysis. Culture, computer literacy and age significantly moderated the influence of all predictors on technology usage; additionally, age moderated the influences on the intention to use, too. The strongest differences were determined by culture in the influence of performance expectancy on the intention to use, and in the influence of the facilitating conditions and computer anxiety on the technology usage. For users with low computer literacy, the influence of computer anxiety on technology usage was stronger, and the influence of performance expectancy on technology usage was weaker. For users over 50, the influence of computer anxiety (ß = - .60, $p < .001$) and of facilitating conditions (ß = .43, $p < .001$) on technology usage was stronger than for users under 30. As for sex, although there were some significant differences in the mean values of the male vs. female users, this was not a significant moderator of the UTAUT model. Significant interaction effects were found between age, sex, and computer literacy.

The cluster analysis identified four user clusters, two of them consisting of German, the other two of Romanian users. Further, the clusters were differentiated by high vs. low computer literacy. The highest values in performance/effort expectancy and social influence were found with the Romanian, high-literacy cluster, the lowest with the German, low-literacy cluster. The lowest facilitating conditions and intention to use were also found with the German, low-literacy cluster. The highest computer anxiety and the lowest technology usage were found with the Romanian, low-literacy cluster.

Conclusion

The present study confirms the UTAUT on the base of a large sample. For young, German users with high computer literacy, the results are very similar to the findings of Venkatesh et al. (2003). Further, our results suggest several extensions of the model. First, UTAUT appears to apply also for situations related to the use of a generic technology ("computer as a learning tool"), not only for newly introduced, specific technologies. However, users' degree of familiarity with technology, and even saturation effects have to be considered. Second, the model should be extended by the predictor computer anxiety and the moderator culture; the latter appears to determine different acceptance mechanisms. Third, age plays a dramatic role for technology acceptance, especially in interaction with computer literacy and sex.

A practical conclusion is that e-learning cannot be transferred from one culture to another (e.g. in the frame of the extension of the European Union) by simply translating the contents into another language; the acceptance factors must also be taken into account. Further, the demographic changes in European countries reveal people of an advanced age as an important target group for continuing education and e-learning; in this case a different pedagogy may also be necessary.

References

Ajzen, I. & Fishbein, M. (2000). Attitudes and the attitude-behaviour relation: Reasoned and automatic processes. *European Review of Social Psychology, 11*, 1-33.

Nistor, N., Wagner, M., Istvanffy, E., Dragota, M. (in press). The Unified Theory of Acceptance and Use of Technology: Verifying the model from a European perspective. *International Journal of Knowledge and Learning*.

Straub, E. T. (2009). Understanding technology adoption: Theory and future directions for informal learning. *Review of Educational Research, 79*, 625-649.

Venkatesh, V., Morris, M. G., Davis, G. B. & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*, 425-478.

Study and Non-study Related ICT Use of Flemish Students in Higher Education

Steven Bruneel
Centre for Instruction Psychology and Technology, Katholieke Universiteit Leuven
Vesaliusstraat 2 – bus 3770, 3000 Leuven, Belgium
steven.bruneel@ped.kuleuven.be

Kurt De Wit
Office for Education Policy, Katholieke Universiteit Leuven
Krakenstraat 3 – bus 5200, 3000 Leuven, Belgium
kurt.dewit@dowb.kuleuven.be

Jef Verhoeven
Centre for Sociological Research, Katholieke Universiteit Leuven
Parkstraat 45 – bus 3601, 3000 Leuven, Belgium
jef.verhoeven@soc.kuleuven.be

Jan Elen
Centre for Instruction Psychology and Technology, Katholieke Universiteit Leuven
Vesaliusstraat 2 – bus 3770, 3000 Leuven, Belgium
jan.elen@ped.kuleuven.be

Abstract. Numerous higher education institutions have during the last decennia invested in electronic learning management systems (e.g., Blackboard). While the widespread use of information and communication technologies is well-documented, it is far from clear what the meaning of these technologies is for students especially when their studying is concerned. This study investigates students' self-reported ICT-use as well as students' own account for the reasons of that use. The central research question is: *How do institution-provided applications relate to more popular applications like social networking sites and mobile phones in terms of frequency, time and (educational) use of students?* 15 students from different bachelor programmes at K.U.Leuven (Belgium) participated in at least two in-depth interviews. At K.U.Leuven a specific Blackboard-based learning management system was installed: TOLEDO. Findings suggest that students functionally employ institution-provided applications in their study-activities, separate from their social (and non-study related) functioning in social networking sites.

Keywords: Higher Education; ICT; Institution-provided applications; Social Networking Sites; Students' Self-reports

Summary

Introduction

Numerous higher education institutions have during the last decennia invested in electronic learning management systems (e.g., Blackboard, Moodle, WebCT) in order to facilitate the implementation of blended learning environments. Notions such as "digital natives" as well as the increased use of web 2.0 applications such as social networking sites (SNSs e.g. Facebook, Skype) point to the observation that for the current student population ICT-based environments are part of their regular life (Prensky, 2001). The use of electronic learning environments is assumed to fit the regular approach of today's students and consequently evokes educational research attention (e.g. Peluchette & Karl, 2010). While the widespread use of information and communication technologies is well-documented, it is far from clear what the meaning of these technologies is for students especially when their studying is concerned. Some authors have highlighted that the study-related use of ICT is far from optimal (Kennedy, Judd, Churchward, Gray, & Krause, 2008), whereas others have stressed that the use of study-related applications is mediated by the meaning students attribute to these applications (Kirkwood & Price, 2005).

Research question

In line with the cognitive mediational view (Lowyck, Elen, & Clarebout, 2005) the current study investigates students' self-reported use of information and communication technologies as well as students' own account for the reasons of that use. Given the huge investments in learning management systems by educational institutions, we are especially interested in students' use of institution provided systems for both study and non-study related activities. The study compares the self-reported use of these institution-provided applications with the self-reported use of other applications and more specifically web 2.0 applications. The study compares when and how institution provided applications and applications freely available or acquired by the students themselves are used for study and non-study related purposes. Can we notice for example a different pattern regarding the frequency and time between the use of an institution-provided learning management system and the attendance and actions on SNSs? And how do students themselves explain such a difference? The central research question can hence be formulated as follows: *How do institution-provided applications relate to more popular applications like SNSs and mobile phones in terms of frequency, time and (educational) use of students?*

Methodology

From a purposive sample, 15 students (five boys, ten girls) from different programmes at K.U.Leuven (Belgium) participated in at least two in-depth interviews over the semester. At K.U.Leuven a specific Blackboard-based learning management system was installed: TOLEDO. The semi-structured interviews allowed us to systematically explore the research questions, while leaving room for participants to elaborate on their particular experiences and points of view. Furthermore, the structured nature of the interviews allowed us to gather comparable data from each interview. A qualitative data analysis tool, NVivo 8.0, was used to assist with the coding of the data into themes and subcategories which reflect the research question.

(Preliminary) findings

Findings show that the sample in this study consists of "digital natives" as far as their ICT use is concerned. All of the students own a mobile phone and a computer. Students mostly use their mobile phone for sending and receiving text messages. During the week the computer is used daily as students daily consult TOLEDO. SNSs are accessed daily as well. With respect to TOLEDO as well as for SNSs, it seems that the use is declining over the week. In other words, students indicate to jointly use TOLEDO and web 2.0 applications. These patterns seem to suggest that ICT use is linked to study-related activities.

However, the interviews show that the use of web 2.0 applications is hardly study related. TOLEDO is mainly used as an information channel. For instance, one student said: '*For me, the main goal of TOLEDO is to provide very clear all and correct information*[1]*'* (respondent 6). Students use TOLEDO to see where and when teaching events take place and to download course related slides or texts. The use of interactive features of TOLEDO (e.g. discussion fora) is very limited. Students indicate that most of their studying involves studying texts and doing exercises. They also report limited usage by university teachers of more interactive features (e.g. wiki, blog, discussion fora) of TOLEDO.

In general, the interviews reveal three main issues: first, students make a clear distinction between the use of TOLEDO (as an official application that is provided by the university) and the use of other more informal applications: '*I think TOLEDO is a learning environment (...) and people wouldn't ask on TOLEDO things like 'oh, party, will you join us'* (respondent 3)? ' *(...) Because I associate TOLEDO with lessons and stuff that I need to do'* (respondent 5). Second and similarly to the first

[1] All citations are translated from Dutch

issue, students make a clear distinction (also in the use of particular applications) between ICT use for study and non-study related purposes. '*The e-mails about study-related issues come through on TOLEDO, that is very separated.'* (respondent 5). As a third issue, while the use of TOLEDO is highly functional and immediately related to study-related information activities, the use of other –mostly web 2.0 – applications is more integrated in their 'regular' social life. '*I associate Facebook with pure entertainment, and if this suddenly is involved with school.... I don't look forward to it'* (respondent 6).

Conclusion and discussion

The findings ask questions about the meaning and the effectiveness of institution-provided applications and about students' attitude towards using these ICT-applications as support for their study-activities. There are indications that students functionally employ institution provided applications in their study-activities which are totally separate from their social (and non-study related) functioning in SNSs.

The data presented here suggest that students (purposefully) clearly distinguish between their studies and their private lives. In our opinion, and as a topic for further research, the focus of current research on technological innovations in higher education could be blurring this distinction. Moreover, we need more respondents, and students of younger ages, to assess (whether or not) we can generalize our findings.

References

Kennedy, G. E., Judd, T. S., Churchward, A., Gray, K., & Krause, K.-L. (2008). First year students' experiences with technology: are they really digital natives? *Australasian Journal of Educational Technology, 24*(1), 108-122.

Kirkwood, A. & Price, L. (2005). Learners and learning in the twenty-first century: what do we know about students' attitudes towards and experiences of information and communication technologies that will help us design courses? *Studies in Higher Education, 30*(3), 257-274.

Lowyck, J., Elen, J., & Clarebout, G. (2005). Instructional conceptions: analysis from an instructional design perspective. *International Journal of Educational Research, 41*(6), 429-444.

Peluchette, J., & Karl, K. (2010). Examining students' intended image on Facebook: "What were they thinking?!". *The Journal of Education for Business, 85*(1), 30-37.

Prensky, M. (2001). Digital natives, digital immigrants. *On the horizon, 9*(5). Retrieved January 29, 2010, from http://www.marcprensky.com/writing/Prensky%20-%20Digital%20Natives,%20Digital%20Immigrants%20-%20Part1.pdf

Slow MUVEing: Inquiry Learning in a Scenario-Based Multi-User Virtual Environment

Shannon Kennedy-Clark
Centre for Computer Supported Cognition and Learning, Faculty of Social Work and Education
University of Sydney, Sydney, Australia
shannon.kennedy-clark@sydney.edu.au

Abstract. This paper presents the research theory and design of a study that investigates how the slowing down of inquiry learning in a scenario-based multi-user virtual environment impacts upon how students interact and engage with a complex inquiry problem. The research proposes that by slowing down the learning experience and permitting students to explore a problem space without the rigid structure normally encountered in inquiry learning that students will not only be more motivated and engaged, but will result in deeper learning and the acquisition of transferable inquiry skills.

Keywords: Multi-user virtual environment, inquiry learning, scenario-based learning, slow learning,

Introduction

There is an increasing body of research surrounding the use of scenario-based multi-user virtual environments (MUVEs) in inquiry learning in secondary school science education. Scenario-based MUVEs such as *Quest Atlantis*, *River City* and *Virtual Singapura* have all shown that the environments are both highly motivating and challenging to students. Qualitative data, to date, has shown that the value of these tools in maintaining student motivation is substantial (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005; Jacobson, June Lee, Hong Lim, & Hua Low, 2008; Ketelhut, Nelson, Clarke, & Dede, 2010).

Yet, moving beyond the motivational aspects of such environments there has been little proof of actual learning transfer of inquiry skills outside of the learning space (Jacobson et al., 2008), and theoretical and practical strategies for designing pedagogically sound activities for virtual spaces are still embryonic.

This research study draws together slow learning, productive failure and inquiry learning in a scenario based MUVE. This paper addresses the background to the study and provides a brief outline of the research design for this work in progress. The research questions to be addressed in this study include: What is the impact of high structure and low structure inquiry activities on a student's learning outcomes? Does the slowing down of a virtual learning experience, by allowing a learner to control their inquiry learning activity, have a long-term impact on their motivation and attitude towards science education? Can the inquiry skills that are learnt in a virtual environment be transferred to other domains?

Background

Scenario-Based Multi-User Virtual Environments

A MUVE is a virtual environment derived from game technology that has the following five criteria: an avatar that represents the participant; a 3D virtual environment; the ability to interact with artefacts and agents; participants can communicate with other participants and, in some instances, communicate with intelligent agents; and a 'real world' context that is created to provide an authentic experience that a student may not be able to encounter in a classroom environment.

As with most computer games, a scenario-based MUVE is underpinned by a narrative that forms the basis of the learning experience. The benefit of using a scenario-based MUVE in an educational space is that learners are engaged by the narrative and are motivated by the challenge offered by the in-world activities. This study uses *Virtual Singapura. Virtual Singapura* was developed in Singapore as part of a collaborative project between researchers at Singapore Learning Sciences Laboratory and Nanyang Technological University (http://155.69.101.53/wiki/index.php/Main_Page#Introduction).

The story or scenario for the virtual world lends itself to inquiry learning – the scenario is complex and the environment is rich with information. Virtual Singapura is set in 19th century Singapore and is based on historical information about several disease epidemics during that period. The students are transported back in time to help the Governor of Singapore, Sir Andrew Clarke, and the citizens of the city try and solve the problem of what is causing the illnesses and to develop appropriate inquiry skills such as defining the scope of the problem; identification of research variables; establishing and testing hypothesis and presentation of findings. In order to create an authentic learning experience, 19th century artefacts from Singapore have been included in the environment. These artefacts include historical 3D buildings and agents that represent different ethnic groups in Singapore at the time such as Chinese, Malay, Indian, westerners, and historic period photographs.

Slow Learning Movement

The use of technology in education it is often branded as being quicker, faster, more efficient, more effective, just in time, 24/7 and ubiquitous. This paper raises the question that does quicker, faster, just in time and more efficient result in better learning for students? As with the Slow Food Movement, which was a response to fast food, the Slow Learning Movement is a response to the homogenization of education which is driven by national and state standards (Holt, 2002; Narayanan, 2006).

The Slow Learning Movement focuses on learning as a process, and allows learners to create their own learning contexts, boundaries and parameters (Holt, 2002; Narayanan, 2006). Slow learning affords learners with time to develop knowledge that is transferable to the real world. Slow learning integrates narrative and storytelling with learning to help the learner with gaining an understanding of the value and relevance of the learning activity.

How this translates to using a MUVE in the classroom is that rather than being forced to follow a structured sequence of activities (guided inquiry), students are allowed to explore, create and test their own virtual inquiry experiments. This research study explores the slowing down of the learning experience by allowing learners to engage with and explore a complex inquiry problem without the use of structure to guide a student through their initial activity within the virtual space.

Productive Failure

The removal of structure in the initial activity in a sequence of activities that encourage a student to struggle and perhaps even fail at arriving at a solution has come to be known as Productive Failure. Productive Failure, a term coined by Kapur, has been the centre of several studies, all of which have shown that allowing students to explore and create their own problem solving strategies results in greater learning outcomes (Kapur, 2008; Kapur & Kinzer, 2009; Pathak, Jacobson, Kim, Zhang, & Feng, 2008). This study will be the first study that uses of Productive Failure in a scenario-based MUVE.

Research Design

The participants for the study are a cohort of 150 ninth-grade students drawn from five general science classes at a selective government high school. The science classes are taught by five different teachers across the timetable. The school was selected as it had sufficient bandwidth and computers to allow for two classes of approximately thirty students to work in teams of four simultaneously.

The study will run over eight 40 minute lessons, table 1 provides and overview of the study schedule. The study is scheduled to run from July to August 2010 including a pilot with pre-service teachers, teacher training, the trial and follow-up discussions with teachers.

Table 1: Virtual Singapura inquiry learning research design

Class	**Class1/ 2**	**Class 3**	**Class 4**	**Class 5**	**Class 6/7/8**
Productive Failure	*Pre test Orientation*	*Low structure activity*	*High structure activity*	*Low structure activity*	*Post test, Interviews, Assessments*
Guided Inquiry	*Pre test Orientation*	*High Structure activity*	*High structure activity*	*Low structure activity*	*Post test, Interviews, Assessments*

Three of the classes will be given the Productive Failure activities and two of the classes will be given the guided inquiry activities. All 'in world' activities will be completed within the teams. Pre and post tests will be completed individually. The pre and post tests will test for inquiry skills. Students will also complete pre and post attitude surveys to see if there has been a shift in their attitudes towards science. The students will be tested again after a period of twelve-months to see if there has been a long-term shift in attitudes and retention of inquiry skills. Data obtained from focus groups and screen capture software (Camatasia) will be used to analyse the impact of slow learning.

Final Comments

Initial analysis of the pilot with pre-service teachers has emphasised the motivational aspects of the world – engaging, fun, motivating and challenging. The pre-service teachers have also grappled with issues relating to the validity and value of the tool in questioning how they, as teachers, can find a practical use for *Virtual Singapura* in their science classroom. Slowing down of the learning and exposing students to unstructured activities were strategies that were seen as being useful, but again, the practicalities of an outcome driven syllabus was seen as a restraint.

References

Barab, S. A., Thomas, M., Dodge, T., Carteaux, R., & Tuzun, H. (2005). Making Learning Fun: Quest Atlantis, A Game Without Guns. *Educational Technology, Research and Development, 53*(1), 86 -107.

Holt, M. (2002). It's time to start the slow school movement. *Phi Delta Kappan, 84*(4), 265.

Jacobson, M. J., June Lee, B. K., Hong Lim, S., & Hua Low, S. (2008). *An Intelligent Agent Augmented Multi-User Virtual Environment for Learning Science Inquiry: Preliminary Research Findings*. Paper presented at the 2008 American Educational Association Conference. Retrieved 25/06/2008.

Kapur, M. (2008). Productive Failure. *Cognition and Instruction, 26*(3), 379 - 424.

Kapur, M., & Kinzer, C. K. (2009). Productive Failure in CSCL Groups. *International Journal of Computer-Supported Learning, 4*(1), 21-46.

Ketelhut, D., Nelson, B., Clarke, J., & Dede, C. (2010). A multi-user virtual environment for building and assessing higher order inquiry skills in science. *British Journal of Educational Technology, 41*(1), 56-68.

Narayanan, G. (2006). *Crafting Change II: The Project Vision Hypothesis*. Paper presented at the Global Summit 2006: Technology Connected Futures.

Pathak, S. A., Jacobson, M. J., Kim, B., Zhang, B., & Feng, D. (2008). *Learning the Physics of Electricity with Agent-Based Models: The paradox of productive failure.* Paper presented at the ICCE, Taiwan.

Uses of ICT among University Students: an Academic and Social Perspective of Technology-Mediated Learning Processes

Anna Escofet
University of Barcelona
P. Vall d'Hebron 171, 08035 Barcelona, Spain
annaescofet@ub.edu
Begoña Gros Salvat (University of Barcelona)
Josep M Duart Montoliu (Open University of Catalonia)
Francesc Balagué Puxán (University of Barcelona)
Guillermo Bautista Pérez (Open University of Catalonia)
Anna Forés Miravalles(University of Barcelona)
Iolanda García González (University of Barcelona)
Marta Marimon Martí (University of Vic)
Artur Parcerisa Aran (University of Barcelona)

Abstract. ICT-mediated learning experiences arise from the formation and intersection of cognitive, teaching and social areas (Garrison, 2001, 2005), which can be identified in both learning and teaching situations. This paper focuses on the use of ICT in university learning situations. For this analysis, we study the types of technologies that are used in detail; describe in-depth the activities and actions that they enable; and assess student's attitudes to and preferences for them. We consider that students use technological tools in a different way in each of the three areas mentioned above. Our premise is that variations in use are determined by the objectives that are inherent in each area, the kind of actions and tasks to be carried out, and various independent variables (age, type of course, sex, academic field, etc.).

Keywords: ICT, university learning, formal learning, informal learning.

Introduction

Life-long learning

The concept of lifelong learning provides a context for understanding and analysing ICT-mediated learning processes. In such processes, the use of technology for teaching, cognitive and social purposes intersects. The interrelation between these three basic areas was described by Garrison et al. (2001, 2005), who stated that cognitive presence, social presence and teaching presence should be taken into account in the planning and organization of technology-mediated learning experiences. Cognitive presence refers to the expected and attained educational results, and is defined as the extent to which students can construct meaning by sustained reflection in a "community of inquiry". Social presence refers to the ability to relate to other members of the student community on a personal level, and is defined as the ability of participants in a community of inquiry to project themselves socially and emotionally as "real" people through the communication means that are used. Finally, teaching presence refers to the way that the educational process is organised and supported, and is defined as the act of designing, facilitating and directing cognitive and social processes to obtain learning outcomes that are personally meaningful and of educational value. In the intersection of these three areas, a stimulating context is formed that facilitates critical discourse and reflection to construct meaning, and sense is made of a community with educational objectives.

The process of constructing student identity through the use of ICT

The revolution mediated by ICT will lead to changes in the way young people consume and produce culture, socialise and communicate, search for information, and learn. Young people's use of digital technology forms part of all areas of their daily lives, and thus leads to new ways in which they construct their identities. In fact, this process of identity construction can only be explained if we consider the cultural changes brought about by information and communication technology. New,

technology-mediated ways of communicating and creating play a clear and identifiable role in young people's life and world views.

Two recent studies (European Commission, 2007; University College London CIBER Group, 2008) on the question of Internet use have revealed interesting aspects. The research carried out by the European Commission was based on a survey of children between 9 and 14 years old from 27 European Union countries. The report highlighted that children cannot imagine a society without Internet and mobile phones. Apart from communication, one of the most frequent activities was using the computer to play, followed by aspects such as: "looking for information to do homework", "downloading music, films and games, etc." and "using instant messenger programs". Email was hardly used and was considered an activity that was more common among adults. In short, the use of the Internet was basically for recreation. It tended to be the main source of entertainment and leisure, and was used more than television.

The report drawn up in England is also very interesting. The aim of the study was to identify young university students' knowledge of technology use in research. The researchers analysed how students search for, access and select information, and the type of IT tools they use, etc. The results indicated that most young people use the Internet frequently and can carry out several tasks on it simultaneously. Internet use is clearly related to communication and social relations, through instant messaging, music and film downloads, etc. The results of this research do not differ widely from those of the European Commission study. Young people's use of the Internet was based on entertainment and social aspects. Interestingly, the students' ability to use the Internet for more formal purposes was not evident. Young people were not well trained in information selection, the use of databases or other types of software to support study and research. In these areas, young people were not particularly skilled or any more skilled than adults.

These studies question the widespread idea that young people have a good command of technology. This idea needs to be reviewed, as we have no scientific evidence to support the different opinions on this topic. Consequently, it is essential to analyse how young people construct their identity through ICT and the implications of this in learning processes.

Learning networks and the network society

There is a tendency to move away from traditional educational institutions and towards a wide range of ICT-based learning networks. The concepts of learning networks and the network society explain this trend. This type of deinstitutionalisation reflects the increasingly blurred boundaries between formal, non-formal and informal learning. The education society is no longer unattainable, as the available resources help us to get closer to the model. As Carneiro stated, the dream of this new society "will be to bring about unity and continuity of learning: for each individual, in each school, in each community, in each nation" (2007:19). This vision is supported by learning communities and ICT play an important role in attaining this goal.

A recent study involving the Catalan university system (Duart et al, 2008) indicates that there is a difference in Internet uses outside and within classrooms. Outside of the classrooms, teachers and students consider that they are habitual and expert users of the Internet for communication, social relations and information searches. However, the same agents (teachers and university students) recognise that uses are more limited and traditional within the classrooms, where the Internet is an additional tool in the process of learning and teaching. The study reveals the beginning of a digital gap between students who are habitual users of the Internet as a platform for social relations and those who do not use it in this way. Hence at the present time in particular, the digital gap is related not only to Internet access, but also to its social use. In terms of the learning and teaching process, the study shows that there is a lack of institutional strategies for the educational use of the Internet.

In this context, higher education faces major challenges, as students and teachers are greatly responsible for constructing these knowledge societies. "Young people [students] are bound to play a

major role because they are often among the first to use new technologies and to help establish them as familiar features of everyday life. But older people [teachers] also have an important part to play. They possess the experience required to offset the relative superficiality of "real-time" communication and remind us that knowledge is but a road to wisdom" (UNESCO, 2005).

The research

On the basis of the studies by Garrison et al. (2001, 2005), we consider that ICT-mediated learning experiences are made up of cognitive, teaching and social areas.

Our research focuses on the use of ICT in university learning situations, which may be initiated by the teacher or independently by the students. For this analysis, we study the types of technologies that are used in detail; describe in-depth the activities and actions that they enable; and assess student's attitudes to and preferences for them.

The starting hypothesis is that the students use various IT tools in different ways depending on the area (teaching, cognitive and social). We assume that the different uses are determined by the objectives that are inherent in each area, the type of actions and tasks to be carried out, and several independent variables (age, type of course, sex, academic field, etc.). Therefore, the goal is to explain to what extent these factors are involved, how they have an impact and how they intersect with each other. In addition, we correlate the uses of technologies with the academic results that are obtained.

Secondly, we consider that young people's uses of ICT in the different contexts and areas play a significant role in their learning processes in formal situations. Hence, the study of these situations will enable us to draw up a list of "good practices", which will help teaching staff to better understand ICT-mediated learning processes and provide guidelines for design in formal learning and teaching processes.

Finally, we hope that the results of this research will contribute to improving educational offerings in universities, through the design of ICT-mediated learning situations and environments that are better adapted to the profile of today's students and more in line with the ways in which they construct their learning, either individually or in a community.

References

CARNEIRO, R (2007): "La "nueva educación" en la sociedad de la información y de los saberes ". En AA.VV Las tecnologías de la información y la comunicación (TIC) en la educación: retos y posibilidades. Madrid: Santillana.

DUART, J.M., et al. (2008) La universidad en la sociedad red. Usos de la red en el sistema universitario catalán. Barcelona:Ariel.

EUROPEAN COMISSION. Directorate-General Information Society and Media, 2007, "Eurobarometer on Safer Internet for Children: qualitative study 2007". Disponible en:

http://ec.europa.eu/information_society/activities/sip/docs/eurobarometer/qualitative_study_2007/summary_report_en.pdf [consulta, 28-1-2008]

GARRISON, D. R., ANDERSON, T.; ARCHER, W. (2001). «Critical Thinking, Cognitive Presence, and Computer Conferencing in Distance Education». The American Journal of Distance Education. N.º 15, pág. 7-23.

GARRISON, D.R.; ANDERSON, T. (2005): El e-learning en el siglo XXI. Investigación y práctica. Barcelona: Ediciones Octaedro.

UCL-CIBER GROUP (2008) "Information Behaviour of the Researcher of the Future" (University College London CIBER Group, 2008), http://jisc.ac.uk/ . [consulta, 4-3-2008]

UNESCO (2005). «Hacia las sociedades del conocimiento». Informe Mundial de la Educación. París: UNESCO.

Tool use in content management systems: analysis of Blackboard log files

Griet Lust
Norma A. Juarez Collazo
Jan Elen
Geraldine Clarebout
Geraldine.Clarebout@ped.kuleuven.be
Centre for Instructional psychology and technology, Katholieke Universiteit Leuven
A. Vesaliusstraat 2, box 3770 B-3000 Leuven
Griet.Lust@ped.kuleuven.be; Norma.Juarez@ped.kuleuven.be; Jan.Elen@ped.kuleuven.be; Geraldine.Clarebout@ped.kuleuven.be

Abstract. Although content management systems (CMS) are worldwide very popular, there is little insight into how students behave in those learning environments. The paper addresses this gap by focusing on students' behavior (i.e. their tool-use) within a Blackboard (version 9) course. The paper is an outline of the study that currently runs and gives a brief overview of the central problem, the hypotheses and the methodology. Because data collection ends in June, results and discussion are not yet included. However, they could be an interesting point of discussion in the upcoming SIG meeting.

Keywords: content management system; pedagogical implications; tool-use; goal orientation; self-efficacy

Introduction

Among the leading web-based technologies used to facilitate the design of online courses in higher education are content management systems (CMS) such as Blackboard, Moodle and WebCT. There are theoretical assumptions to state that CMS can enrich the learning experience by providing a rich toolset (Dabbagh & Bannan-Ritland, 2005). Research on how the tools are used and the effects on learning, is in its infancy (Hammoud, Love, Baldwin & Chen, 2008). Preliminary evidence reveals that students differ in their tool-use and this impacts their learning (Macfayden & Dawson, 2004; Woods & Kemper, 2009). On top there is some evidence that student variables like students' study orientation affect the tool-use behavior (Hoskins & Van Hooff, 2005).

The current study attempts to address the gap about students' tool-use behavior in CMS. The study addresses students' use of tools, the impact of motivational variables (i.e. goal orientation and self-efficacy) and the effects of tool-use on performance. Based on the preliminary evidence four key hypotheses are derived (see table I).

Table I *Key hypotheses*

Hypotheses
1. Students differ in their tool-use.
2. Tool-use differences lead to differences in performance.
3. Tool-use patterns differ in adaptivity. The following pattern is expected to be most adaptive.
3.1. Content delivery tools (Outline notes)
- frequent use before the college during the whole semester (Grabe & Christopherson, 2005).
3.2. Content elaboration tools (external links)
- use of additional information
3.3. Assessment tools (practice quizzes)
- Finishing the used practice quizzes (Macfayden & Dawson, 2010)
3.44. Collaboration tools (discussion board)
- Active use (reading and posting) (Hammoud et al, 2008; Hoskins & Van Hooff, 2005)
4. Higher levels of mastery orientation and self-efficacy result in more adaptive use of tools.

Methodology

The sample

The study runs in a first year undergraduate course at the department of 'Educational Sciences' at the Katholieke Universiteit Leuven. It contains 95% of the course-participants (n=167). The course integrated a Blackboard (version 9) content management system into the traditional classroom. The access and the use of the CMS environment is under control of the students. The following support

tools are provided: (1) administrative information about the course (e.g,. course info, announcements, student support and planning); (2) basic and expanded information about the course content (e.g. course material, external links, video records and the course content); (3) reflective learning by two self-assessment quizzes; and (4) opportunities for collaboration and communication with peers, instructor and course content (e.g. discussion board).

Data collection

Data about tool-use behavior are collected through log files. Data about student characteristics were collected using two translated questionnaires. Goal orientation was measured with the Elliot (1999) instrument containing 12 items that measured students' mastery (α=0.721) and performance (α=0.800) orientation. Self-efficacy was measured with a part of the MSLQ (Pintrich, Smith, Garcia & McKeachie, 1991) containing 8 items (α=0.879). Both surveys use a 6 point Likert scale.

Data analysis

Since the study under investigation is still running preliminary results cannot be presented yet. A short description regarding the planned data analysis is however possible. Note that this is not something robust, it can –and probably will- chance dependent on the intermediate results.

First, some general assumptions regarding homogeneity and normality will be tested. This will be complemented by some general descriptives regarding students' goal orientation and self-efficacy.

Second, correlation analyse will be executed between the different tool-use indicators and the final performance for the course. This will give a first insight in the connections between the two.

Third, the continuous data on tool-use will be transformed to categorical variables in order to increase its comprehensibility (Romero, Ventura & Garcia, 2008). Table 2 gives an overview on the way categorical variables will be formed. Each decision is based on evidence from previous empirical work (for the overall CMS use, for the use of the collaboration tool and for the use of the content delivery tool) or on a distribution analysis.

Table 2 *Continuous and categorical variables to measure students' tool use in the Blackboard course*

	Continuous variables	Categorical variables
Overall CMS use	# homepage hits Date of hits	General use of CMS[2] Intensive Regular Exceptional
Use of collaboration tool	# messages read # messages posted	Use of collaboration tool: Active use (read and post messages) Passive use (read messages) Inactive use
Use of assessment tools	Quiz 1 # quiz attempts # quiz finished Mean time on quiz 1	Use of quiz 1 No use Attempt (attempt, not finished) Strategic (attempt & finished, short time) Intensive (attempt & finished, long time)
	Quiz 2 # quiz attempts # quiz finished Mean time on quiz 2	Use of quiz 2 No use Attempt (attempt, not finished) Strategic use (attempt & finished, short time) Intensive use (attempt & finished, long time)
Use of content elaboration	# web links viewed	Use of the content

[2] Specific indicators for the categories will be derived from the distribution analysis of the data

tool	Date of views	elaboration tool:[3] Intensive Regular Exceptional
Use of learning tool	# downloads of student support information	Use of the learning tool[4]
Use of content delivery tool	# first view course material X	Use of the course material outlines:
	Date of view	- No use - Before (continuous use before the college) - Cram (highest use in the period (1 week) before the exam) - Between (irregular use, between college and exam)
	# views video college X Date of views	Use of the course material videos [5]

When looking for tool-use patterns, a hierarchical cluster analysis using the squared Euclidean distance and Ward's method will be executed with all categorical tool-use variables. This technique is preferable due to the explorative nature, the medium dataset and the categorical variables (Garon, 2010). The optimal number of clusters will be chosen based on the statistical output (agglomeration schedule) and on the theoretical framework. The clusters will be added to the data matrix as new variables.

Finally a SEM analysis will be executed to investigate the relationship between student variables, tool-use (the clusters or the different categorical variables, depends on the results of the cluster analysis) and performance. The analysis will start by the beginning of June, so first results can already be presented and put under discussion at the upcoming SIG.

References

Dabbagh, N., & Bannan-Ritland, B. (2005). *Online learning: strategies, concepts and application.* Merrill: Upper Saddle River, NJ. .

Elliot, A., & McGregor, H. (2001). A 2x2 achievement goal framework. *Journal of Personality and Social Psychology*, *80*(3), 501-519.

Garon, D. G. (2010). *Quantitative research in public administration: cluster analysis.* Retrieved 03/04/2010, from Statnotes: Topics in Multivariate Analysis: http://faculty.chass.nscu.edu/garson/pa765/statnote.htm

Hammoud, L., Love, S., Baldwin, L., & Chen, S. Y. (2008). Evaluating WebCT use in relation to students' attitude and performance. *International Journal of Information and Communication Technology Education*, *4*(2), 26-43.

Hoskins, S. L., & van Hooff, J. C. (2005). Motivation and ability: which students use online learning and what influence does it have on their achievement? *British Journal of Educational Technology*, *36*(2), 177-192.

Macfayden, L. P., & Dawson, S. (2010). Mining LMS data to develop an "early warning" system for educators: A proof of concept. *Computers & Education*, *54*(2), 588-599.

Pintrich, P., Smith, D., Garcia, T., & McKeachie, W. (1991). *A manual for the use of the motivated strategies for learning questionnaire (MSLQ).* University of Michigan, National Center for Research to Improve Postsecondary Teaching and Learning.: Ann Arbor, MI.

Romero, C., Ventura, S., & Garcia, E. (2008). Data mining in course management systems: Moodle case study and tutorial. *Computers & Education*, *51*(1), 368-384.

Woods, C. R., & Kemper, K. J. (2009). Curriculum Resource Use and Relationships with educational outcomes in an online curriculum. *Academic Medicine*, *84*(9), 1250-1258.

[3] Specific indicators for the categories will be derived from the distribution analysis of the data

[4] Specific indicators for the categories will be derived from the distribution analysis of the data

[5] Categories will be based on the plot where the timeline is the X-axes and the view frequency the Y-axes.

Can representational fading enhance multimedia learning?

Maria Opfermann
Duisburg-Essen University
P.O. Box, 45117 Essen
maria.opfermann@uni-due.de

Katharina Scheiter & Peter Gerjets
Knowledge Media Research Center (IWM-KMRC)
Konrad-Adenauer-Str. 40, 72072 Tuebingen

Abstract. The study investigates whether instructional support such as fading of representations can enhance learning and avoid cognitive overload. Learners worked with a multimedia environment on probability theory and were assigned to one of four conditions (Fading In, Fading Out, Baseline, or Full Size). Although all conditions led to significant knowledge gains, these were not higher for the fading conditions. In contrary, especially fading out of representations seems to irritate learners and cause additional cognitive load. As a result, it might be advisable to use additional instructional support only for high prior knowledge learners or after making learners more familiar with such devices.

Keywords: multimedia learning; instructional support; fading; cognitive load.

Introduction

When learning with multimedia environments that offer a variety of navigational and representational choices, learners can easily get overloaded. The current study thus investigated, whether learning can be supported through fading of external representations. This stepwise adjusting or weaning has already been proven beneficial for learning with regard to the use of worked examples' solution steps (e.g., van Gog, Paas & van Merriënboer, 2004). It was expected that the fading in of representations might help learners to minimize cognitive load and disorientation especially at the beginning of a learning phase, so that they can slowly get used to all possible options and representations. On the other hand, the fading out of representations might be beneficial in a way that learners -who optimally show continuous knowledge gains during learning anyway- are not overloaded with increasingly unnecessary and redundant information. Thus, both kinds of fading might be suitable to decrease extraneous cognitive load and free capacities for learning-related germane cognitive load, also depending on learners' prior knowledge and expertise.

Method

Participants were 64 teacher students aged 20 to 35 years (M = 24.59; SD = 3.14; 48 female) of a German university. They learned with a multimedia environment on probability theory, where basic principles were taught by means of eight worked examples. The presentation of these worked examples was subject to experimental manipulation. In a first condition ("baseline"), all worked examples were presented by means of arithmetical information only and additional written for the respective problem statement. In a second condition ("fading in"; *cf.* Fig. 1), the first two examples were presented arithmetically only. For the third and fourth example, written text was added. For the fifth and sixth example, animations were added; and for the last two examples, spoken text was added. In the third condition ("fading out"), this was the other way round: While all representations were provided for the first two examples, spoken text was removed for the third and fourth, and so on. Finally, a fourth condition ("full size") presented all examples including all representations.

When starting to work with the learning environment, students first answered some demographic questions regarding age, gender, subjects they studied, or experience with learning environments and computers. In a second step, an online questionnaire about cognitive and metacognitive strategies was administered. Third, participants received some instructions on how to work with the environment,

and this was followed by the 12-item pretest including items on conceptual and procedural knowledge. After the pretest was finished, a short theoretical introduction made students familiar with the concepts of probability theory, in particular with the calculation of single and complex events. When students had read through this theoretical section, the actual learning phase with the eight examples started. These examples were administered in a linear fashion, that is, students had to work through all examples one after the other, before they could proceed with the posttest. The 19-item posttest included items on conceptual, procedural and situational knowledge; whereby eight items were identical to the pretest and therefore suitable to measure knowledge gains directly. In addition, cognitive load was asked for four times during learning (after each second worked example) with five items aiming at covering Intrinsic, Extraneous, and Germane Load (Opfermann, 2008).

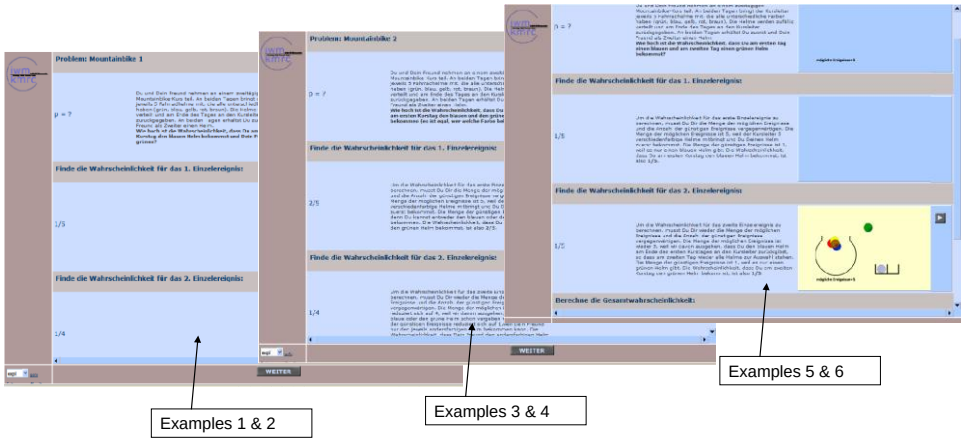


Figure 1. Example screenshots of the "fading in" condition. Examples 7 & 8 were visually similar to 5 & 6, but included additional spoken text that was identical to the written text.

Results

A paired comparisons t-test revealed significant knowledge gains for the overall sample, $t(63) = 7.48$, $p < .001$ as well as for each of the four experimental conditions (all $p < .05$; *cf.* Fig. 2). That is, all learners benefited from working with the environment. However, contrary to expectations, experimental conditions did not differ from each other. As revealed by a multivariate analysis of variance (MANOVA), neither the differences for the overall knowledge gains ($F < 1$) nor for conceptual ($F(3,60) = 1.35$; $p = .267$; *part.* $\eta^2 = .06$) or procedural knowledge ($F < 1$) reached statistical significance. This also applied to all of the overall posttest scores (all $F < 1$).

For procedural knowledge, however, there seems to be an interaction between experimental condition and expertise. Students, whose future teaching subject was mathematics, were best off with the baseline condition, whereas this was just the other way round for the students who did not have mathematics as their future teaching subject ($F(3,55) = 2.34$; $p = .083$; *part.* $\eta^2 = .11$).

With regard to cognitive load, interesting interactions were found between experimental conditions and time of measurement for ICL ($F(3,60) = 14.54$; $p < .001$), ECL ($F(3,60) = 8.45$; $p < .001$) and GCL ($F(3,60) = 5.22$; $p = .003$), indicating that during learning, fading in led to continuously decreasing CL, while fading out even increased CL over time. The scores for the baseline and the full-size condition did not change over time. In addition, again interactions between experimental condition and expertise was found, indicating that the above mentioned CL changes over time mainly applied to learners with low expertise, whereas for ongoing mathematics teachers, CL scores were generally low (maximum scores of 3 on 9-point Likert scales) and did not change over time.

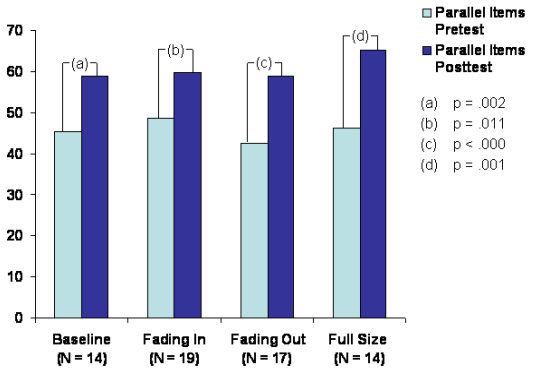


Figure 2. Percentage of parallel items answered correctly for the pre- and posttest.

Discussion

Our results indicate that contrary to expectations, representational fading did not necessarily lead to improved learning. While all learners benefited from the environment and worked examples in general, knowledge gains were not higher for those receiving fading. We found, however, interactions with learners' expertise, which may be interpreted in a way that learners with high expertise do not need additional instructional support or much representational choice because for them, this would be redundant information (Sweller, 2005) and are best off with a very basic condition that includes only arithmetical information. Learners with low expertise seem to benefit most from either a condition where all representations are provided or from a fading in of representations, which is also supported by the cognitive load scores. Fading out, on the other hand, seems to be quite ineffective as it leads to increasing cognitive load scores during learning (again, especially for learners with low expertise). This might be due to learners not reading the introductory page carefully enough and thus being irritated that the explanations they heard during the first two worked examples or the animations they could watch during the first four examples suddenly "did not work" anymore. On the other hand, our results are in line with previous research suggesting that instructional support is not equally effective for all learners but that the use of such options should be optional (Schnotz, Heiß, & Eckhardt, 2005) to give learners the freedom to adapt learning to their individual preferences and prerequisites.

As the data collection for this study still takes place, the results should be seen as preliminary. With an increasing number of students and after having been able to go into more detail with data analysis, we will present and discuss the final findings during the conference.

References

Opfermann, M. (2008). There's more to it than instructional design – The role of individual learner characteristics for hypermedia learning. Berlin: Logos.

Schnotz, W., Heiß, A., & Eckhardt, E. (2005). Wann sind Lernhilfen in hypermedialen Lernumgebungen erfolgreich? [When is learning support in hypermedia learning environments effecticve?] In A. Schütz, S. Habscheid, W. Holly, J. Krems, & C. G. Voß (Eds.), *Neue Medien im Alltag: Befunde aus den Bereichen Arbeit, Lernen und Freizeit* (pp. 189-203). Lengerich: Pabst Science Publishers.

Sweller, J. (2005). Implications of cognitive load theory for multimedia learning. In R.E. Mayer (Ed.), The Cambridge Handbook of Multimedia Learning (pp.19-30). Cambridge: Cambridge University Press.

Van Gog, T., Paas, F., & Van Merriënboer, J. J. G. (2004). Process-oriented worked examples: Improving transfer performance through enhanced understanding. *Instructional Science, 32,* 83-98.

Effects of a Mobile Performance Support System on Students' Learning Outcomes

Wendy Kicken
Open University of the Netherlands, Centre for Learning Sciences and Technologies
Valkenburgerweg 177, 6401 DL Heerlen, The Netherlands
Wendy.Kicken@OU.nl

Slavi Stoyanov
Open University of the Ne130herlands, Centre for Learning Sciences and Technologies
Valkenburgerweg 177, 6401 DL Heerlen, The Netherlands
Slavi.Stoyanov@OU.nl

Abstract. Mobile performance support system (mPSS) adapted from Electronic Performance Support system (EPSS) used in industry, is a promising approach to increase students' learning outcomes in educational settings. MPSS focuses on helping students to perform an authentic task with minimum support of others, providing them with sufficient information such as expert advice and procedures, just-in-time. Providing this support on a mobile device enables students to make their learning more efficient and relevant. To examine the effects of this approach on students' performance two pilot studies have been conducted at two different courses provided at two different universities in Bulgaria. Both qualitative (i.e., perceptions) and quantitative (performance scores) data have been gathered. In addition students have been interviewed to examine their perceived effectiveness of the mPSS. Results will be used to formulate practical implications for the implementation of a mPSS.

Keywords: mobile performance support system; learning outcomes; students' perceptions; teacher's perceptions; triangulation.

Introduction

Performance support system (PSS) is a promising approach in business and industry training to empower workers to perform tasks with a minimum amount of external intervention or training (Gery, 2002). The idea of PSS could also be introduced in the field of education, making the learning process more performance-centred (Puterbaugh, 1990). In a performance-centred approach to learning this would mean that students are instructed to perform an authentic task, related to their future job, and are provided with access to a full range of information such as data, images, advice, tools, assessment and monitoring systems (Raybould, 1991), while performing this task. The support helps students to perform the task at hand with minimum support provided by others. One medium through which this support and information can be provided is by a mobile device. The use of a *mobile* performance support system (mPSS) is further investigated in the pilot studies described in this paper. Mobile technologies offer the opportunity to embed learning in a natural environment. Furthermore, given the trend to lifelong learning, many 'students' are working adults with full-time or part-time jobs. Mobility offers them an opportunity to maximize learning time and to learn anywhere, anytime.

However, in order to be effective, it is important that the mPSS which is implemented in education is relevant and supportive for the different types of learning processes students can engage in (Leigh & Spindler, 2004). Different types of learning processes require different functionalities of the mobile devices. For instance, for learning processes in which information is studied independently, the mere distribution of structured information is sufficient. Learning processes which involve the acquisition of complex knowledge and skills require expert advice and performance support. Learning processes related to the construction of new knowledge or ideas requires the possibility of interaction with the environment and to brainstorm with others. By basing the design and use of mobile technology on the aforementioned processes, the mobile technology will have a meaningful contribution to the learners' performance and learning (Laurillard, 1993; Raban & Litchfield, 2007). In the pilot studies, the mPSS will focus on both the distribution of structured information for individual processing and expert advice and performance support for complex knowledge and skill acquisition.

To evaluate the effects of a mPSS it is important to evaluate the effects of the system on the learning processes for which it was designed. The evaluation of the impact of mobile devices on learning and teaching is in research on mobile learning often an underestimated issue or it is dominated by anecdotal reports. Experiments have been used rarely and a combination of both quantitative and qualitative methods for data collection and analysis is often not considered as necessary. Ignoring the use of powerful methods for data collection and analysis considerably reduces the opportunity for making scientifically grounded conclusions, recommendations and predictions about the use of mobile devices for educational and training purposes.

In the pilot studies described in this paper, a post-test experiment-control group design is used, in which the effects of mPSS on students' learning outcomes and their perceptions of the effectiveness, efficiency and usability of the mPSS are investigated. The evaluation methodology used in these pilot studies combines both quantitative and qualitative methods for data collection.

It is hypothesized that the mPSS will help students to adapt the learning environment to their needs and to consult information just-in-time, which will have a positive result on their learning outcomes. Regarding the perceptions of the students it is hypothesized that the feeling of being in control of when to learn, what to learn and to ask for support when needed, will have a positive effect on students' motivation and appreciation of the mPSS.

Method

Participants

In total 62 students participated in a course on Information Technology or a course on Microelectronics provided at one of two Bulgarian universities. Students voluntary decided whether they wanted to learn the topic by means of Dipseil (an e-learning environment developed according to the principles of PSS, Mileva & Tzanova, 2002; control group) or in mDipseil (the mobile version of Dipseil; experimental group)

Materials and measurement instruments

Course material. The course material (e.g., text, figures, graphs, powerpoint slides) from the existing courses provided at the universities was redesigned to fit the standards for a *mobile* PSS. The course structure and design already met the principles of performance support system, including an advisory component, an information component, a training component, and an user-interface component (Mileva & Tzanova, 2002; Stoyanov et al, 2008).

Learning style questionnaire. Because students' learning style might influence the effectiveness the mPSS, the short 40-items Learning Style Questionnaire (LSQ) of Honey and Mumford (1992) is used to identify students' learning style (i.e., activist, reflector, theorist, or pragmatist).

Think aloud protocols. To investigate how students perceive the effectiveness, efficiency and usability of the mPSS, students are asked to perform two tasks in which they use the mPSS (e.g., upload a task and the necessary performance support to your mobile device) while they are at the same time encouraged to think out loud. The think aloud session is recorded, transcribed and analyzed.

Learning outcomes. To measure students' learning outcomes, students' grades for the performance tasks completed during the course are gathered.

Reflective questionnaire. A reflective questionnaire was developed and provided. This questionnaire existed of 30 open and multiple choice questions asking for the students' opinion on: the effectiveness of the learning environment on students' performance, the effects of the learning environment on students' motivation, and the usability of the learning environment. Students' opinion is measured on a 4-point scale (1 = I totally agree, 4 = I totally disagree). The learning environment pertains in the experimental conditions to the mDipseil (i.e., mPSS) and in the control condition to Dipseil (an electronic PSS) *Interviews with students*. Information on the experiences with the mPSS and its

effectiveness on performance and motivation are examined by means of individual semi-structured interviews with students. Interview questions pertain to (a) use of the mPSS, (b) perceived effectiveness, (c) perceived usability, and (d) directions for improvement of the mPSS.

Procedure

During the first week of the course, all students filled out the 40-items Learning Style Questionnaire. In the third week after the start of the course 10 students in each course performed a think aloud protocol. At the end of the course all students filled out the reflective questionnaire. Next, 10 students within the experimental condition were individually interviewed.

Conclusion

The diversity of the students and the courses helps to gain more insight in factors that can positively or negatively influence the effectiveness of mPSS with respect to students' learning outcomes and perceived effectiveness. The results of the pilot study are used to formulate practical guidelines for the implementation of a mobile performance support system.

References

Gery G., (2002). *Performance support – driving change*. In A. Rossett (Ed.), The ASTD e-learning handbook. Best practices, strategies, and case studies for an emerging field (pp. 24-37). New York: McGraw-Hill.

Honey, P., &. Mumford, A. (1992) *The Manual of learning style*s. Maidenhead, Berkshire.

Laurillard, D., 1993. *Rethinking University Teaching*. London: Routledge

Leigh, E., & Spindler, L., (2004). Simulations and games as chaordic learning contexts. *Simulation and Gaming. 34* (1), 53 - 69.

Mileva, N., & Tzanova, S (March, 2002). Performance-Centered Vocational Education - Needs, Directions, Innovations. *Paper presented at the 5th International Academic Conference on Electronic Packaging Education and Training*, Dresden, Germany.

Puterbaugh, G. (1990). CBT and performance support. *CBT Directions, 3*(6), 18-25.

Raban, R. & Litchfield, A. (2007). Supporting peer assessment of individual contributions in group work. *Australasian Journal of Educational Technology, 23*(1), 34-47.

Raybould, B. (1990). Solving human performance problems with computers. A case study: Building an electronic performance support system. *Performance and Instruction, 29*(10), 4-14.

Stoyanov, S., Kommers, P., Bastiaens, T., & Martínez Mediano, K. (2008). Performance support system in higher engineering education – introduction and empirical validation. *International Journal of Continuing Engineering Education and Lifelong Learning*, *18* (4), 491-506

Accuracy of Immediate and Delayed Judgments of Learning During Problem Solving

Martine Baars
Institute of Psychology, Erasmus University Rotterdam
P.O. Box 1738, 3000 DR Rotterdam, The Netherlands
baars@fsw.eur.nl

Tamara van Gog
Institute of Psychology, Erasmus University Rotterdam
P.O. Box 1738, 3000 DR Rotterdam, The Netherlands
vangog@fsw.eur.nl

Fred Paas
Institute of Psychology, Erasmus University Rotterdam
P.O. Box 1738, 3000 DR Rotterdam, The Netherlands
paas@fsw.eur.nl

Abstract. For self-regulated learning to be effective, people need to judge their learning process to determine what they have learned and what is yet to be learned. The assessment by the learner of how well information is learned is called a judgment of learning (JOL). Only with an accurate JOL can a learner judge accurately what information needs to be restudied, and thus allocate study time efficiently. Whereas, most studies on JOLs and their accuracy have focused on language learning, this study aimed to investigate JOLs during problem solving in primary education.

Keywords: Judgments of learning; problem solving; self-regulation, primary school

Introduction

For self-regulated learning to be effective, people need to be able to accurately judge their learning process to find out what information they have already learned and what is yet to be learned, and then use that information as a basis to regulate further learning. The assessment by the learner of how well information is learned is called a judgment of learning (JOL). A JOL is often operationalized as the degree of understanding or a prediction about performance on a subsequent test of learned material (Dunlosky & Lipko, 2007). JOLs are presumably used to control further studying (Dunlosky & Lipko, 2007; Koriat, 2000; Metcalfe & Finn, 2008; Nelson & Dunlosky, 1991; Son & Metcalfe, 2005; Thiede, Anderson, & Therriault, 2003; Thiede, Dunlosky, Griffin, & Wiley, 2005), and therefore, it is important that JOLs are accurate. Indeed, accurate JOLs have been shown to be positively related to learning outcomes (Thiede et al., 2005).

There is a considerable amount of research on JOLs while learning language tasks. In a typical experiment, participants would read multiple texts, word pairs, or letter strings and provide a JOL after each text or word-pair (immediate), or after all texts or word-pairs (delayed). By comparing JOLs to performance on those items on a subsequent test, accuracy can be measured. Research has shown higher accuracy of delayed JOLs (Nelson & Dunlosky, 1991; Thiede et al., 2005). There are several explanations for this effect, such as retrieval from long-term memory instead of working memory (Nelson & Dunlosky, 1991) or spaced study opportunities (Metcalfe & Kimball, 2003) with delayed JOLs.

Most studies on JOLs and their accuracy have focused on adults. Nevertheless, it was established that even primary school children are able to judge their learning (Koriat, Ackerman, Lockl, & Schneider, 2009a; 2009b; Schneider, Visé, Lockl, & Nelson, 2000). They found higher accuracy of delayed JOLs (i.e., higher compared to immediate) for primary school children of different ages.

Little research exists on JOLs while learning to solve problems. Similar to the mental representation that has to be created in learning from a text (Anderson & Thiede, 2008), in problem solving tasks a mental representation has to be created of how to solve a particular type of problem. A

JOL can be provided on the extent to which a representation has been acquired to solve this type of problem, which can then be used to guide decisions on what types of problems should be restudied.

Metcalfe (1986; Metcalfe & Wiebe, 1987) investigated memory judgments in problem solving for insight and non-insight problems. It was found that participants could not predict their performance on insight problems accurately because these kinds of problems were solved by a sudden illumination (Metcalfe, 1986), whereas they could predict their performance for non-insight problems (algebra problems) because of the more incremental way of solving these problems (Metcalfe & Wiebe, 1987).

The current study focused on immediate and delayed JOL accuracy during problem solving. We expected to replicate the delayed JOL effect. By measuring invested mental effort, the relation between the mental effort invested during solving a problem and a subsequent JOL was explored.

Method

Participants and Design

Participants were 76 Dutch primary education students in grade three, they were randomly assigned to either the Immediate (n = 35) or Delayed (n = 41) JOLs condition.

Materials

Problems. Four math problems were provided to students, one of each of the following types: addition without carrying, addition with carrying, subtraction with borrowing tens and subtraction with borrowing tens and hundreds.

Rating scales. Students rated the amount of mental effort they invested in solving a problem on the 5-point rating scale developed by Paas (1992). Judgments of Learning were provided on a 5-point rating scale (cf. Dunlosky & Lipko, 2007; Thiede et al., 2003) asking students to rate how well they understand this type of problem.

Tests. The pre-test and two post-tests each consisted of four problems, one problem of each type of the four math problems per test.

Procedure

All students first completed the pretest. Then, they engaged in problem solving. They rated the amount of mental effort they invested in solving the problem immediately after each problem. Depending on their assigned condition, they also rated their judgment of learning immediately after each problem or at the end of the four problems. Next, they indicated which types of problems they would like to restudy. This was done *before* the first test to ensure restudy choices would be based on JOLs more than on experience during the test. Then they completed the first post-test, after which they again indicated which types of problems they would like to restudy. They were allowed to restudy those problems, after which they completed the second post-test. On the post-tests, students also rated the amount of mental effort they invested immediately after each problem.

Results

Data analysis is in progress but preliminary analyses suggest that –in contrast to the findings from text and word pair studies- students in the immediate condition provided more accurate JOLs (i.e., compared to their performance on the first test) than students in the delayed condition and made more accurate restudy choices (as indicated *before* the first test compared to their performance on the first test). There seem to be no differences between conditions in final learning outcomes as measured by the second test. Complete analyses will be presented at the conference.

Acknowledgement

This work was funded by the Netherlands Organization for Scientific Research (project #: 411-07-152).

References

Anderson, M. C. M., & Thiede, K. W. (2008). Why do delayed summaries improve metacomprehension accuracy? *Acta Psychologica, 128*, 110-118.

Atkinson, R. K., Derry, S. J., Renkl, A., & Wortham, D. (2000). Learning from examples: Instructional principles from the worked examples research. *Review of Educational Research, 70*, 181-214.

Dunlosky, J., & Lipko, A. R. (2007). Metacomprehension: A brief history and how to improve its accuracy. *Current Directions in Psychological Science: A Journal of the American Psychological Society, 16*, 228-232.

Koriat, A. (2000). The feeling of knowing: Some metatheoretical implications for consciousness and control. *Consciousness and Cognition, 9*, 149-171.

Koriat, A., Ackerman, R., Lockl, K., & Schneider, W. (2009a). The easily learned, easily remembered heuristic in children. *Cognitive Development, 24*, 169-182.

Koriat, A., Ackerman, R., Lockl, K., & Schneider, W. (2009b). The memorizing effort heuristic in judgments of learning: A developmental perspective. *Journal of Experimental Child Psychology, 102*, 265-279.

Metcalfe, J. (1986). Feeling of knowing in memory and problem solving. *Journal of Experimental Psychology: Learning, Memory, & Cognition, 12*, 288-294.

Metcalfe, J., & Finn, B. (2008). Familiarity and retrieval processes in delayed judgments of learning. *Journal of Experimental Psychology / Learning, Memory & Cognition, 34*, 1087-1097.

Metcalfe, J. & Kimball, D. R. (2003). Delaying judgments of learning affects memory not metamemory. *Memory & Cognition, 31,* 918- 929.

Metcalfe, J., & Wiebe, D. (1987). Intuition in insight and noninsight problem solving. *Memory & Cognition, 15*, 238-246.

Nelson, T. O., & Dunlosky, J. (1991). When people's judgments of learning (JOLs) are extremely accurate at predicting subsequent recall: The "delayed-JOL effect". *Psychological Science, 2*, 267-270.

Paas, F. (1992). Training strategies for attaining transfer of problem-solving skill in statistics: A cognitive-load approach. *Journal of Educational Psychology, 84*, 429- 434.

Schneider, W., Visé, M., Lockl, K., & Nelson, T. O. (2000). Developmental trends in children's memory monitoring: Evidence from a judgment-of-learning task. *Cognitive Development, 15*, 115-134.

Son, L. K., & Metcalfe, J. (2005). Judgments of learning: Evidence for a two-stage process. *Memory & Cognition, 33*, 1116.

Thiede, K. W., Anderson, M. C. M., & Therriault, D. (2003). Accuracy of metacognitive monitoring affects learning of texts. *Journal of Educational Psychology, 95*, 66-73.

Thiede, K. W., Dunlosky, J., Griffin, T. D., & Wiley, J. (2005). Understanding the delayed-keyword effect on metacomprehension accuracy. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31*, 1267-1280.

Inventing Prepares Learning not only Cognitively, but also Motivationally

Inga Glogger
University of Freiburg
Institute of Psychology, Engelbergerstr. 41, 79085 Freiburg, Germany
glogger@psychologie.uni-freiburg.de

Julian Kappich
Rolf Schwonke
University of Freiburg
Institute of Psychology, Engelbergerstr. 41, 79085 Freiburg, Germany
kappich|schwonke@psychologie.uni-freiburg.de

Lars Holzäpfel
University of Education
Department of Mathematics, Kunzenweg 21, 79117 Freiburg, Germany
holzaepfelfr@ph-freiburg.de

Matthias Nückles
University of Freiburg
Institute for Educational Science, Rempartstr. 11, 79098 Freiburg, Germany
matthias.nueckles@ezw.uni-freiburg.de

Alexander Renkl
University of Freiburg
Institute of Psychology, Engelbergerstr. 41, 79085 Freiburg, Germany
renkl@psychologie.uni-freiburg.de

Abstract. Inventing activities can prepare students to better learn from direct instruction by providing both a cognitive and a motivational anchor. In an experiment (N = 44), we tested to what extent inventing activities prepare teacher students to learn from a computer-based learning environment about learning strategy diagnosis in learning journals. The inventing group produced ideas about criteria to evaluate learning strategies in learning journals prior to the learning phase. The control condition read a text about possible ideas about such criteria prior to the learning phase. Results showed that the inventing activity enhanced motivation prior to the learning phase and diagnosis skills as assessed by diagnosis problems requiring transfer. Hence, the inventing activity prepared teacher students to learn in a motivational as well as in a cognitive way.

Keywords: inventing activity; learning strategy diagnosis; motivation.

Introduction

Inventing activities can appear inefficient in comparison to direct instruction: students do not generate canonical solutions to problems and they are not led directly to relevant concepts and principles of the learning domain. However, especially in the case of low prior knowledge or motivation, directly presented information (direct instruction) is often processed merely superficially, which leads to difficulties in knowledge application and transfer. Inventing activities can prepare students to process direct instruction deeply (Schwartz & Martin, 2004) by providing an anchor for learning.

Schwartz and Martin (2004) assumed primarily cognitive inventing effects. By inventing prior knowledge is activated and maybe even "generated". For example, in the present study, the learners were asked to find learning strategies in students' learning journals and invented criteria to evaluate the quality of applied learning strategies. Such inventing efforts activate prior knowledge about learning strategies. It also reveals the teacher students' knowledge gaps, for example, when they find instances that they find hard to classify. If prior knowledge is not sufficient for mastering the inventing task, a perceived “vacuum” results that helps to see the "information needs" more clearly and to focus on

relevant contents in a subsequent learning phase. Activating prior knowledge and noticing knowledge gaps constitute a cognitive anchor for further learning.

Although Schwartz and Martin (2004) concentrate on cognitive mechanisms, several studies on problem-based learning (see Norman & Schmidt, 1992) suggest that an activity such as inventing has also motivational effects. More specifically, the authentic problem of evaluating a student's learning journal can provide a motivational anchor, too. Teacher students are more curious how to diagnose learning strategies and find it more important and more useful to learn about learning strategy diagnosis after having perceived their deficits during the inventing activity. By enhancing motivation, deep processing and understanding is fostered (Entwistle & Ramsden, 1983; Pintrich, 2000). In particular, transfer performance might be enhanced.

The Present Study

In the present study, teacher students learned about learning journals and how to diagnose learning strategies in such journals. By writing learning journals, students are encouraged to use learning strategies such as elaboration, organisation, and metacognitive learning strategies. For example, they could identify the main points of a lesson (organisation strategy).

Part of the teacher students in our study that learned to identify learning strategies and evaluate their quality were requested to invent. Thereby a cognitive and motivational anchor should be created that fosters the preparedness for further learning. We expected that an inventing activity enhances teacher students' motivation for learning and diagnosis skills with respect to learning strategies.

Methods

Forty-four German teacher students (age: M = 23.93; SD = 3.16; sex: 25 female; 19 male) were randomly assigned to two conditions. They either engaged in an inventing activity (n = 23) or read a text (n = 21) prior to learning in the computer-based learning environment. In the inventing condition, the students were asked to diagnose learning strategies in learning journals, that is, they studied two student cases in order to invent criteria for judging learning strategies. While the experimental group generated answers, the control group read a text. The text summarized possible answers to the problem posed to the experimental condition (collected in a pilot study with teacher students). Since we investigated inventing effects which implies some prior knowledge activation, we did not use a pretest. Such a test would have activated prior knowledge and thereby potentially interfere with the experimental variation. After inventing or reading a text the participants filled in a questionnaire on motivation right before and right after the learning phase with the computer-based learning environment (7-point-scale ranging from 1: "not at all true" to 7: "absolutely true"). In the learning environment, the diagnosis of organisation strategies in learning journals was taught for about 20 minutes. Several sub-categories of organisation strategies were introduced with examples. Low, medium, and high quality-versions of the strategies were explained with examples. The posttest consisted of six multiple-choice items testing the conceptual knowledge about quantity and quality of learning strategies. In additional 14 items, participants had to apply their knowledge (diagnosis skill problems). The participants had to identify learning strategies, to evaluate the quality of applied learning strategies, and to provide reasons for their judgments. Five items required substantial transfer (e.g., an example passage with a new kind of strategy was given with the item: "I evaluate the quality of the organisation strategy in passage 1 as ... [low, middle, high], because...") Nine items required the application of the learned skills to similar problems (e.g., an organisation strategy known from the learning environment was given with the item: "Explain, why the marked passage is an organisation strategy"). Answers to open-ended questions were rated on a six-point-scale ranging from 1 (= no central aspects, no relation between aspects, incoherent) to 6 (= all central aspects, coherently related to each other). Inter-rater reliability as determined by an intraclass coefficient was very good (transfer: ICC = .83; similar problems: ICC = .91).

Results

Motivation prior to the learning phase was significantly higher in the inventing condition (M = 6.22, SD = .66) than in the reading condition (M = 5.62, SD = 1.35; $t(42) = 1.89$, p = .033, one-tailed, d = .56). Motivation after learning in the learning environment was rather high in both groups and did not differ significantly (inventing condition: M = 5.85, SD = 0.65; control condition: M = 5.77, SD = 0.56; $t(42) = .42$, p =.680, one-tailed). For example, the item "I would like to work on the other parts of the learning environment (assessment of rehearsal, elaboration, and metacognitive learning strategies)" was rated 6.55 on average (SD = 0.70), on a 7-point scale (7: absolutely true).

Participants in the inventing condition showed significantly better diagnosis skills at transfer problems (M = 3.33, SD = .76 vs. M = 2.85, SD = .64; $t(42) = 2.27$, p =.014, one-tailed, d = .68). They did not perform significantly better on similar problems (inventing condition: M = 3.97, SD = .59; control condition: M = 3.98, SD = .62; $t(42) = -.08$, p =.465, one-tailed, d = .17). In addition, there was no significant difference between conditions with respect to conceptual knowledge (inventing condition: M = 4.20, SD = .58; control condition: M = 4.22, SD = .64; $t(42) = -.15$, p = .443, one-tailed, d = .32).

Discussion

The inventing activity enhanced both motivation prior to learning and diagnosis skills as measured by transfer problems. Hence, the inventing activity prepared teacher students to learn not merely by cognitive mechanism but also by enhancing motivation.

After working with the learning environment teacher students in both groups were highly motivated. This high motivation can be regarded as a positive finding with respect to the evaluation of the computer-based learning environment, which was a further goal of our project.

With respect to instructional design, our findings show that students can be effectively prepared for learning from direct instruction by inventing activities. Further studies should investigate the specific cognitive and motivational processes that lead to favourable inventing effects.

References

Entwistle, N. J., & Ramsden, P. (1983). *Understanding student learning*. London: Croom Helm.

Norman G. R., Schmidt, H.G. (1992). The psychological basis of problem-based learning: A review of the evidence. *Academic Medicine. 67*, 557-65.

Schwartz, D. L., & Martin, T. (2004). Inventing to prepare for future learning: The hidden efficiency of encouraging original student production in statistics instruction. *Cognition and Instruction, 22*, 129-184.

Pintrich, N. E. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. Pintrich & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 452-502). Orlando, FL: Academic Press.

Effects of a Learning Strategy Training for Children

Silja-Susann Taxis[1],
Cornelia Gutmann[1],
Petra Herzmann[2] &
Tina Seufert[1]
[1]*Ulm University, Institute of Psychology and Education*
Albert-Einstein-Allee 47, 89081 Ulm, Germany
silja-susann.taxis@uni-ulm.de; cornelia.gutmann@uni-ulm.de; tina.seufert@uni-ulm.de
[2]*University of Cologne, Institute of general Didactics and School research*
Gronewaldstr. 2, 50931 Köln
petra.herzmann@uni-koeln.de

Abstract. In school, reading scientific texts and pictures is a crucial part of lessons. Learning strategies facilitate understanding of scientific topics. In an experimental field study, we analyzed the effects of a learning strategy training on learning performance, strategy use and cognitive load, and whether training effects are dependent on learners´ spatial abilities. Two 7th grade Gymnasium biology classes were trained in learning strategies for text and picture reading. Results indicate a positive trend for text reading strategies, but not for picture reading and elaboration. Especially learners with low spatial abilities benefited from the training of text reading strategies. Moreover, the increased use of learning strategies is associated with higher mental effort, but not with a higher extraneous cognitive load. An overall effect on learning performance could not be revealed.

Keywords: learning strategies; multiple representations; text reading; spatial abilities; ATI-effects.

Introduction and Theoretical Background

When learning with science textbooks, learners need specific strategies for encoding texts, pictures, graphs and formulas. Many studies investigated the success of using learning strategies with differing results. The primary strategies especially have a positive impact on learning outcomes (for an overview see Artelt, 2000).

As we know from other studies, effects of instructional support often depend on learners´ prerequisites (e.g. Kalyuga, Chandler & Sweller, 1998), i.e. not all learners benefit from support or training in the same way. For understanding texts or pictures learners have to construct a mental model – in biology often a spatial mental model. Therefore learners need spatial abilities. Hence we assume an ATI-effect, i.e. learners with low spatial abilities should benefit more from the training, whereas learners with high spatial abilities do not need this kind of support because they already use learning strategies implicitly, or could compensate for deficits due to their abilities (compensator effect, see Mayer, 2001). Furthermore we investigated the cognitive load students had during the strategy training. We differentiated between interference effects of the strategies in terms of extraneous cognitive load and the amount of invested effort due to the strategy use. We expected low extraneous cognitive load because the strategy provide step-by-step instructions, but higher mental effort because the strategy is an extra task learners have to deal with.

Method

We conducted an experimental field study to investigate the effects of a learning strategy training on learning performance, strategy use and cognitive load, and whether training effects are dependent on learners´ aptitude (spatial abilities: low versus high). Spatial abilities have been assessed in a pretest and learners have been categorized by a median split as low versus high.

We compared two 7th grade Gymnasium classes in biology. Both of them received learning strategy training over six weeks during their usual biology lessons. They received the same instructions from the same teacher on the topics immunobiology and ecology but with the order reversed. The training was implemented for both classes in the second phase, i.e. for each group on different topics (see figure 1).

During the training two strategies for learning from texts (5-step-reading-method (Klippert, 1994) and reciprocal teaching (Palinscar & Brown, 1984)) and one strategy for learning from text-picture combinations (Seufert & Brünken, 2006) were implemented. After the direct instruction the students received cards where the three strategies were described in steps. These cards were implemented in lessons and homework whenever students had to deal with the respective materials.

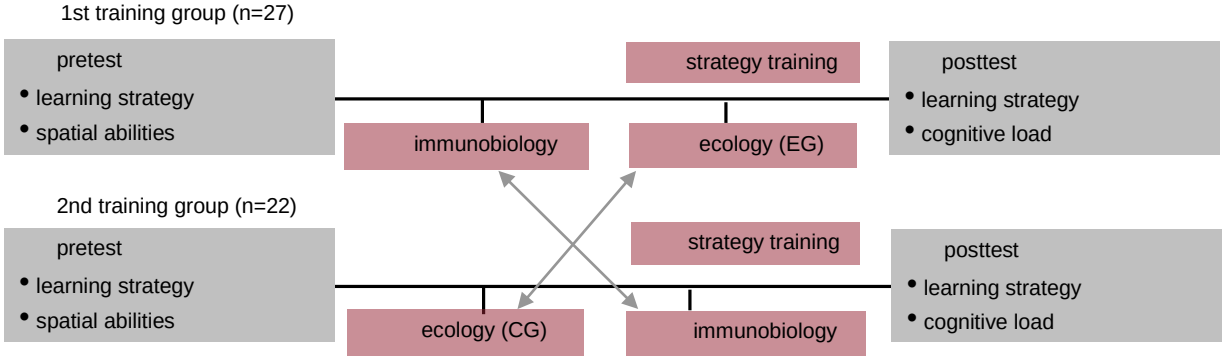


Figure 1. Design and procedure of the study

Learning performance has been measured by three tests on the topic immunobiology and two tests on ecology. Thus the two training groups were simultaneously control groups for each other concerning their learning outcomes (see figure 1). Moreover, before and after the training we measured self-reported strategy use for text comprehension (α = .78), picture comprehension (α = .55), and elaboration as a parameter for a more general learning strategy (α = .61). We also asked students to rate their actual use of the strategy cards during the training (with a range from 1 to 5).

Moreover, we analyzed two different aspects of cognitive load, rated after the respective training phases. First, we asked for the invested mental effort. Second, we asked students whether they experienced interfering effects between strategies and learning itself (α = .56) to measure extraneous cognitive load. All ratings on cognitive load have been made on a 5-point Likert-scale that ranges from very low to very high cognitive effort.

Results

To analyze training effects on learning outcomes we conducted a 2x2 ANOVA with the factors treatment (training versus no training) and spatial abilities (low versus high) with repeated measurements for learning outcomes. No main effect of the strategy-training could be revealed: the trained group outperformed the one without training in only one performance test (MD = 1.08, SE = .06, p_1 = .04). We found a main effect for spatial abilities (F(1, 28) = 7,09, p = .01, η^2 = .20), but no ATI-effect.

The development of strategy use was analyzed for both classes together in an ANOVA with repeated measurements for strategy use and the factor spatial abilities. For text reading strategies we found a trend for a main effect (F(1, 40) = 2.40, p_1 = .07, η^2 = .06): learners used more text reading strategies after the training than before. For picture reading and elaboration no main effect could be revealed. Furthermore, no main effects for spatial abilities could be found for either of the strategies. The expected ATI-effect could be found for text reading strategies (F(1, 40) = 5,56, p = .02, η^2 = .12): only learners with low spatial abilities profited from the training, whereas high ability learners showed no significant development. No ATI-effect could be found for elaboration and picture reading strategies.

For the cognitive load ratings we found that the students who reported intensive strategy use (categorized by a split above the mean score from 3) invested more mental effort than those with less strategy use (t(42) = -2,94, p_1 < .01, d = .89). On the other hand intensive users didn't report more interfering effects (t(42) = 1,15, p_1 = .13, d = -.35).

Summary and Discussion

We analyzed the effects of a learning strategy training on learning outcomes, the development of strategy use, and cognitive load. Furthermore we examined if learners with low spatial abilities benefited more from the training than learners with high spatial abilities.

The training didn't result in an overall improvement of learning outcomes. This may be due to a lack of metacognitive regulation of the strategies. Monitoring and regulation while using the cognitive strategies are crucial for positive effects on learning outcomes (Berthold, Nückles & Renkl, 2007). Considering the development of strategy use, after the learning strategy training learners used more text reading strategies by trend than before, and especially those learners with low spatial abilities profited from training. For them, the structuring process may have been prompted by the step-by-step instruction of the strategy. Learners with higher spatial abilities may have started this process deliberately. That we found no significant improvement for the other strategies may be due to the fact that the teacher had a strong focus on text reading strategies during the training. Concerning cognitive load, students had to invest more mental effort to conduct the strategies effectively, but on the other hand the training didn't cause extraneous load: the strategy served as a guideline and with increasing routine in conducting the strategies students needed less additional effort to carry out the strategy.

From a methodological point of view we have to state that the sample of our field experiment is very small and all results regarding strategies are based on self-reported data. Moreover, the measurement of cognitive load with children needs further analysis, but the idea to separate "active parts" of investing effort in contrast to "passive aspects" of experiencing interfering effects seems to be fruitful.

References

Artelt, C. (2000). *Strategisches Lernen*. Münster: Waxmann.

Berthold, K., Nückles, M., & Renkl, A. (2007). Do learning protocols support learning strategies and outcomes? The role of cognitive and metacognitive prompts. *Learning and Instruction, 17*, 564-577.

Kalyuga, S., Chandler, P., & Sweller, J. (1998). Levels of expertise and instructional design. *Human factors, 40*, 1-17.

Klippert, H. (1994). *Methoden-Training: Übungsbausteine für den Unterricht*. Weinheim Beltz.

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

Palinscar, A. S., & Brown, A. L. (1984). Reciprocal Teaching of Comprehension-Fostering and Comprehension-Monitoring Activities. *Cognition and Instruction, 1*, 117-175.

Seufert, T., & Brünken, R. (2006). When training needs expertise. Proceedings of the EARLI SIG 2 meeting "Learning by interpreting and constructing educational representations" (pp. 79-80). Nottingham, UK.

On-Line Forums in Teacher Education: Does it Effect Pedagogical Knowledge and Self-Regulation in Lesson Planning?

Zvia Fund
School of Education Bar-Ilan University
Ramat-Gan 52900, Israel
fundzv@mail.biu.ac.il

Abstract. The paper examines relationships between participation in online forums, as part of a teacher-training course, and pedagogical knowledge (PK) and self-regulation (SR) as evident from lesson planning (LP). "Mindful LP" requires synthesis of disciplinary and pedagogical knowledge, along with willingness for self-assessment and self-regulation (SR), as expressed in rewriting and improving LP. 83 students from three parallel groups of a teacher-training course were scored separately for 2 variables: *active* and *passive* participation. PK and SR measures (dependent variables) were defined and validated, based on LP tasks that the students submitted at the end of the course. Results indicate generally high positive correlations between active participation and level of PK and SR. Further ANOVA analyses reveal significant differences among three levels of participation (L, M, H) in both PK and SR. Additional interesting differences were found among the three groups and are further elaborated upon in the paper.

Keywords: online forums; lesson planning; self-regulation; pedagogical knowledge; learning community.

Introduction

The use of online learning technologies, such as asynchronous discussion forums, is becoming part of many university courses, including teacher-training (Ellis, Goodyear, Prosser & O'hara, 2006). Online forums provide a virtual environment of "textual meeting" among learners, and promote collaborative dialogue. They also offer opportunities to engage learners in an interactive and cohesive learning community (Fund, in press; Henri & Pudelko, 2003). Based upon constructivistic theories - interactions in such learning communities should contribute to students' construction of knowledge. Furthermore, research suggests that self regulated (SR) learning can be enhanced by engaging students in interactive discussions in which they reflect on the learning processes (Butler, Lauscher, Jarvis-Selinger & Beckingham, 2004). Positive effects on practical tasks, of such online forums, were found in different disciplines, such as: technical reporting in e-commerce courses and professional social work (Ellis et al., 2006). In the current paper we assume that similar peer interactions in online forums in teacher training courses might also have effects on professional and practical tasks such as lesson planning.

Lesson Planning

Lesson planning (LP) is one of the most frequent practical tasks in teacher and student-teacher professional work. Professional and mindful LP in a specific discipline requires the synthesis of two factors: a) content knowledge (CK), pedagogical knowledge (PK) and pedagogical content knowledge (PCK) (Child & McNicholl, 2007; Shulman, 1986), and b) self-regulation (SR), including cognitive self-regulation (preplanning, reviewing and editing output) that writers need for any text production (Zimmerman & Risemberg, 1997), along with self-evaluation and self-monitoring (Flower & Hayes, 1984). Both of these factors are enhanced by peer feedback (advice and comments). For simplicity purposes, in the current study, we refer to the combination of PK and PCK as general PK.

The main goals of the current paper are:

1. An examination of the relationships between *peer interactions* in the online forums and student SR and PK, as evident in 'mindful lesson planning'.
2. A comparison of these relationships among different discipline groups.

Method

The Study

The study was part of an ongoing action research project, conducted during a basic, one-semester teacher-training course in the first stages of the training program. The course dealt with didactic and core issues of teaching and learning. Fourteen face-to-face weekly meetings of four hour duration each, were held followed by an online forum, wherein students discussed a specific tasks or issues raised in the lesson.

The students' final assignment consisted of preparation of a portfolio including, among other tasks, at least two versions (first trial and additional improved versions) of two lesson plans (in their own subject area). The improved versions were to be based upon peer feedback and mindful pedagogical considerations. Each student had to supply didactic/pedagogical explanations for the specific improvements.

Participants

Participants (N=83) were teacher-students from three parallel groups drawn from different disciplines: a mathematics and computer-science group (MATHCOMP) (N=20), a biology and chemistry group (BIOCHEM) (N=25), and a 'blended' group (BLEND) (N=38) composed of students from several disciplines (mostly from: history, sociology, psychology, Judaic studies, music, art and political science).

Instruments and Measures

Management reports supplied by the learning environment platform, supplied information about two separate measures: number of messages posted (*active participation*), and number of entries into the e-forums (*passive participation*) for each student. Mason (1991) suggests that much useful information can be gained from such simple quantitative approaches as counting the number of posts or the proportion of posts by each participant.

The dependent variables were derived from a qualitative and quantitative analysis of all versions of the *lesson plans* in the *portfolio*. The PK measure was derived from: 1) the quality of the student's pedagogical explanations of the performed improvements, 2) the quality of feedback each student *offered* to his peers, and 3) the number of notes per feedback each student *offered*. The SR measure was derived from the number of improved versions, the number of feedbacks received (which depended upon the student's request for feedback), and the quality of improvement (e.g. surface, vs.substantial changes).

Procedure

The students attended the face-to-face meetings, and were required to participate in an online forum conducted after each meeting (a total of 11 forums). At the end of the course each student submitted a portfolio, including the LP tasks (and additional assignments not discussed in the current paper). All students were asked to offer feedback to their peers' lesson plans. The recipients were to modify and rewrite their lesson plans accordingly.

Two judges formulated criteria and constructed keys for the qualitative analysis of the received feedback and lesson plans (including improvements and pedagogical explanations for improvment). After content validity processing (95% agreement among judges), ten portfolios were analyzed by both judges (with an inter-judge reliability coefficient of 0.96) and the rest were analyzed by one judge.

Results

Pearson correlation tests between the variables *(active* and *passive* participation) and the dependent variables indicate significant and high positive correlations. These were higher for *active* participation (for all groups) and lower for BLEND (for both PK and SR).

The participants were then sorted into three levels (L, M, H) of active participation. A one way analysis of variance (ANOVA) was performed for each measure. Significant differences among the

levels of participation were found for PK ($F(2,78)=6.08$, $p<.01$) and for SR ($F(2,64)=12.36$, $p<.001$). The scores of the three levels of participation were subjected to Scheffe's post hoc analyses. Higher scores for higher levels of participation (L<M<H) were found for both measures. A subsequent 3 X 3 (groups X participation level) ANOVA was performed for each measure. While differences among levels of participation were significant for MATHCOMP and BIOCHEM for both PK and SR, for the BLEND group these differences were highly significant only for SR but not for PK. These results are further elaborated upon below.

Discussion and Conclusions

The presented results indicate that high active participation of students in the online forums is positively correlated with high PK and SR. Even passive participation in the forums is correlated in most groups with SR, and in some cases with PK. The peer interactions in the online forums actually encourage creating a cohesive learning community, with interdependence among the community members. This stimulates mutual support and cooperation (van Gennip, Segers & Tillema, 2009). Consequently, high quality feedback (a component of PK in the current paper) indicates willingness and motivation to help others improve their lesson planning. Similarly, high quality explanation of improvement in lesson planning (another component of PK) is evidence of trust, respect and readiness to accept feedback that exists in socially cohesive communities. The unexpected findings for the BLEND group (significant differences among activity levels in SR but not in PK; lower correlations for PK) might be explained by the unique atmosphere created in this group: A "culture" of messages in *rhyming form* dominated the forums, actually initiated by one student and continued by other students in the subsequent forums, implying its "sweeping" effects. While interacting in the forum – as the students explained - they experienced an unusual adventure, and felt as "honoured" to be members in an "exclusive club". Consequently, even the low and medium level participants "were caught up in the magic of the forum" and felt themselves to be "important" members of the community. This increased their motivation and commitment to participating in new knowledge construction, and they were highly motivated to help their peers. Further research is required to relate the current results to possible differences among the humanity and science disciplines

References

Butler D. L., Lauscher, H. N., Jarvis-Selinger, S.& Beckingham, B. (2004). Collaboration and self-regulation in teachers' professional development. *Teaching and Teacher Education, 20*, 435–455.

Childs, A.& McNicholl, J. (2007). Investigating the relationship between subject content knowledge and pedagogical practice through the analysis of classroom discourse. *International Journal of Science Education, 29*, 1629-1653.

Ellis, R. A, Goodyear, P. Prosser, M. & O'Hara, A. (2006). How and what university students learn through online and face-to-face discussion: conceptions, intentions and approaches. Journal of Computer Assisted Learning, 22, 244-256.

Flower, L. S. & Hayes, J. R. (1984). A cognitive process theory of writing. *College Composition and Communication, 32*, 335-387.

Fund, Z. (in press). Effects of communities of reflecting peers on student-teacher development--including in-depth case studies. *Teachers and Teaching: Theory and Practice.*

Henri F. & Pudelko B. (2003) Understanding and analysing activity and learning in virtual communities. *Journal of Computer Assisted Learning 19*, 474–487.

Mason R. (1991). Evaluation methodologies for computer conferencing applications. In A.R. Kaye (Ed.), *Collaborative Learning Through Computer Conferencing* (pp. 105–117). Berlin: Springer-Verlag.

Shulman, L. S. (1986). Those who understand: knowledge growth in teaching. *Educational Researcher*, *15*, 4-14.

van Gennip, N.A.E., Segers, M.S.R., & Tillema, H. (2009). Peer assessment for learning from a social perspective: the influence of interpersonal variables and structural features. *Educational Research Review*, *4*(1), 41-54.

Zimmerman, B.J. & Risemberg, R. (1997). Becoming a self-regulated writer: a social cognitive perspective. *Contemporary Educational Psychology*, *22*, 73–101.

Facilitating the Analytical Competency of Pre-Service Teachers with Digital Video Cases: Effects of Hyperlinks to Conceptual Knowledge and Multiple Perspectives

Jan Zottmann
LMU Munich, Department of Psychology
Leopoldstr. 13, D-80802 Munich, Germany
jan.zottmann@psy.lmu.de

Annika Goeze
University of Tuebingen, Institute of Educational Science
Muenzgasse 11, D-72070 Tuebingen, Germany
annika.goeze@uni-tuebingen.de

Frank Fischer
LMU Munich, Department of Psychology
Leopoldstr. 13, D-80802 Munich, Germany
frank.fischer@psy.lmu.de

Josef Schrader
University of Tuebingen, Institute of Educational Science
Muenzgasse 11, D-72070 Tuebingen, Germany
josef.schrader@uni-tuebingen.de

Abstract. Analytical competency in classroom situations can be seen as a crucial aspect of teachers' professional competency. While case-based learning is considered to have great potential for the promotion of analytical skills of teachers, there have been few attempts to investigate the effects of corresponding instructional support. The empirical study presented here investigates the effects of instructional support in the form of hyperlinks to conceptual knowledge or multiple perspectives in a computer-supported case-based learning environment based on the principles of cognitive flexibility theory. 97 prospective foreign-language teachers participated in a field study with a 2x2-factorial design. The pre-post comparison of the individual participants reveals that specific components of analytical competency could be fostered by the different treatments. Process analyses show that particularly the multiple perspectives affected the small group discussions of the cases. These results underline the importance of adequate instructional support for effective case-based learning in teacher education.

Keywords: Case-Based Learning; Cognitive Flexibility; Media in Education; Multiple Perspectives; Skills Acquisition; Teacher Education

Research background

The professional competency of teachers is strongly connected to their competency of being able to understand and analyze classroom situations (Schrader & Hartz, 2003). Analytical competency can be structured into (1) the ability to portray pedagogical situations in a differentiated way, (2) the ability to become immersed in multiple perspectives (for example, to adopt teacher and learner perspectives), and (3) the ability to apply conceptual knowledge to case information in order to better understand the situation at hand (see Schrader & Hartz, 2003). Methods of case-based learning are considered to have great potential for promoting analytical and problem-solving abilities in teacher education (Lundeberg, 1999). This is especially true for methods that utilize authentic cases with the purpose of enabling learners "to explore the complex and messy problems of practice" (Merseth, 1996, p. 725). Cases implemented to educate learners in analytical skills usually comprise complex and authentic situations that require analysis, problem-solving, and decision making.

Recent empirical studies have demonstrated that learners do not get the most out of case-based learning without additional instruction (e.g., Fitzgerald et al., 2009). In order to foster the analytical competency of teachers effectively, instructional support needs to be designed that supports learners to apply their conceptual knowledge to a case and immerse in multiple perspectives. Cognitive flexibility

theory (CFT) can be drawn upon as a basis for such instructional support as it aims to further flexible knowledge application in different real situations, increase awareness of one's own perspective, and allow for the construction of connections to alternative perspectives (Spiro, Collins, Thota, & Feltovich, 2003). The CFT further recommends the use of hypermedia environments to realize a non-linear, multi-dimensional presentation of contents. Since digital video allows dynamic processes to be visualized, presenting learners with a fuller picture of complexity, the use of this technology has been recommended for training in ill-structured domains (Goldman, Pea, Barron, & Derry, 2007).

Against this backdrop, the research question of this study was: how do hyperlinks to conceptual knowledge, hyperlinks to multiple perspectives, and a combination of both influence the acquisition of analytical competency among pre-service teachers in a computer-supported case-based learning environment? Moreover, learning processes were investigated to find out if these instructions could help counteract some of the known deficits of case-based learning, which include learners tending to get sidetracked instead of analyzing the case in a goal-oriented way, or insufficient immersion of the case-based learners, who are often having difficulties to identify the relevant perspectives for the case. We hypothesized for learning process and outcomes alike that the availability of conceptual knowledge would have a positive effect on the application of conceptual knowledge, and that the availability of multiple perspectives would have a positive effect on the immersion of the learners.

Methodology

A total of 97 prospective foreign language teachers participated in this field study with a 2x2-factorial design, the factors being "conceptual knowledge" (with / without) and "multiple perspectives" (with / without). The case-material for the study was recorded in regular English lessons for intermediate learners. Authentic case sequences of 10 to 15 minutes were implemented in the computer-supported learning environment "Case Viewer" that was developed for this study based on the ideas of the CFT. Functions offered by the learning environment included video replay with standard video-player functions (e.g., stop, start, rewind, forward), but also the option to annotate the video cases.

The study was realized as a four-day university course for prospective foreign language teachers. The person conducting the courses was a full-time professional trainer for pre-service school teachers. He was trained on the basis of a facilitator script prior to the study to ensure standardized proceedings for all experimental groups. All participants were given two readers for their preparation two weeks before the training started: one reader introduced them to pedagogical models and theories of learning and instruction relevant to the cases, while the other reader explicated the importance of multiple perspectives for the understanding of learning and instruction processes. On day one, the participants were introduced to case-based learning within the scope of a lecture, before control variables and demographic data were assessed. After that, learners wrote the first case analysis without instructional support (pre-test). For the subsequent four training cases on days two and three, the experimental conditions were realized: the factor "conceptual knowledge" was varied by providing / not providing hyperlinks to pedagogical models and theories of learning and instruction, while the factor "multiple perspectives" was varied by providing / not providing hyperlinks to authentic statements of the teacher and learners from the video. For quantifying the dependent variable analytical competency, a complex coding scheme for the measurement of analytical competency was developed that incorporated its aforementioned three components. Regardless of the condition, learners analyzed each training case individually (40 min.) and in groups of three (65 min.). The small group interactions were recorded on video to investigate the learning processes. On day four, learners had to write another case analysis individually without instructional support (post-test).

Results and Conclusions

In the pre-post comparison (cf. Goeze, Zottmann, Schrader, & Fischer, 2010), individual learners drew on conceptual knowledge more often in the post-test case analyses when hyperlinks to conceptual knowledge were available to them, $F(1;92)=9.97$; $p<.01$; partial $\eta^2=.10$. Learners supported with hyperlinks to multiple perspectives adopted teacher and learner perspectives more often in the post-test than participants who did not have this support, $F(1;92)=6.04$; $p<.05$; partial $\eta^2=.06$. With respect to the learning processes observed in the small groups, particularly the multiple perspectives had an impact as they led to an increase of immersion, $F(1;92)=4.90$; $p<.05$; partial $\eta^2=.05$, but likewise to (marginally significant) sidetracking, $F(1;92)=3.01$; $p<.10$; partial $\eta^2=.03$. In summary, these results show that additional instructional support in the shape of hyperlinks to conceptual knowledge and multiple perspectives embedded in a computer-supported learning environment can increase the effectiveness of case-based learning by fostering specific components of analytical competency.

References

Fitzgerald, G., Koury, K., Mitchem, K., Hollingshead, C., Miller, K., Park, M. K., & Tsai, H. (2009). Implementing case-based instruction in higher education through technology: what works best? *Journal of Technology and Teacher Education, 17*(1), 31-63.

Goeze, A., Zottmann, J., Schrader, J., & Fischer, F. (2010). Instructional Support for Case-Based Learning with Digital Videos: Fostering Pre-Service Teachers' Acquisition of the Competency to Diagnose Pedagogical Situations. In C. Crawford et al. (Eds.), *Proceedings of the Society for Information Technology & Teacher Education (SITE) International Conference 2010* (pp. 1098-1104). Chesapeake, VA: AACE.

Goldman, R., Pea, R. D., Barron, B., & Derry, S. (Eds.). (2007). *Video research in the learning sciences.* Mahwah, NJ: Erlbaum.

Lundeberg, M. A., Levin, B. B., & Harrington, H. L. (Eds.). (1999). *Who learns what from cases and how? The research base for teaching and learning with cases* (pp. 3-23). Mahwah, NJ: Erlbaum.

Merseth, K. K., (1996). Cases and case methods in teacher education. In J. Sikula, T. J. Buttery, & E. Guyton (Eds.) *Handbook of Research on Teacher Education* (2nd ed., pp. 722-744). New York, NY: Macmillan.

Schrader, J. & Hartz, S. (2003). Professionalisierung - Erwachsenenbildung - Fallarbeit. In R. Arnold & I. Schüssler (Eds.). *Ermöglichungsdidaktik in der Erwachsenenbildung* (pp. 142-155). Baltmannsweiler: Schneider Verlag Hohengehren.

Spiro, R. J., Collins, B. P., Thota, J. J., & Feltovich, P. J. (2003). Cognitive flexibility theory: hypermedia for complex learning, adaptive knowledge application, and experience acceleration. *Educational Technology, 42*(5), 5-11.

Learning with interactive videos in history education[6]

Martin Merkt
Psychological Institute, University of Tübingen
Konrad-Adenauer-Str. 40, 72072 Tübingen, Germany
e-mail: m.merkt@iwm-kmrc.de

Sonja Weigand
formerly: Psychological Institute, University of Tübingen

Anke Heier
formerly: Psychological Institute, University of Tübingen

Stephan Schwan
Knowledge Media Research Center (KMRC)
Konrad-Adenauer-Str. 40, 72072 Tübingen, Germany
e-mail: s.schwan@iwm-kmrc.de

Abstract. The effectiveness of computer-administered interactive videos and an illustrated textbook was compared in two complementary studies in the field and in the laboratory when students learned complex contents in the domain of history. Two videos affording different levels of interactivity and a content-equivalent illustrated textbook were used. The common video was fit with features such as start / stop and browsing. The enhanced video additionally offered a table of contents and a register. The illustrated textbook also contained a table of contents and a register. In both studies, the interactive videos were at least comparable to the illustrated textbook, while the common video outperformed the enhanced video. Hence, interactivity not requiring search strategies involving the use of table of contents and register was more beneficial for learning than interactivity requiring such strategies. This finding is explained by a lack of familiarity with appropriate search strategies.

Keywords: interactive videos; learning with media; media comparison

Theoretical Background

National standards for history education mention videos as one crucial source for historical reasoning (Ministerium für Kultus, Jugend und Sport Baden-Württemberg, 2004). Additionally, videos are regularly used in German classrooms (Feierabend & Klingler, 2003). Therefore, videos can be seen as an important component of the instructional world students face today. Considering this, earlier findings that videos are inferior to written texts when it comes to learning complex contents (e.g., Furnham & Gunter, 1985; Walma van der Molen & van der Voort, 2000) are delicate. However, while the videos used in these studies were presented in a medium-controlled fashion, the written texts afforded several strategies such as re-reading difficult passages, browsing / skipping easy or unimportant passages and matching one's reading speed to one's individual cognitive needs, thus enabling active and self-regulated information processing (Furnham, de Siena, & Gunter, 2002). As these processes were shown to benefit learning (Coté, Goldman, & Saul, 1998), this explanation of earlier results can be considered a valid starting point for future research. What if videos are fit with interactive features such as start / stop, forward and rewind, thus affording more active and self-regulated processing of the contents? First studies using such interactive videos for learning to tie nautical knots yielded promising results (Schwan & Riempp, 2004).

In two studies, we tested whether interactive features such as start / stop, forward and rewind affording interactivity on a micro-level and table of contents and register affording interactivity on a macro-level improve learning with videos in a more cognitive-centered and complex domain. Therefore and because national standards for history education explicitly require the use of videos as a historical source, history was chosen as the domain for the current studies. It was assumed that the

[6] This research was supported by German Research Foundation (DFG) Grant Schw706/1-1.

additional implementation of features affording macro-level activities indeed proves to be beneficial for learning leading to a superiority of the media including features affording such activities.

Method

We used a combination of one field (with 162 subjects) and one laboratory study (with 60 subjects) to test our hypotheses. Subjects in both studies were students attending 11th to 13th grade of German grammar school. While the field study served to maximize ecological validity, the laboratory study was conducted to replicate the findings under a more controlled setting and to check whether the interactive features implemented in the videos are used while working with the different media.

To increase the comparability of the results, the same materials were used in both studies. Three content-equivalent media based on an educational video about post-war Germany under the occupation of the four Allies between 1945 and 1949 (FWU, 2003) were created: a common video, an enhanced video and an illustrated textbook. The two videos afforded different levels of interactivity. The common video offered its users familiar features such as start / stop as well as forward / rewind. These features mainly served to establish user interactivity on a micro-level regarding words, phrases or short paragraphs. The enhanced video additionally was fit with features such as a table of contents and a register. Further, forward and rewind were replaced by a slider affording more comfortable and precise browsing. Thus, the enhanced video afforded micro-level interactivity as described above and macro-level interactivity regarding easy navigation through different chapters or key concepts of the medium via table of contents and register. Both forms of interactive video were administered via computer. The illustrated textbook was created from the transcription of the video's audio track and screenshots from the video. It offered a table of contents and a register.

The procedure of the reported studies can roughly be divided into three blocks. First, demographic data and control variables such as interest and prior knowledge were assessed. Second, one of the media versions, a written source document and three open-ended questions (essays) that had to be answered using the medium were handed out to the participants. Third, knowledge and reading strategies were assessed. In the laboratory setting, all three blocks were applied in one session of maximum 3 hours. In the field, the three blocks were divided into two lessons (block 1 and 3) and a homework assignment (block 2) that had to be finished within one week between these lessons.

Results

AN(C)OVAs revealed no media differences for knowledge acquisition – as measured with a multiple choice test – in both studies (field: $M = 51.74$, $SD = 6.42$; $F(2, 6.41) = 1.56$, $p = .280$; laboratory: $M = 57.80$, $SD = 5.38$; $F<1$). The essays were coded by two independent raters for two indicators of learning: (1) the number of facts mentioned in the essays and (2) the distribution of these facts across the medium. For the number of facts, there was no main effect of medium in the laboratory ($M = 26.53$, $SD = 7.03$; $F<1$), however there was a main effect of medium in the field ($F(2,155) = 3.19$, $p=.044$): Bonferroni-adjusted post hoc tests revealed that the common video ($M = 19.18$, $SD = 8.22$) outperformed the enhanced video ($M = 15.54$, $SD = 8.73$; $p = .069$). The common video and the illustrated textbook ($M = 15.89$, $SD = 7.26$; $p = .154$), as well as the enhanced video and the illustrated textbook ($p = 1$) did not differ. For the distribution of facts across the medium, there was a main effect of medium in both studies (field: $F(2,154) = 6.61$, $p = .002$; laboratory: $F(2,57) = 4.82$, $p = .012$): again, Bonferroni-adjusted post hoc tests revealed that the common video (field: $M = 2.71$, $SD = .86$; laboratory: $M = 3.93$, $SD = .50$) was superior to the enhanced video (field: $M = 2.07$. $SD = 1.01$; $p = .013$; laboratory: $M = 3.28$, $SD = .74$; $p = .009$) in both studies. Additionally, the common video outperformed the illustrated textbook (field: $M = 2.03$, $SD = .96$; $p = .004$; laboratory: $M = 3.63$, $SD = .73$; $p = .474$) in the field study. There were no differences between the enhanced video and the illustrated textbook in neither of the two studies (field: $p = 1$; laboratory: $p = .301$).

In the laboratory study, log-files revealed that students spontaneously used the interactive features implemented in both videos. However, as the results for knowledge acquisition indicate, the use of features affording macro-level activities in videos did not benefit learning, as the enhanced video was outperformed by the common video.

Discussion

The reported studies do not support our hypothesis that interactive video features affording macro-level activities benefit learning. In contrast, the enhanced video affording both micro-level and macro-level activities was outperformed by the common video only affording micro-level activities. This finding could be explained by a lack of familiarity with underlying search strategies required for an efficient use of table of contents and register. Assuming a lack of such strategies is supported by the finding that the illustrated textbook didn't outperform any of the videos in any measure. Therefore, when implementing less familiar features, learners should be familiarized with the strategies underlying the use of the respective features before using the video for learning.

The studies present first evidence that interactivity in videos benefits learning in more cognitive-centered domains such as history. However, to gain stronger evidence for this claim, future research should test videos affording different levels of interactivity against non-interactive control conditions.

References

Coté, N., Goldman, S., & Saul, E. (1998). Students making sense of informational text: relations between processing and representation. *Discourse Processes, 25*, 1-53.

Feierabend, S., & Klingler, W. (2003). *Lehrer/-Innen und Medien 2003.* Medienpädagogischer Forschungsverbund Südwest.

Furnham, A., de Siena, S., & Gunter, B. (2002). Children's and adults' recall of children's news stories in both print and audio-visual presentation modalities. *Applied Cognitive Psychology, 16*, 191-210.

Furnham, A., & Gunter, B. (1985). Sex, presentation mode and memory for violent and non-violent news. *Journal of Educational Television, 11*, 99-105.

FWU Institut für Film und Bild in Wissenschaft und Unterricht (2003). *Sieger und Besiegte im Nachkriegsdeutschland 1945-1950* [Film]. Grünwald: FWU.

Ministerium für Kultus, Jugend und Sport Baden-Württemberg (2004). *Bildungsplan 2004: Allgemein bildendes Gymnasium.* Retrieved on 23.06.2009 from http://www.bildung-staerkt-menschen.de/service/downloads/Bildungsplaene

Schwan, S., & Riempp, R. (2004). The cognitive benefits of interactive videos: Learning to tie nautical knots. *Learning & Instruction, 14*, 293-305.

Walma van der Molen, J., & van der Voort, T. (2000). Children's and adults' recall of television and print news in children's and adult news formats. *Communication Research, 27*(2), 132-160.

Students' use of tools in content management systems: Towards a research framework

Griet Lust
Norma A. Juarez Collazo
Jan Elen
Geraldine Clarebout
Centre for Instructional psychology and technology, Katholieke Universiteit Leuven
A. Vesaliusstraat 2, B-3000 Leuven
Griet.Lust@ped.kuleuven.be; Norma.Juarez@ped.kuleuven.be; Jan.Elen@ped.kuleuven.be; Geraldine.Clarebout@ped.kuleuven.be

Abstract. Content management systems (CMS) are very popular in higher education, research about student's use of the CMS is however limited. The following review analyzes research on students' tool-use behavior in CMS. First a tool-classification system was developed based on literature regarding the educational implications of the CMS tools. Second studies investigating students' tool-use in CMS were analyzed. Results are discussed and compared with evidence gained in experimental settings. This lead to the development of a general research framework, addressing the important issues when investigating students' tool-use behavior in content management systems.

Keywords: content management system; pedagogical implications; tool-use

Introduction

Despite the high popularity of content management systems (CMS) in higher education, there is limited empirical evidence about students' behavior in those systems (Coates, James & Baldwin, 2005). CMS systems are claimed to offer an enriched learning experience by providing a rich toolset but little is known on how students act on the tools and the impact on learning. The problem about students' tool-use in a complex learning environment is widely addressed in the tool-use literature. Evidence is growing that the use of tools is problematic (Iiyoshi & Hannafin, 1998). Students differ in their tool-use and those differences have an impact on their learning (Liu & Bera, 2005). Although the results are mainly retrieved in experimental settings (Grabinger, 2008) and thus lack ecological validity, one can wonder why this assumption wouldn't be problematic in ecological contexts like CMS.

Given the popularity of CMS; the assumption of enriched learning; the learner control in benefitting from it and the evidence that tool-use is problematic in similar experimental settings, it is necessary to investigate students' tool-use in a CMS. A first step in investigating students' tool-use in CMS is to come up with a general research framework. This general research framework needs to be based on educational assumptions about CMS, tools in CMS and on first empirical evidence about tool-use behavior in CMS. On top, research frameworks in the experimental setting can be of great informative value in addressing the key issues when investigating students' tool-use behavior in CMS.

Methodology

A systematical search with three search engines –ERIC, Web of Science and PsychInfo- was done with sixteen descriptors (e.g. CMS AND use; CMS AND tools, CMS AND tool-use). The descriptors were broad, so the final selection was in hands of the researchers. Studies that focused on the educational implications of CMS, the educational implications of CMS tools and on the tool-use behavior of students were selected. In total, 31 studies were used for the analysis.

Results & Discussion

Theoretical evidence about tool-use in CMS

Nine studies explicitly addressed CMS tools and their pedagogical implications. Although they varied in their labels, they all gave similar functions to groups of tools. Detailed information about the tool classification that is retrieved and is used for analyzing the empirical evidence is given in table 2.

Table 2: *Tool classification CMS*

Static tools		Interactive tools	
Content delivery tools	What? Tools giving information about basic course information. Learning function? Multiple representations of the content (textual, aural, visual)	Assessment tools	What? Tools tracking the students' progress, managing the learning process or giving grades Learning function? Reflection, monitoring and engagement
Content elaboration tools	What? Tools elaborating on basic course information. Learning function? Deeper content exploration	Communication tools	What? Tools making interaction possible. Learning function? Support help-seeking
Administrative tools	What? Tools managing learning by giving general course information Learning function? Support the planning and the organization	Collaboration tools	What? Tools making collaboration possible. Learning function? Critical thinking, knowledge building,
Learning tools	What? Tools supporting learning in general or course-specific. Learning function? Supporting the learning process.		

Empirical evidence about tool-use in CMS

Research on how different tools in a CMS are used, their effects on performance and the conditions for effective use is limited. Seventeen studies were retrieved; they can be classified in three categories. The first category contains studies that focus on the general use of a CMS system and its relation with performance. Results are conclusive that the use of a CMS is positively related with the performance (DeNeui & Dodge, 2006).

The second category contains studies that investigate the use of a specific tool in consideration (Grabe & Christopherson, 2005). Finally, the last category implies studies that focus on the use of different tools in a CMS system (Hoskins & Van Hooff, 2005; Huon et al, 2007; Macfayden & Dawson, 2010). With respect to collaboration tools results reveal that students differ in their use; from no-use, over passive use to active use (Hoskins & Van Hooff, 2005). There is preliminary evidence that using these tools actively will lead to higher performance (Hammoud et al., 2008) and is influenced by students' personal study approach (Hoskins & Van Hooff, 2005). Evidence about using content delivery tools is limited, but seems to indicate that students differ in their moment of use (Grabe & Christopherson, 2005). Preliminary evidence exists that content elaboration tools are not very often used (Huon et al, 2007) suggesting that motivational reasons could be an influencing factor (Huon et al, 2007). Finally assessment tools are very often used by students (Hoskins & Van Hooff, 2005; Huon et al, 2007). Results are however inconclusive regarding the effects on performance (Hoskins & Van Hooff, 2005; Macfayden & Dawson, 2010).

Although results are incoherent and sometimes inconclusive, some preliminary conclusions can be drawn which is a first step towards a general research framework. First of all, the assumption that providing a rich tool-set results in an enriched learning experience is problematic. Students seem to differ in their tool-use and those differences have an impact on performance. Second, student variables seem to influence tool-use.

As stated in the introduction, the research question on students' tool-use is widely addressed in the tool-use literature. Although research is mainly focused on experimental settings, they share the same research concerns and constellations with the focus of this review. For this reason research models in the experimental setting can be informative for the ecological setting of content management systems. In general there is growing evidence that tool-use differences are so high that distinct tool-use patterns exist (Iiyoshi & Hannafin, 1998; Liu & Bera, 2005). Those patterns are influenced by affective, cognitive, metacognitive and motivational student variables and have an impact on performance (Elen & Clarebout, 2006). Assuming that tool-use is mediated by help-seeking, similar insights can be given. Different types of help-seeking exist, the type has an impact on the performance and is influenced by student variables (Aleven & Koedinger, 2000).

Conclusion

Results from the analysis legitimate the fact that tool-use in the ecological setting of CMS is something problematic and needs a serious research agenda. This lead to an attempt in giving a general research framework on tool-use in content management systems as visualized in figure 1.

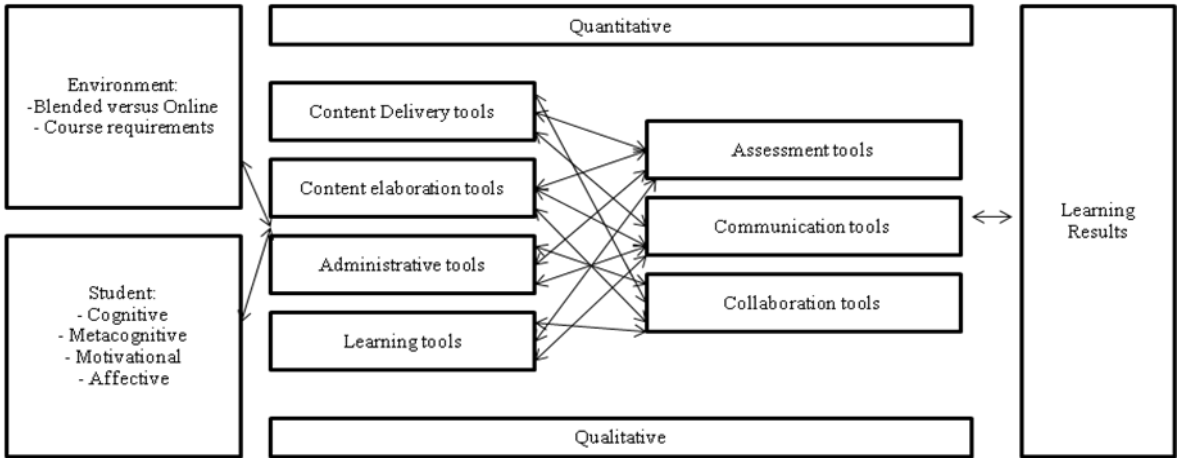


Figure 1. Research framework

References

Aleven, V., & Koedinger, K. R. (2000). Limitations of student control: do students know when they need help? In *Lecture Notes in computer science* (pp. 292-303). Heidelberg: Springer Berlin.

Coates, H., James, R., & Baldwin, G. (2005). A critical examination of the effects of learning management systems on university teaching and learning. *Tertiary Education and Management* , 11, 19-36.

DeNeui, D. L., & Dodge, T. L. (2006). Asynchronous learning networks and student outcomes: the utility of online learning components in hybrid courses. *Journal of instructional psychology* , 33 (4), 256-259.

Grabe, M., & Christopherson, K. (2005). Evaluating the advantages and disadvantages of providing lecture notes: the role of internet technology as a delivery system and research tool. *Internet and Higher education* , 8 (4), 291-298.

Hoskins, S. L., & van Hooff, J. C. (2005). Motivation and ability: which students use online learning and what influence does it have on their achievement? *British journal of educational technology* , Vol. 36, (2), 177-192.

Huon, G., Spehar, B., Adam, P., & Rifkin, W. (2007). Resource use and academic performance among first year psychology students. *Higher education* , Vol. 53, 1-27.

Iiyoshi, T., & Hannafin, M. J. (1998). Cognitive tools for open-ended learning environments: theoretical and implementation perspectives. *Annual meeting of the American Educational Research association*, (p. 11p). San Diego, CA.

Liu, M., & Bera, S. (2005). An analysis of cognitive tool use patterns in a hypermedia learning environment. *ETR&D* , Vol. 53,(1), 5-21.

Macfayden, L. P., & Dawson, S. (2010). Mining LMS data to develop an "early warning" system for educators: A proof of concept. *Computers & Education* , 54 (2), 588-599.

Which individual characteristics facilitate knowledge transfer in e-learning?

Birgitta Kopp
Ludwig-Maximilians-University, Leopoldstraße 13, 80802 Munich, Germany
birgitta.kopp@psy.lmu.de

Heinz Mandl
Ludwig-Maximilians-University, Leopoldstraße 13, 80802 Munich, Germany
heinz.mandl@psy.lmu.de

Laura Gunkel
Ludwig-Maximilians-University, Leopoldstraße 13, 80802 Munich, Germany
laura.gunkel@psy.lmu.de

Abstract. Transfer in e-learning contexts is a very important topic as learning is only successful when transfer takes place. There are many different models on learning transfer which focus mainly on three factors: organizational factors, training design factors and learner-related factors. These three factors have a direct impact on transfer. This study focuses on the individual characteristics of the learner, namely learner's motivation, expectations and emotions, as well as the learning outcome and how these relate to learning transfer. Twenty-nine individuals who participated in an e-learning course completed a questionnaire on individual characteristics, learning outcome, and learning transfer. Results showed that especially transfer motivation and learning outcome influence transfer, while the correlations between expectations and transfer and between emotions and transfer are small. Thus, the intention to transfer knowledge to practice and the acquired knowledge are the key factors for transfer.

Keywords: Transfer; learning outcome; transfer motivation; expectations; emotions.

Theoretical framework

Transfer is a very important topic in every kind of learning as the sustainable use of knowledge is only guaranteed when the learned and acquired knowledge is applied in different contexts so that transfer takes place. Transfer of learning is defined as the extent of retention and application of the knowledge, skills and attitudes from the training environment to the workplace environment (Subedi, 2004). Thus, transfer is a main indicator of the success of learning. But how can transfer be increased? Which factors actually influence learning transfer?

There are several models which explain learning transfer, e. g. the model of Baldwin and Ford (1988), the integrative transfer model of Rank and Wakenhut (1998), and the learning transfer system of Choi and Ruona (2008). In all of these models, there are mainly three different factors which affect learning transfer, namely organizational or workplace related factors, training design and delivery related factors and learner-related factors (Subedi, 2004).

Organizational or workplace-related factors include the post-training transfer environment, supervisory behaviors, the opportunity to practice, or the perceived level of supervisor support. The training design and delivery-related factors consist of job/task relevance, the design of the training, methods and mode of training delivery or technology and instructional techniques. Learner-related factors include, among other things, the learner's pre-knowledge, skills and attitudes, motivation, expectations, and emotions. Furthermore, the learning outcome has also a direct impact on transfer. In this study, we will focus on learner-related factors, especially motivation, expectations and emotions, and learning outcome, even though the other factors were also evaluated.

Motivation is specified as transfer motivation. This is the desire or the intention to transfer the acquired knowledge to a specific situation, problem or task in the workplace. Initiating transfer means the "attempts to apply any aspect of the learning to the work environment" (Foxon, 1993, p. 132). Transfer motivation is a main antecedent for transfer and thus may influence transfer (Foxon, 1993).

Expectations relating to opportunities to apply the acquired knowledge to workplace tasks and situations may influence transfer. Research showed a positive correlation between fulfilling expectations and post-training attitudes (Tannenbaum, Mathieu, Salas, & Cannon-Bowers, 1991).

Positive emotions during the learning process stimulate curiosity or confidence for the learning content, while a negative mood reduces knowledge acquisition and the understanding of logical structures (Brand, Reimer, & Opwis, 2007). Thus, emotions may also influence transfer.

Research Question

There are several factors that influence transfer in e-learning. In this study, we will specifically focus on two main questions:

1. "To what extent does learning outcome influence transfer in e-learning?"
2. "To what extent do individual characteristics (motivation, expectations, and emotions) influence transfer in e-learning?"

Method

Object of investigation

The object of investigation was the e-learning course "E-Tutors VHB" which took place in the summer term 2009 at the University of Munich. In this course, the key content for e-tutors was delivered virtually. Participants were asked to work through the material and solve cases in collaboration with other participants.

Sample and Design

Forty-eight participants of the online course „E-Tutors VHB" were asked to complete a questionnaire on their learning transfer. Twenty-nine individuals answered the questionnaire, which is a return rate of 60.4 per cent. 18 participants were female (62.1%), 11 male (37.9%). Almost half of the participants were university lecturers and scientific university researchers.

Data Sources

A specific questionnaire was developed to gain insights into individual characteristics, learning outcome, and learning transfer. Learners were surveyed using a five-point Likert scale with 1 "agree not at all" and 5 "totally agree". Transfer motivation included three items (e.g. "I was motivated to transfer the acquired knowledge to practice after the training."), expectations included three items (e.g. "My expectations regarding the online course were totally fulfilled."), and emotions included two items (e.g. "I liked working with the modules."). Cronbach's Alpha was .71 for transfer motivation, .82 for expectations and .69 for emotions. The section on learning outcome contained 5 items (e.g. "I acquired a lot of knowledge in the online course.") with a Cronbach's Alpha of .68. Learning transfer had 18 items (e.g. "I applied my experiences of the online course in my own online project."). Cronbach's Alpha was .94.

Results

Descriptive data

Transfer motivation (M=4.42; SD=.61), expectations (M=3.91; SD=0.63), and emotions after the e-learning training (M=4.45; SD=.63) were evaluated positively. The learning outcome was also evaluated positively with a mean of M=3.86 (SD=.65) as well as the overall transfer with M=3.73 (SD=.75).

Correlations

First of all, the correlation between learning outcome and learning transfer was calculated. The medium correlation was highly significant with r=.45 (p<.01). Regression analyses show also a significant influence of learning outcome on transfer (β=.45; B=.52; $SE\ B$=.20; t=2.62, p<.05).

Regarding the correlations between individual characteristics and transfer, we obtained the following results: Transfer motivation and transfer was calculated using a regression analyses. This showed a significant influence of transfer motivation on transfer (β=.64; B=.79; $SE\ B$=.20; t=4.02; p<.001). Correlating expectations with transfer showed no significant effect (r=.29, p=.12). Furthermore, the correlations between emotions and transfer showed also no significant effect (r=.19, p=.317). There was a significant correlation between emotions and learning outcome with r=.39 (p<.05) and between transfer motivation and learning outcome (r=.41, p<.05).

Discussion

In terms of the factors that influence transfer in an e-learning environment, it was clear that especially transfer motivation and learning outcome have an impact on transfer in the workplace. This result confirms the importance of motivation and learning outcome in face-to-face learning contexts. This concept is highly important to transfer, since transfer motivation is also correlated with learning outcome. Further analyses show that transfer motivation is a mediator for learning outcome and transfer. The more learners intend to apply the learned content to practice, the more they acquire knowledge and the more they transfer this knowledge to their workplace. Thus, transfer motivation is a key predictor for learning outcome and for transfer. Expectations and emotions showed no significant, but positive correlations. And it seems that emotions are also indirectly important for transfer as they correlate positively with the learning outcome. Further studies with a greater sample may show more sophisticated results.

References

Baldwin, T.T. & Ford, J.K. (1988). Transfer of training: A Review and directions for future research. Personnel Psychology, 41, 63-105.

Brand, S., Reimer, T. & Opwis, K. (2007). How do we learn in a negative mood? Effects of a negative mood on transfer and learning. Learning and Instruction, 17, 1-16.

Choi, M. & Ruona, W. (2008). *An Update on the Learning Transfer System*. Paper presented at the Academy of Human Resource Development International Research Conference in the Americas, Panama City, FL. Verfügbar unter http://www.eric.ed.gov/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/80/3d/ea/d7.pdf [20.01.2010].

Foxon, M (1993). A process approach to the transfer of training. Australian Journal of Educational Technology, 9 (2), 130-143.

Rank, B., & Wakenhut, R. (1998). *Sicherung des Praxistransfers im Führungskräftetraining*. München/Mering: Rainer Hampp.

Subedi, S. B. (2004). Emerging trends of research on transfer of learning. International Education Journal, 5(4), 591-599.

Tannenbaum, S., Mathieu, J., Salas, E. & Cannon-Bowers, A. (1991). Meeting Trainees' Expectations: The Influence of Training Fulfillment on the Development of Commitment, Self-Efficacy, and Motivation. Journal of Applied Psychology, 76 (6), 759-769

Effects of internet-specific epistemic beliefs and search interface design on the selection of Web search results

Yvonne Kammerer
Peter Gerjets
Knowledge Media Research Center, Konrad-Adenauer-Str. 40, 72072 Tübingen, Germany
y.kammerer@iwm-kmrc.de; p.gerjets@iwm-kmrc.de

Abstract. This study examined how internet-specific epistemic beliefs and the interface design of search engines influence students' evaluations and selections of search results during Web search on a medical topic. Results revealed that as compared to a standard Google-like list interface, in a tabular interface with search results grouped according to objective, subjective, and commercial information, university students fixated less on commercial search results. Furthermore, they selected objective search results more often and commercial ones less often than in the list format. In addition, the epistemic belief that the Web provides certain and true knowledge was related to an increased selection of objective search results in the list interface, and to a reduced selection of subjective search results in the tabular interface.

Keywords: Web search; epistemic beliefs; search interface design; quality evaluations.

Introduction

In recent years, the World Wide Web (WWW) has evolved into a major information source for research on (controversial) science-related topics, for example in the domain of medicine and health care. Due to the relatively low barriers to publishing content on the WWW, the quality of Web information, however, varies greatly. Besides scientifically sound, objective information, the Web also provides Websites with subjective opinions and personal experiences or commercial information. Despite this fact, in the results lists returned by search engines such different types of information sources are usually presented mixed together. Moreover, in many cases popular commercial or social Websites that may be doubtful with regard to authors' motives or expertise are listed among the highest-ranked search results. Accordingly, in order to avoid the selection and use of incomplete, biased, or even false information, Web users may not only be required to critically evaluate the topical relevance of search results but also their quality. Previous research, however, has shown by means of think alouds, eye-tracking, and selection data that searchers usually rely on the ranking offered by the search engine. They predominantly select the search results presented in the top of the search engine results page (SERP) and only rarely utter evaluation criteria with regard to information quality (e.g., credibility, trustworthiness, reliability), even during Web search for controversial topics (e.g., Gerjets, Kammerer, & Werner, in press).

In this paper, we examine two potential moderators of quality evaluations during Web search: personal epistemology and the interface design of SERPs. Recent findings suggest that epistemic beliefs, that is, people's personal beliefs about the nature of knowledge and knowing (Hofer, 2004), play an important role in source evaluations during Web search on controversial topics. For instance, it has been demonstrated that searchers with naïve epistemic beliefs (e.g., knowledge consists of certain and unchanging facts, provided by authorities) are rather uncritical and do not reflect on the credibility and accuracy of the sources they inspect, whereas searchers with sophisticated beliefs (e.g., knowledge is contextual, evolving, derived through reasoning) are more critical Web users (e.g., Hofer, 2004). With regard to internet-specific epistemic beliefs (Strømsø & Bråten, 2010), results by Kammerer and Gerjets (2010a) indicate that more naïve beliefs, for example that the Web provides certain and true knowledge, were related to less source monitoring during Web search. The interface design of SERPs might be a second factor affecting quality evaluations. Search result descriptions of standard search engines such as Google are mostly confined to topic information, whereas quality-related source information is rather sparse and non-salient. Furthermore, the typical list format of SERPs suggests processing the results from top to bottom. Thus, the standard search interface might not provide sufficient affordances to engage in quality evaluations. Studies investigating the possible effects of

additional quality cues, such as information about the type of source of the Web page or the number of ads in a Web page, on the evaluation of search results are still rare but yield promising results (see Kammerer, Wollny, Gerjets, & Scheiter, 2009 for a review). Besides providing quality cues, another approach to stimulate quality evaluations is to change the spatial layout of the search results, thereby increasing the awareness of the selection process. A study by Kammerer and Gerjets (2010b) showed that the presentation of search results in multiple rows and columns (grid interface) as compared to a standard list interface caused a more equal attention distribution across all search results on a SERP and increased the selection of trustworthy search results.

The present study investigated whether an interface with an alternative tabular layout of search results and additional quality cues (indicating the type of information) stimulates the search for and the selection of high quality information as compared to a standard list interface. In addition, the study examined the impact of searchers' internet-specific epistemic beliefs on their evaluation and selection behavior on SERPs as well as interactive effects between search interface design and epistemic beliefs.

Method

Participants, who were 58 German university freshmen (mean age: 20.52, 83% female) from different majors were given the task of seeking information on the WWW about two competing therapies for Bechterew's disease in order to give informed advice to a fictitious friend. To complete the experimental task, participants were provided with two prearranged SERPs, each containing nine search results linked to offline Web pages. The search results were either presented in a Google-like list interface or in a tabular interface with the search results being grouped in three columns labeled as objective information (e.g., a scientific article), subjective information (e.g., a forum discussion), and commercial information (e.g., information provided by the pharma industry). Participants were randomly assigned to the two interface conditions. To avoid order effects, for each participant the search results in the list or in the columns were presented in random order and in the tabular interface the order of the columns was permuted. Participants' eye movements and mouse clicks were registered during task performance, which was limited to eight minutes. One week after the experiment participants were administered the *Internet-Specific Epistemological Questionnaire (ISEQ;* Bråten, Strømsø, & Samuelstuen, 2005). In line with prior work, the dimension "certainty and source of knowledge" (8 items; Cronbach's $\alpha = .72$) was used as continuous factor in the present study. High scores represented the view that certain knowledge and right answers are to be found on the Web, and low scores indicated that participants are more likely to doubt that the Web is a good knowledge source that provides certain knowledge.

Results

Results of an ANCOVA showed a significant interaction between interface (list vs. tabular) and search result type (objective, subjective, or commercial search results) on the total time for which search results were fixated ($F(2, 110) = 3.53$, $p < .05$). Post hoc tests revealed that in the tabular interface commercial search results were fixated significantly shorter than in the list interface ($p < .05$). Furthermore, with regard to the number of selected search results the ANCOVA showed a main effect of search result type ($F(2, 108) = 67.56$, $p < .001$) and an interaction between interface and search result type ($F(2, 108) = 3.93$, $p < .05$). In both interfaces objective search results were selected most often, and commercial search results least often. Moreover, as compared to the list interface in the tabular interface objective search results were selected marginally significantly more often ($p = .057$) and commercial search results significantly less often ($p < .05$). In addition, there were significant interactions between search result type and internet-specific epistemic beliefs ($F(2, 108) = 3.90$, $p < .05$) and between interface and internet-specific beliefs ($F(2, 108) = 8.90$, $p < .01$). For the list interface correlation analyses revealed a positive relationship between beliefs that the Web provides

certain and true knowledge and the selection of objective search results (r = .39, p = .056). Instead, for the tabular interface a negative relationship between such beliefs and the selection of subjective search results was shown (r = -.56, p < .01).

Conclusions

Taken together, results from this study indicate that a tabular interface which presents search results grouped according to different types of information sources seems to support the selection of neutral, high quality information and the disregard of commercial information. Interestingly, in contrast to previous findings, however, results of the present study also indicate that at least today's university freshmen may have developed a certain awareness concerning the high variability of information quality on the Web, as in the standard list interface they also selected significantly more search results linked to objective information than to subjective or commercial information. Furthermore, contrary to previous findings, results indicate that students with the belief that the Web contains certain and true knowledge (traditionally considered to be a naïve belief), in the present study showed a rather sophisticated Web selection behavior, as in the standard list interface they selected more search results linked to objective information. This finding raises the question of whether beliefs traditionally labeled naïve may actually be adaptive in certain contexts. Future research thus should aim at investigating in detail under which circumstances a certain internet-specific epistemic belief of a person with a certain background should be considered naïve or sophisticated (cf. Strømsø & Bråten, 2010).

References

Bråten, I., Strømsø, H.I., & Samuelstuen, M.S. (2005). The relationship between Internet-specific epistemological beliefs and learning within Internet-technologies. *Journal of Educational Computing Research, 33*, 141-171.

Gerjets, P., Kammerer, Y., & Werner, B. (in press). Measuring spontaneous and instructed evaluation processes during Web search: Integrating concurrent thinking-aloud protocols and eye-tracking data. *Learning & Instruction.*

Hofer, B.K. (2004). Epistemological understanding as a metacognitive process: Thinking aloud during online searching. *Educational Psychologist, 39,* 43-55.

Kammerer, Y., & Gerjets, P. (2010a, March). Searching the Web for science-related information: The impact of evaluation instructions, user characteristics, and search interface design on evaluations of information quality. Seminar on Computational Cognitive Modeling of Web-Navigation. Utrecht, The Netherlands.

Kammerer, Y., & Gerjets, P. (2010b). How the interface design influences users' spontaneous trustworthiness evaluations of Web search results: Comparing a list and a grid interface. In C. Morimoto, & H. Instance (Eds.), *Proceedings of the 2010 Symposium on Eye Tracking Research & Applications ETRA '10* (pp. 299-306). New York, NY: ACM.

Kammerer, Y., Wollny, E., Gerjets, P., & Scheiter, K. (2009). How authority-related epistemological beliefs and salience of source information influence the evaluation of web search results: An eye tracking study. In N.A. Taatgen & H. van Rijn (Eds.), *Proceedings of the 31st Annual Conference of the Cognitive Science Society* (pp. 2158-2163). Austin, TX: Cognitive Science Society.

Strømsø, H.I., & Bråten, I. (2010). The role of personal epistemology in the self-regulation of internet-based learning. *Metacognition and Learning, 5*, 91-111.

Fostering Online Search Competence With Classroom And Small-Group Scripts In Web-based Inquiry Learning

Ingo Kollar
Department Psychology, Ludwig-Maximilians-University (LMU) München
Leopoldstr. 13, 80802 Munich, Germany
Email: ingo.kollar@ psy.lmu.de

Christof Wecker
Department Psychology, Ludwig-Maximilians-University (LMU) München
Leopoldstr. 13, 80802 Munich, Germany
Email: christof.wecker@ psy.lmu.de

Sybille Langer
Department Psychology, Ludwig-Maximilians-University (LMU) München
Leopoldstr. 13, 80802 Munich, Germany
Email: sybille.langer@ psy.lmu.de

Frank Fischer
Department Psychology, Ludwig-Maximilians-University (LMU) München
Leopoldstr. 13, 80802 Munich, Germany
Email: frank.fischer@ psy.lmu.de

Abstract. Online search competence can be regarded as an important component of scientific literacy which needs to be facilitated during secondary education. This study investigated the effects of a small-group collaboration script (present vs. not present) and two versions of a classroom script on the acquisition of online search competence during a five weeks inquiry-based curriculum unit on Genetic Engineering. The two classroom scripts differed in the way they distributed learning activities over the plenary and the small group level (small-group level only vs. alternations between small-group and plenary activities) Results indicated that the classroom script that alternated online search activities on the plenary and the small-group level led to the highest level of online search competence in the posttest, but only without the small-group collaboration script. Thus, distributing learning activities over the different social planes of the classroom can make further scaffolds for small-group collaboration obsolete.

Keywords: scientific literacy; small-group collaboration scripts; classroom scripts; inquiry learning; CSCL.

Introduction

The development of scientific literacy can be regarded as an important goal of secondary education (Laugksch, 2000). It is needed to form well-grounded positions in societal debates on science issues, such as whether pre-implantation diagnostics should be allowed or not. One way to develop such well-grounded positions is to search the Internet for relevant information. However, finding information that is relevant, credible and scientifically sound is a challenging task for high school students.

One promising approach to foster high school students' online search competence is (web-based) inquiry learning (Slotta & Linn, 2009). During inquiry learning, students are supposed to engage in similar activities as scientists to solve a science problem or to form a well-grounded position in a science-related debate. Yet, as research has repeatedly shown, inquiry learning needs to be properly scaffolded (de Jong, 2006). When realized within a classroom setting, at least the following two types of scaffolds can be distinguished: (a) scaffolds on the classroom level (e.g., classroom scripts that distribute learning activities over the different social planes of the classroom such as plenary level, small-group level, individual level; see Dillenbourg & Jermann, 2007) and (b) scaffolds on the small-group level (e.g., collaboration scripts that specify, sequence and distribute learning activities and roles among the members of a small group; see Kollar, Fischer & Hesse, 2006).

This study examined the effects of a small-group collaboration script (present vs. not present) and two different classroom scripts (online search to be conducted in small-groups only vs. alternately on the small-group and the plenary level) and their different combinations. We expected the combination

of a small-group collaboration script and a classroom script that alternated search activities on the plenary and the small-group level to best help students acquire online search competence.

Method

Participants and setting. 174 9th graders from eight classes from urban high schools participated. 90 students were female, 84 students were male. The study was conducted within regular Biology lessons which were led by the regular Biology teachers of the classes, who were trained to implement the respective experimental conditions (see below). Learners were equipped with laptops and worked on a web-based inquiry learning curriculum unit on Genetic Engineering. The main task was to develop a well-grounded position towards the question whether Genetic Engineering should be allowed or not. The learning phase spanned seven regular Biology lessons and consisted of three content-specific cycles (economic, ecological, and health aspects of Genetic Engineering) with three sub-steps each. In the first sub-step, dyads worked through an online library that contained domain-specific information on Genetics and Genetic Engineering. Then, an online search took place (either on the small-group or alternately on the small-group and the plenary level, see below). Finally, each cycle finished with a classroom discussion on the students' arguments that resulted from the preceding online search.

Design. We realized a 2x2-factorial design (see table 1) with the factors "small-group collaboration script" (present vs. not present) and "type of classroom script" (small-group level only vs. alterations between small-group and plenary level). Classes were randomly assigned to conditions.

Table 1: Design of the empirical study.

		Type of classroom script	
		Small-group level only	Alterations btw. small group and plenary level
Small-group collaboration script	Without	N = 43 students (2 classes)	N = 28 students (2 classes)
	With	N = 52 students (2 classes)	N = 51 students (2 classes)

Independent variables. Both treatments were realized during the online search phases. In all groups, a software tool called S-COL (Wecker et al., in press) was used to allow for collaborative browsing. I.e., during their online search processes, the laptops of the two co-present partners of a dyad were connected so that the browser displayed identical web pages on both screens, no matter who of the two learners had accessed them. The *small-group collaboration script* was realized as an S-COL plug-in, which segmented the browser window into two frames (a scaffolding frame and the regular browser frame). In the scaffolding frame, S-COL displayed prompts related to the actual step in the search process (Google start page, Google hit list, chosen web site) and distributed them among the two learning partners. For example, when being on a Google hit list, the scaffolding frame displayed prompts such as "Suggest a link which from your perspective is likely to contain valuable information" to one learner and "Listen to your partner's suggestion and estimate whether the link s/he suggested is (a) credible, (b) relevant and (c) scientifically grounded" to his/her learning partner. In the conditions without the small-group collaboration script, these prompts were not visible.

The particular *type of classroom script* was also realized during the online search phases. In the classroom script that located online search activities solely at the small-group level, online search was to be conducted in dyads. In the classroom script that alternated search activities between the small-group and the plenary level, single steps were modeled in front of the class before this activity was to be conducted on a dyadic level.

Dependent variable and control variable. The dependent variable *online search competence* was measured by the students' performance in an individual test. This test asked them to describe in as much detail as possible, how they would use the Internet to form a position concerning the question

whether nuclear power plants should be abandoned. 15 % of the resulting data were analyzed by two independent coders. Coding was based on a coding scheme that captured adequate steps and important quality characteristics during successful online search. Intra-class correlation was sufficient (*ICC* = .83). An analogous test on a different topic was used as a pretest (*ICC* = .51). Pretest scores were used as a control variable for the subsequent statistical analyses.

Results and discussion

An ANCOVA with post test online search competence as the dependent variable, the small-group collaboration script and type of classroom script as well as classes nested within the kinds of instructional support as independent variables, and the pretest online search competence as a covariate showed a significant interaction effect ($F(1,165) = 12.41$; $p < .01$; partial $\eta^2 = .07$): If students worked under the conditions of a classroom script that alternated online search activities on a plenary and the small group level, adding a small group collaboration did not have further positive effects. However, the small group script was effective when the classroom script located online search activities solely on the small group level. Thus, it appears that modelling (as part of the classroom script alternating between the small group and the plenary level) can be regarded as a viable alternative to scripting small group collaboration. Combining both treatments, however, may have overwhelmed learners by having to follow the instruction and simultaneously perform high level online search processes. Further process analyses will be performed to confirm or disconfirm this interpretation.

References

de Jong, T. (2006). Technological advances in inquiry learning. *Science, 312,* 532-533.

Dillenbourg, P. & Jerman, P. (2007). Designing integrative scripts. In F. Fischer, I. Kollar, H. Mandl, & J. M. Haake (Eds.), *Scripting computer supported communication of knowledge: Cognitive, computational and educational perspectives* (pp. 275-301). New York: Springer.

Kollar, I., Fischer, F., & Hesse, F. W. (2006). Computer-supported collaboration scripts - a conceptual analysis. *Educational Psychology Review, 18*(2), 159-185.

Slotta, J. D. & Linn, M. C. (2009). *WISE Science: Web-based inquiry in the classroom.* New York, NY: Teachers College Press.

Wecker, C., Stegmann, K., Bernstein, F., Huber, M. J., Kalus, G., Rathmeyer, S., Kollar, I. & Fischer, F. (in press). A Copernican Turn for the development of flexibly re-usable scaffolds and collaboration scripts: The S-COL approach. *International Journal of Computer-Supported Collaborative Learning.*

Designing and empirically testing computer-supported collaborative learning for vocational education

Dr. Taiga Brahm
University of St. Gallen
Dufourstr. 40a, 9000 St. Gallen, Switzerland
taiga.brahm@unisg.ch

Abstract. The evolution of the networked society leads to new demands for educational institutions and companies such as increasing cooperation among employees or the spreading of communication technology. Accordingly, vocational education has to come up with new approaches to address these challenges. Research has shown computer-supported collaborative learning (CSCL) to be a suitable learning method, however, up to now, there is hardly any evidence of its usage in vocational education. This paper aims at narrowing this research gap by proposing a holistic CSCL approach suitable for vocational education and reporting on first experiences with this approach. The learning design was tested with 700 students in 135 teams. As a result, a tentative model of computer-supported collaborative learning in vocational education is proposed.

Keywords: computer-supported collaborative learning; vocational education; cooperative learning

The challenge of designing a CSCL environment for vocational education

"The goal of design in CSCL is to create artifacts, activities, and environments that enhance the practice of group meaning making" (Stahl et al., 2006, 417). Educational theory and research provide certain guidelines concerning the didactical design of CSCL environments. Such theoretically or empirically founded principles also informed the design of the CSCL environment for our context of vocational education:

- students play an active part in their own learning according to the constructivist paradigm (Neo, 2003, 463); thus, the student takes responsibility for his or her own learning process.
- interaction among learners and co-construction of meaning are crucial for the learning process as well (Woo & Reeves, 2007, 15).

It is noteworthy that putting learners into an active role does not imply the omission of instruction. In contrast, "some kind of additional structuring is needed to facilitate learning and interaction" (Dillenbourg & Fischer, 2008, 118). Such structuring can, for instance, be incorporated in the tools to be used for CSCL (e.g. Baker & Lund, 1997) or in collaboration scripts (e.g. O'Donnell & Dansereau, 1992). A simple method to provide structure is to design the task for the students accordingly.

The aims of this study were to design a CSCL environment suitable for vocational education and to empirically validate the design with a holistic model of team learning. For this purpose, a longitudinal study with three questionnaires was conducted. The data was analyzed using structural equation modeling with partial least squares (PLS) which resulted in a first model of computer-based team learning. Using this method of analysis, conditions for successful team learning could be identified.

The learning design in its context

When designing a CSCL environment, it is necessary to take the learners' context into account. Vocational education in Germany is first and foremost characterized by the combination of learning at school and at the workplace. In most apprenticeships in Germany, learners go to school for one or two days a week or for a certain amount of consecutive weeks each year. The rest of the time is spent within a company working as an apprentice in the chosen profession. In total, 700 apprentices from 10 different subsidiaries of the corporation participated in the study. The collaborative learning experience lasted for the first three months of their first year with the company (September to December). The students' task was to design a media product (e.g. a podcast, presentation slides) presenting relevant information for first year apprentices of their company. The task had to be fulfilled by using information and communication technology (ICT). The students had access to asynchronous collaboration tools (e.g. discussion forums, file sharing, e-mail, wikis and blogs) and could decide on

their own which tools to use. The team members were located across different subsidiaries in Germany. Co-location of more than one learner was avoided in order to make communication via ICT necessary. The average age of the students was 18.75 years. 65 percent were male, 35 percent female.

Methodology

The methodology of the study is a longitudinal design using online surveys. Data was collected on the pre-conditions for CSCL, the process, and the outcome. Instruments that were not yet available in German were translated using Brislin's (1980) back-translation method. According to the holistic model that formed the basis of this study, the constructs included (among others) learning style, motivation, group efficacy, team goals, team reflexivity, frequency of communication, cohesion, and trust. All instruments showed good reliabilities (between .79 and .94). Aggregation on the team level was possible since ICC values and $r_{wg(j)}$ were appropriate.

Results and discussion

The following figure shows the empirical model of team learning.

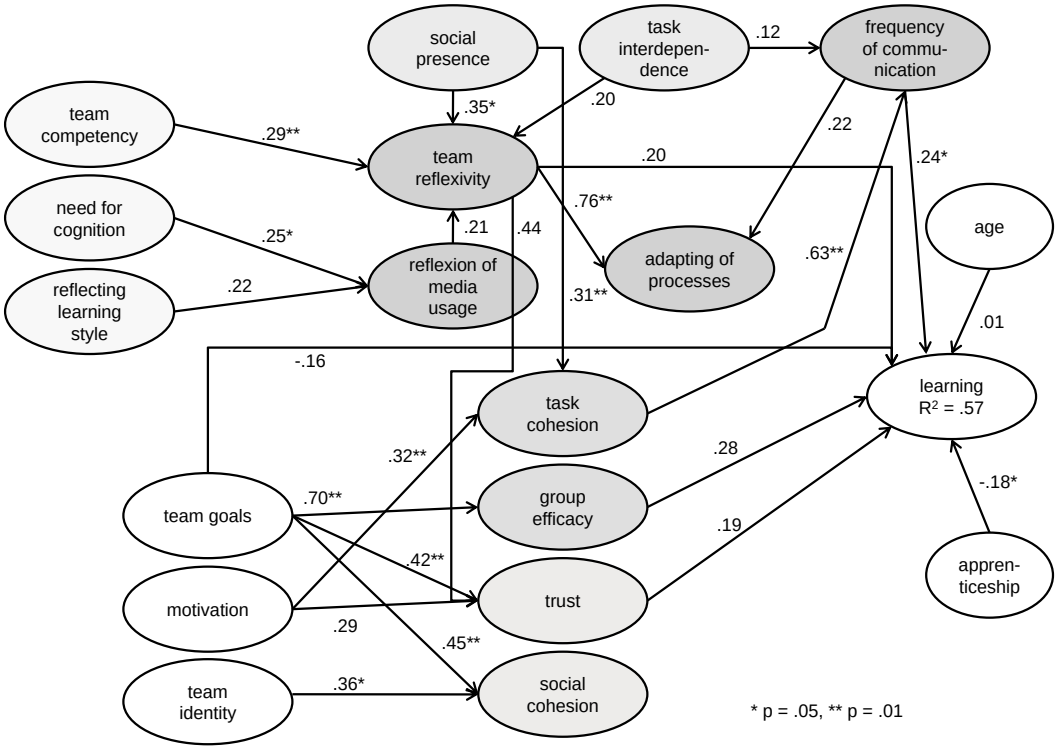


Figure 1. Model of team learning.

The figure shows that the relations between the process factors and the outcome (team learning) do not become significant. This is due to the fact that the model was calculated using team-based data – due to data restrictions a total of 50 teams could be included in the analysis. Nevertheless, the results show that group efficacy, the frequency of communication and team reflexivity are determinants for team learning in this particular context. Additionally, task cohesion and social presence seem to have indirect effects on learning.

Also in other CSCL studies, frequency of communication was identified as a major determinant for team learning (e.g. Harasim, 2003; Kreijns et al., 2003). The descriptive results of this study show that a major challenge of the CSCL environment was missing social interaction caused by organizational factors. For instance, the learners reported that they were not able to contact their co-learners in reasonable time. As mentioned above, the students are not only involved in their learning context, but they also work as part of their apprenticeship. Thus, some of them did not have the opportunity to

reply in a timely manner. Although the CSCL project was announced as part of their learning tasks, the students, when being in their working environment, did not seem to have the possibility to use their assigned learning time for the team project. Another organizational problem seemed to be the availability of the technology that the students used for their CSCL project.

Implications for practice and further research

A CSCL environment for vocational education and its evaluation were briefly described. The goal of the paper was to analyze which factors contribute to team learning in vocational education. *In general, CSCL seems to provide possibilities to enhance the learning design in vocational education. Learning goals such as the development of team competencies and the expanded usage of ICT, which are current issues in vocational education, could be supported by CSCL. Yet, since apprenticeships, especially when taking place at different locations (i.e. school and company), follow other organizational patterns than learning in schools or universities, care has to be taken with regard to the organizational context of the learning design. In a future design of the environment, it might be useful to employ a CSCL script (e.g. certain roles) to further enhance interaction among the learners.*

References

Baker, M., & Lund, K. (1997). Promoting reflective interactions in a CSCL environment. *Journal of Computer Assisted Learning, 13*(3), 175-193.

Brislin, R. W. (1980). Translation and content analysis of oral and written materials. In H. C. Triandis & J. W. Berry (Eds.), *Handbook of cross-cultural psychology* (Vol. 2, pp. 389-444). Boston, MA: Allyn & Bacon.

Dillenbourg, P., & Fischer, F. (2008). Basics of Computer-Supported Collaborative Learning. In D. Euler, G. Pätzold & S. Walzik (Eds.), *Kooperatives Lernen in der beruflichen Bildung* (Vol. 21, pp. 111-130). Stuttgart: Franz Steiner Verlag.

Harasim, L. (2003). What makes online learning communities successful? In C. Vrasidas & G. V. Glass (Eds.), *Distance education and distributed learning* (pp. 181-200). Greenwich, CT: Information Age Publishing.

Kreijns, K., Kirschner, P. A., & Jochems, W. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: a review of the research. *Computers in Human Behavior, 19*(3), 335-353.

Neo, M. (2003). Developing a collaborative learning environment using a web-based design. *Journal of Computer Assisted Learning, 19*, 462-473.

O'Donnell, A. M., & Dansereau, D. F. (1992). Scripted Cooperation in Student Dyads: A Method for Analysing and Enhancing Academic Learning and Performance. In R. Hertz-Lazarowitz & N. Miller (Eds.), *Interaction in cooperative groups: the theoretical anatomy of group learning.* (pp. 120-141). Cambridge: Cambridge University Press.

Stahl, G., Koschmann, T., & Suthers, D. (2006). Computer-supported collaborative learning. In R. K. Sawyer (Ed.), *Cambridge Handbook of the Learning Sciences* (pp. 409-426). Cambridge et al.: Cambridge University Press.

Woo, Y., & Reeves, T. C. (2007). Meaningful interaction in web-based learning: A social constructivist interpretation. *Internet and Higher Education, 10*(1), 15-25.

Exploring the Functionality of Different Tools in a Learning Environment

Norma A. Juarez Collazo,
Griet Lust,
Jan Elen,
Geraldine Clarebout
Centre for Instructional Psychology and Technology
Katholieke Universiteit Leuven
Andreas Vesaliusstraat 2 box 3770, 3000 Leuven, Belgium
Norma.Juarez@ped.kuleuven.be; Griet.Lust@ped.kuleuven.be; Jan.Elen@ped.kuleuven.be; Geraldine.Clarebout@ped.kuleuven.be

Abstract. This study on the perceived functionality of tools first investigated the effect of tool use on performance to check whether tools were functional. Second, learners' perceived functionality of tools and the determinants of this perception. Learners had to complete a psychomotor task by building a LEGO® figure with help of a tool depending on the condition. Two tools were used: a video with intentionally low functionality demonstrating the figure assembly, and a step-by-step guideline with visual instructions. There were three experimental conditions: guideline (G), video (V) and both tools (GV) condition; and one control condition (C). Results revealed that the tools were proven to be functional (G) and (V) conditions significantly outperformed the (C) condition. Regarding perceived functionality, all learners perceived tool functionality in the (GV) condition, thus chose a tool, but did not identify the most functional one (V). No significant difference between conditions and learners' characteristics was found.

Keywords: tool use; tool functionality; learning environment; performance; metacognition; self-efficacy; GEFT.

Introduction

Tools are opportunities offered in learning environments that work as aids to enhance learning (Baber, 2006). However, providing tools to learners is not sufficient to help learners succeed. Learners have to grasp the opportunity offered by the tools (Perkins, 1985), and when they grasp the opportunity they will have to use the tool as intended by the designers (Elen & Clarebout, 2006). Cognitive, metacognitive and motivational variables have been found to influence this tool use (e.g. Aleven, Stahl, Schworm, Fischer, & Wallace, 2003). Additionally, in line with the TAM model (Davis, Bagozzi & Warshaw, 1989), the *perceived functionality* (one's beliefs that using a certain tool would enhance his/ her performance in order to reach a goal) seems to influence tool use. However, not only learner variables influence tool use behavior, but also some tool-related variables, such as the actual *tool functionality* and tool type (e.g. Clarebout & Elen, 2006). Therefore, learner variables and tool characteristics seem to be factors influencing tool use. In the present study, the focus is on the tools functionality and perceived tool functionality. First, the effect of tool use on performance is studied to determine whether or not the tool is functional. Second, by providing different tool options and analyzing choices made, perceived functionality is assessed.

Method

Fifty-eight first-year master students in Educational Studies (74% female), on average 23 years old (*SD*=3.51) participated in this study. They had to complete a psychomotor task which involved the making of a LEGO®[7] figure in a learning environment. To do this, they were provided with two main tools: a guideline and a video. The design of the tools was based on the assumption that the video would be the least functional and the guideline the most functional. The video showed at a high pace the building of the LEGO® figure without pause or spoken instructions. Learners were not allowed to pause, stop, forward or rewind it; they could only watch it as many times as they could or wanted to and/or leave it in the last frozen image. The guideline had step-by-step visual instructions and learners could use it freely. By doing this, we also intended to see if students could detect the functionality of

[7] LEGO® is a line of construction toys manufactured by the Lego Group, a company based in Billund, Denmark.

the tool when they were provided with both tools or a single one. Thus, there were three experimental conditions: with guideline (G), video (V) and both tools (GV); and a control (C) condition –no tools-.

Because of the nature of the psychomotor task, perceptual styles ranging from field-dependence to field-independence were considered and measured through the Group Embedded Figures Test (GEFT) (Oltman, Raskin, & Witkin, 2003). Besides, since previous research has provided evidence of the effect of learners' variables on tool use (Aleven et al., 2003; Clarebout & Elen, 2006), we controlled for metacognition and self-efficacy. Metacognition was measured through the metacognitive awareness inventory (MAI) (Schraw & Dennison, 1994), and self-efficacy through an adaptation of Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, & McKeachie, 1991) and the Self- and Task-Perception Questionnaire (STPQ) (Lodewyk & Winne, 2005).

The study was done in two 30-minute sessions. In a first session, with all the participants, the GEFT, MAI and self-efficacy questionnaires were administered. In the second session, students attended in groups of maximum four and were placed randomly in a condition (G, V and GV). There were 17 students in each experimental condition and seven in the control one. First, they were given LEGO® bricks and attempted to build a figure possibly using the support tools (guideline and/or video) in 10 minutes. If they were in the V or GV condition, the number of times they watched the video was filed. Then, as the result was collected and disassembled, they were given a word puzzle as a distracter. Later, they were given the bricks back to build the figure again, but without any tool. They had maximum 15 minutes to complete the figure. Time spent to construct the figure was registered. Finally, the figure was stored to verify the number of pieces placed correctly (performance).

For the data analysis, different ANOVA's and descriptive statistics were conducted. For the effect of tool use on performance to check whether tools are functional, condition (G, V and C) was the independent variable and performance the dependent one. To address learners' perceived functionality of the tools, a comparison was made between the frequency of video and guideline consultation within the GV-condition. Additionally, an ANOVA was done with tool of choice as independent variable and performance as dependent variable. ANOVA's were also run to see if there was any difference between the conditions and the variables from which we controlled, as well as, with the time spent.

Results and conclusion

Regarding the learners' determinants, no significant difference between conditions self-efficacy $F(3,54) = 1.01$, $p = .40$, $\eta^2 = .05$, and metacognition $F(3,54) = .31$, $p = .81$, $\eta^2 = .02$ was found neither in relation to time $F(3,51) = .78$, $p = .51$, $\eta^2 = .04$. Concerning the effect of tool use on performance to check *tool functionality*, descriptive statistics revealed a difference between conditions. (G) condition had M=12.59 correct pieces SD= 4.65, (V) condition M=17.41 correct pieces SD= 4.78 and (C) condition M= 9.29 correct pieces SD= 3.09. This was corroborated by the ANOVA which showed a large significant effect for the condition on performance $F(2,38) = 9.56$, $p < .001$ $\eta^2 = .34$. The Tukey post hoc test revealed that the difference in the mean for learners between the (V) condition and (G) condition was 4.82, and with (C) condition 8.13 which indicated a significant difference $p < .05$ and $p < .001$, respectively. With regard to learners' *perceived functionality* of the tool, the use of the tools in the (GV) condition was recorded as only guideline, only video, both guideline and video or none. Fifty-three percent of them picked both guideline and video and the rest (47%) picked the guideline itself. Observational data indicates that from the 53% that opted for both tools; 67 % of them started using the guideline, and then they finalized by watching the video, 11% of them chose the video first and ended with the guideline, 11% used the video first, then the guideline and then went back to the video. The rest (11%) used the guideline first, then the video and finished with the guideline. None of the participants selected just the video. The tool choice within the (GV) condition did not have a significant effect on performance $F(1,15) = .41$, $p = .53$, $\eta^2 = .03$.

This contribution attempted to broaden the tool research by addressing the tool's functionality and the perceived functionality of the tool itself. In regard to *tools functionality*, this study showed that

both tools (G and V) were indeed functional, but contrary to our expectations, the (V) seemed to be more functional due to the results in performance. Concerning *perceived functionality*, learners seemed to identify that the tools were indeed functional, but they did not seem to be able to define which of the two tools was the most functional when confronted with both tools. As a conclusion, these data offer information to establish a future line of research. First, on the learners variables that might influence in identifying the most functional tool for better learning results. Second, on the tool features such as the tool presentation and the tool type that might affect tool functionality. Third, on learner variables and tool features being mediated by perceived functionality which influences tool use, thus performance.

References

Aleven, V., Stahl, E., Schworm, S., Fischer, F., & Wallace, R. (2003). Help seeking and help design in interactive learning environments. *Review of Educational Research*, *73*(3), 277-320.

Baber, C. (2006). Cognitive aspects of tool use. *Applied Ergonomics, 37*(1), 3-15.

Clarebout, G., & Elen, J. (2006). Tool use in computer-based learning environments: Towards a research framework. *Computers in Human Behavior*, *22*(3), 389-411.

Davis, F.D., Bagozzi, R.P., Warshaw, P.R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science*, *35*(8), 982-1003.

Elen, J., & Clarebout, G. (2006). The use of instructional interventions: Lean learning environments as a solution for a design problem. In J. Elen & R. Clark (Eds.), *Handling complexity in learning environments: Theory and research. Advances in Learning and Instruction* (pp. 185-200). Amsterdam: Elsevier.

Lodewyk, K. R., & Winne, P. H. (2005). Relations among the structure of learning tasks, achievement, and changes in self-efficacy in secondary students. *Journal of Educational Psychology*, *97*(1), 3-12.

Oltman, P. K., Raskin, E., & Witkin, H. A. (2003). *Group Embedded Figures Test*. Palo Alto, CA: Consulting Psychologists Press.

Perkins, D. N. (1985). The fingertip effect: How information-processing technology shapes thinking. *Educational Researcher, 14*(7), 11-17.

Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1991). *A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ)*. Ann Arbor, MI: National Center for Research to Improve Postsecondary Teaching and Learning, University of Michigan.

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology, 19*(4), 460-475.

Does Task Complexity Affect Task Performance in EFL? The Mediating Role of Self-efficacy Beliefs and Learning Strategy Use

Xiaoli Wu,
Joost Lowyck,
Jan Elen
Centre for Instructional Psychology and Technology
Faculty of Psychology and Educational Sciences
Katholieke Universiteit Leuven
Vesaliusstraat 2, B-3000, Leuven, Belgium
Xiaoli.Wu@student.kuleuven.be; Joost.Lowyck@ped.kuleuven.be; Jan.Elen@ped.kuleuven.be

Lies Sercu
Research Group of Foreign Language Acquisition and Education
Faculty of Arts
Katholieke Universiteit Leuven
Blijde-Inkomststraat 21, B-3000, Leuven, Belgium
Lies.Sercu@arts.kuleuven.be

Abstract. The study was conducted in an attempt to further our understanding of how students' self-efficacy beliefs contribute to EFL (English as a Foreign Language) instructional design in the framework of cognitive mediating paradigm. The aim was to examine the relationship among task complexity, self-efficacy beliefs, domain-related prior knowledge, learning strategy use and task performance as they were applied to English vocabulary learning from reading tasks. Results show that self-efficacy beliefs had a very significant direct effect on learning strategy use. Self-efficacy beliefs and learning strategy use mediated the effect of vocabulary level on task performance. Vocabulary level had a significant direct effect on task performance. Task complexity showed no significant effect. Our findings indicated that the predictive power of self-efficacy on task performance lied in its association with learning strategy use, and students' domain-related prior knowledge played a crucial role on both self-efficacy beliefs and task performance.

Keywords: task complexity; self-efficacy beliefs; learning strategy use; vocabulary learning

Introduction

When coming to explore the relationship between instructional input (e.g. teaching) and output (e.g. learning outcomes), studies in the mediating paradigm line of research have shown that environmental elements such as instructional methods do not have a direct impact on learning outcomes, but are mediated by learners' cognitive processes and activities (Elen & Lowyck, 1999). A variety of student variables have been proposed mediating between learning environments and learning outcomes, such as prior knowledge (Elen & Lowyck, 1999), learning strategies (Wittrock, 1986) and self-efficacy beliefs (Pajares & Schunk, 2005). In this study, we focused on the major construct drawn from the social-cognitive perspective of self-regulated learning - self-efficacy, and examined the relationships among self-efficacy, domain-related prior knowledge, task complexity, learning activities and task performance as they are applied in the context of Chinese students learning English as a foreign language (EFL) in a university in China, with a specific focus on the acquisition of EFL vocabulary from reading texts.

Research Hypotheses

We hypothesized that students' domain-related prior knowledge, measured by vocabulary level, would have a direct positive effect on learners' self-efficacy beliefs (H1). Task complexity would have a direct negative effect on students' self-efficacy beliefs (H2). It was also predicted that students with higher self-efficacy beliefs would have significantly more frequent use of learning strategies than students with lower self-efficacy beliefs in performing the task (H3), and frequency of learning strategy use would have a direct effect on task performance (H4). With regard to the effect on task

performance, we hypothesized that vocabulary level would have a direct effect (H5); task complexity would, on the other hand, have a direct negative effect on task performance (H6). Self-efficacy would have a direct effect on task performance (H7). To examine these hypothesized relationships, a path model was proposed (see Figure 1).

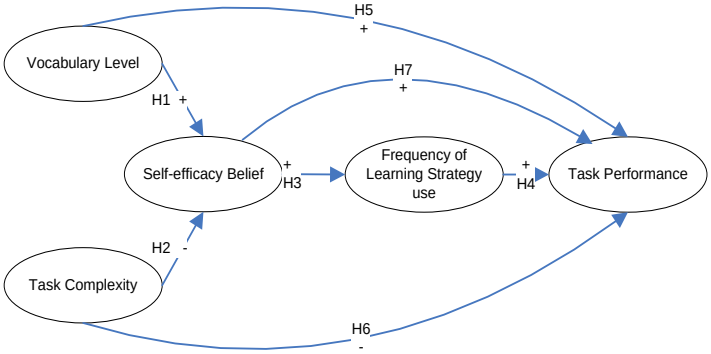


Figure 1. Hypothesized Path Model

Method

Materials

Based on the componential framework for second language task design (Robinson, 2005), a simple and a complex learning task were designed along the dimension of single and dual task demand. In the simple task, participants were instructed to learn the new words from the text. Participants were instructed beforehand that after finishing the task, their knowledge on target words would be tested. In contrast to the simple task, the complex task required the participants to not only learn the same amount of new words from the same text, but also understand the content of the text. Participants were instructed beforehand that their knowledge on the target words as well as their comprehension of the text would be tested.

Design and Procedure

120 second-year university students from a Chinese university participated in the study. Participants were randomly assigned to one of the two experimental conditions, i.e. Task Simple and Task Complex. They were first administered task booklets together with the self-efficacy scale (α = .86), and then measures of learning strategy use (α = .82) and post-tests. The post-tests included a vocabulary test and a reading comprehension test.

Results

The Effect of Task Complexity on Self-efficacy Beliefs, Frequency of Learning Strategy Use and Task Performance

Using self-efficacy belief, frequency of learning strategy use and task performance as dependent variables, a 2 (task complexity) × 3 (vocabulary level) MANOVA was conducted. The analysis detected no significant main effect of task complexity (F (3, 113) = .62, $p > .05$) on the dependent variables. As hypothesized, the result showed a main positive effect of vocabulary level (F (6, 226) = 6.88, $p < .001$, $\eta_p^2 = .17$).

The Interrelationship among Vocabulary Level, Self-efficacy Beliefs, Frequency of Learning Strategy Use and Task Performance

In order to examine the complex interplay among these variables, the hypothesized model was then tested with path analysis. Figure 2 illustrates the respecified path model for the entire student sample.

The standardized parameter estimates for the model were all significant at the .05 level. The insignificant paths were in the dotted lines.

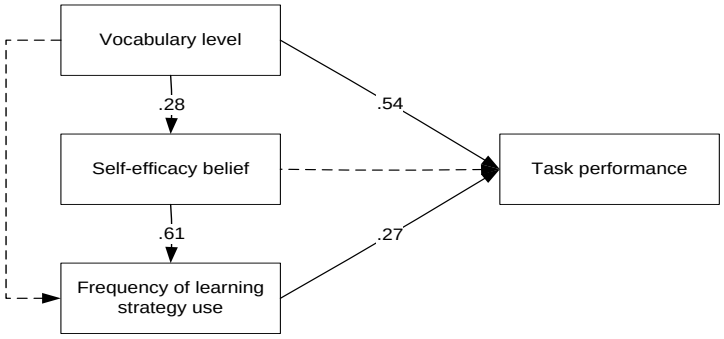


Figure 2. Respecified path model for the entire student sample

Discussion and Conclusions

To sum up, in the framework of the cognitive mediating paradigm, the present study examined the effect of task complexity, and the interrelationship among domain-related prior knowledge, self-efficacy beliefs, frequency of learning strategy use and task performance with two versions of EFL vocabulary learning from reading tasks. The results of the present study suggest that the relationship of self-efficacy and task performance with students' domain related prior knowledge and use of learning strategies may not be as straightforward as previously assumed. For example, previous research on self-efficacy has typically associated students' self-efficacy beliefs directly with learning outcomes. If one focused only on the direct relationship between these two variables, one would arrive at the same conclusion. However, in our study, when students' frequency of learning strategy use was considered, the pattern of relationships that emerged was different. Thus, future research should examine the relationship of self-efficacy and its related variables, especially, the process variables that depict the quantity and quality of students' learning activities, with learning-related outcomes. In addition, one should examine these variables simultaneously at task specific and context specific level. Our findings also suggest that it is potentially important for future theoretical and empirical work in EFL instructional design to explicitly consider the impact of learner variables. In practice, teachers and instructional designers should also pay more attention to students' interpretations of a learning task, especially of a complex task, and perceptions of competence to performing the task because it is the students' interpretations and perceptions that may more accurately predict their motivation and learning activities.

References

Elen, J., & Lowyck, J. (1999). Metacognitive instructional knowledge: Cognitive mediation and instructional design. *Journal of Structural Learning and Intelligent Systems*, *13 (3-4)*, 145-169.

Pajares, F., & Schunk, D. H. (2005). Self-efficacy, self-concept, and academic achievement. In J. Aronson & D. Cordova (Eds.), *Psychology of education: Personal and interpersonal forces*. San Diego: Academic Press.

Robinson, P. (2005). Cognitive complexity and task sequencing: Studies in a triadic componential framework for second language task design. *International Review of Applied Linguistics in Language Teaching*, *43(1)*, 1-32.

Wittrock, M. (Ed.). (1986). *Handbook of research on teaching* (3rd ed.). New York: Macmillan.

Basic principles of motivation and volition to guide the development and implementation of digital instruction

Markus Deimann
FernUniversität in Hagen
Universitätsstraße 11, 58084 Hagen, Germany
Markus.Deimann@Fernuni-hagen.de

John M. Keller
Florida State University
3204G Stone Building, Tallahassee, FL 32306-4453, USA
jkeller@fsu.edu

Abstract. The present paper introduces basic principles of motivation and volition in the form of a coherent conceptual framework that is intended to augment recent paradigms for technology-enhanced learning. In particular, cognitive load theory and the theory of multimedia learning have been dominated past research in instructional design and technology. Yet, they do not fully explain learning behavior as they have neglected motivation and volition. These variables will be dealt with according to a validated approach (ARCS-model) combined with recent developments (volitional design model). Based on that, a set of guiding principles will be formulated that is also useful for generating new research questions.

Keywords. Educational technoloy; motivation; volition; instructional design

Research on learning in technology-enhanced settings has been dominated by a cognitive perspective, in particular stimulated by the cognitive-load-paradigm (Paas, Renkl, & Sweller, 2003) and the generative theory of multimedia learning (Mayer, Heiser, & Lonn, 2001). In these concepts, motivation was neglected or subsumed under the bigger cognitive umbrella. Meanwhile, several studies have been conducted in an attempt to shed light on motivational aspects in cognitive-oriented research settings (e.g., Moreno, 2007). In this regard, Deimann and Keller (2006) argued that self-regulation or volition should be integrated in multimedia learning theory to provide valuable strategies for some of the most urgent challenges such as lost in hyperspace.

However, these are rather separated approaches and have not yet been incorporated into a coherent conceptual framework. Consequently, the present paper suggests a set of principles that bundles consolidated knowledge from instructional design and motivation. These principles are grounded on the ARCS-model of motivational design (Keller, 2010) and recent developments in volitional research (Deimann, 2007; Deimann & Bastiaens, 2010). The following section presents a set of principles from Keller (2008) and explains how they can be beneficial for motivated and competent learning in a digital world.

Motivation To Learn Is Promoted When The Knowledge To Be Learned Is Perceived To Be Mmeaningfully Related To One's Goals

After learners' attention has been caught, some references concerning the purpose of the instruction should be given. This is referred to as the relevance category by the ARCS-model. Connections between the instructional environment and the learner (e.g., learning styles, past experiences) should be made. In recent years, the concept of authentic learning environments emerged as an influential concept in instructional design to explain how relevance can be utilized (Gulikers, Bastiaens, & Martens, 2005). In applications such as virtual enterprises, learners are facing complex situations that are very close to real economic settings.

Motivation To Learn Is Promoted When Learners Believe They Can Succeed In Mastering The Learning Task

This principle refers to the ARCS category confidence which entails variables related to students' feelings of personal control and expectancy for success. Some of the most currently popular areas of

motivational research have been summarized such as self-efficacy to extract strategies. Not only for traditional learning but also for electronic-supported learning research has provided evidence that confidence-related variables are strongly related to learning success. Lee and Lee (2008) present a model that specifies self-efficacy and its relationship to self-regulated learning in a learning management system.

Motivation To Learn Is Protected And Maintained When Learners Employ Volitional (Self-Regulatory) Strategies To Protect Their Intentions.

It is questionable that learners always follow a direct, uninterrupted path from goal-setting to goal achievement. Instead, students pursue not one but multiple goals aimed not only at learning but also at a variety of positive experiences. Thus, different goals interact in complex ways and change over time. In cases when those goals collide, volitional strategies can help students prioritize their goals and avoid being distracted by those that are less important at a given moment (Corno, 2004). This is even more important for learning with educational technologies as they provide numerous potentials to satisfy goals different from the current learning task. Deimann and Keller (2006) outline a list of challenges such as seductive details and suggest volitional strategies that may help the learner to keep on their learning route.

Instructional Designers And Teachers Can Predictably Influence Motivation And Volition In A Positive Way By Applying A Systematic Process Of Design.

Combining instructional design and substantiated knowledge about motivation has been the target of the ARCS-model (Keller, 2010). It provides a systematic approach to diagnosing motivational problems and designing motivational tactics into instruction. The well validated model incorporates needs assessment (audience analysis, existing materials), supports the creation of motivational objectives and measurements based on the analysis, provides guidance for selecting and creating strategies, and follows a process that is in close concordance with instructional design and lesson planning. Its theoretical foundation draws heavily on an expectancy-value-approach which has come under criticism during the past decades. Following that, volitional concepts such as action control have been reintroduced into learning research (Corno, 2004) as well as in instructional design (Deimann, 2007).

Besides this conceptual work, some practical applications have also been developed based upon an integrative perspective of motivation, volition, and instructional design. Based on the Volitional Design Model (Deimann, 2007), an online instrument (http://willenstest.fernuni-hagen.de/) to analyze volitional competence has been developed, called Volitional Persona Test (VPT, Deimann & Bastiaens, 2010). Immediately after the final item, participants automatically receive a detailed profile and helpful strategies are generated. Approximately 30,000 people from German-speaking educational institutions have participated since February 2007 indicating considerable practical benefits.

To sum up, learning with educational technology clearly provides outstanding opportunities for students in order to be prepared for changed global demands. Surprisingly, motivation has not yet received the kind of attention that one may expect from such a powerful variable. This paper attempts to bridge this gap and introduces a set of validated principles that guide both researchers and designers.

References

Corno, L. (2004). Introduction to the special issue work habits and work styles: Volition in education. *Teachers College Record, 106*(9), 1669-1694.

Deimann, M. (2007). *Entwicklung und Erprobung eines volitionalen Designmodells*. Berlin: Logos.

Deimann, M., & Bastiaens, T. (2010). The role of volition in distance education: An exploration of its capacities. *International Review of Research in Open and Distance Learning, 11*(1), 1-16.

Deimann, M., & Keller, J. M. (2006). Volitional aspects of multimedia learning. *Journal of Educational Multimedia and Hypermedia, 15*(2), 137-158.

Gulikers, J. T. M., Bastiaens, T. J., & Martens, R. L. (2005). The surplus value of an authentic learning environment. *Computers in Human Behavior, 21*(3), 509-521.

Keller, J. M. (2008). First principles of motivation to learn and e3-learning. *Distance Education, 29*(2), 175-185.

Keller, J. M. (2010). *Motivational design for learning and performance. The ARCS model approach*. New York: Springer.

Lee, J.-K., & Lee, W.-K. (2008). The relationship of e-Learner's self-regulatory efficacy and perception of e-Learning environmental quality. *Computers in Human Behavior, 24*(1), 32-47.

Mayer, R. E., Heiser, J., & Lonn, S. (2001). Cognitive constraints on multimedia learning: When presenting more material results in less understanding. *Journal of Educational Psychology, 93*(1), 187-198.

Moreno, R. (2007). Optimising learning from animations by minimizing cognitive load: Cognitive and affective consequences of signaling and segmentation methods. *Applied Cognitive Psychology, 21*, 765-781.

Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive load theory and instructional design: Recent developments. *Educational Psychologist, 38*(1), 1-4.

Toward a Community of Practitioners

Astrid Wichmann
Ruhr University Bochum
Universitätsstraße 150, 44801 Bochum, NRW, Germany
astrid.wichmann@rub.de

Ulrich Hoppe
University Duisburg-Essen
Forsthausweg 2, 47057 Duisburg, NRW, Germany
hoppe@collide.info

Abstract. Sharing and re-using ideas is a crucial ingredient to create a community of practitioners. It allows teachers to draft scenarios and to compare them even at early stages with existing scenarios. One problem of existing tools for developing educational designs is the lacking feature of supporting practitioners in finding scenarios of interest made by others. The SCY Scenario Editor offers functions to retrieve scenarios created by others based on a similarity measure. The goal of this study was to examine the validity of this similarity measure. Twenty five participants were asked to produce graphical scenarios from given textual descriptions. First results strongly indicate that the calculated similarity was much higher between corresponding scenarios (related to the same text, but by different modellers) than between non-corresponding scenarios. Also, scenarios created by the same person show high dissimilarity for different scenarios. Findings indicate that the graph matching method used to determine similarity was effective.

Keywords: community of practice; modeling; learning design

Science Created by You

One of the goals in a community of practice is to learn from each other by sharing information of mutual interest (Lave & Wenger, 1991). In our ongoing Project, we aim at achieving this goal of sharing information among a networked community of practitioners. In the SCY Project [8] learners work with inquiry tools such as simulations, (system dynamics) modeling tools and concept maps to explore scientific phenomena by developing hypotheses, running experiments and drawing conclusions, which may result in a new research question (de Jong, Joolingen van, Weinberger, 2009). In SCY-Lab (the SCY learning environment) students go on missions such as creating a CO_2 neutral house, which involve individual as well as collaborative activities. A pivotal role in SCY, play emerging learning objects. In SCY missions, students not only receive learning material (e.g. in form of text), they also produce material (e.g. in form of data by running experiments). These emerging learning objects (ELOs) are re-usable and sharable products of learning activities, which are created by learners. As part of SCY's pedagogical approach, several so-called *learning activity spaces* (LASs) have been identified. These are characterised by specific combinations of tools, activities and types of input/output ELOs. *Learning scenarios* are defined on an upper level by a set of LASs with partial sequencing.

The characteristics of the SCY activities described above were the basis for the development of a SCY Scenario Editor (SCY-SE) to be used by teachers in our SCY practitioner community. Besides integrating the concepts of SCY (ELOs, LASs, Learning scenarios and missions) as a visual modelling language in SCY-SE to develop educational designs, the main challenge was to develop a community support feature, which allows practitioners to share and to re-use SCY scenarios. In order to support teachers even at early design stages to find other scenarios of interest, we developed a similarity measure based on the SCY concepts. The similarity algorithm used for this study was based on a number of LASs, number and type of tools and activities and ELO's. The overall process of calculating the similarity including the similarity algorithm is described elsewhere (Wichmann, Engler, Hoppe, 2010).

[8] [8] SCY – "Science created by You" is an EU project of the 7th Framework Programme. For more information, see http://www.scy-net.eu (last visited in April 2010).

Research goals and questions

The main goal of this study was to test the validity of the similarity algorithm. We prepared three textual descriptions of scenarios consisting of inquiry learning activities. Based on these textual scenarios, students created graphical scenarios using SCY-SE. In addition, expert solutions were created beforehand by researchers, to which the student scenarios were compared. To distinguish between student scenarios and expert solutions, scenarios created by students use a lower case letter (a, b, c) and expert solutions use an uppercase letter (A, B, C). The following questions were of interest:

1) Are SCY-SE scenarios created based on the textual scenario a, more similar to a corresponding expert solution A than to a non-corresponding expert solution B?

Hypotheses: Sim(a, A) > Sim(a, B); Sim(a, A) > Sim(a, C); Sim(b,B) > Sim(b,A) etc.

2) Are the differences induced by the given textual scenarios still discernable in the graphical scenarios produced by the same subject?

Hypotheses: Sim(a, b) < Sim(a, A); Sim(a, c) < Sim(a, A); Sim(b, c) < Sim(b, B) etc.

Design of the Study

Participants, procedure and instrument

Twenty-five students of media-technology or teaching were participating in the study, taking place at a university lab in Germany. After an introduction to SCY-SE, everyone received a small manual and the task description. For two hours, every student worked individually on one computer. The task was to translate three textual scenarios into graphical scenarios using SCY-SE. When a student was finished with the last scenario, she was requested to save the SCY-SE scenario c under a different name, to use the checking button, and to revise SCY-SE scenario c-checked accordingly.

Material

Every textual scenario consisted of four paragraphs. Each paragraph represented one LAS. All textual scenarios described activities following an inquiry approach within the subject matter of photosynthesis. The textual scenarios differed from each other with respect to activities, tools and ELOs. The following paragraph is an example of how activities were described in the textual scenario:

> *"Students work in groups to do their experiments using SCY Simulator. They define their experiment goals in SCY Simulator. Afterwards the students start doing their experiment runs. Then, the students compare the results with their hypothesis stated earlier. They make notes, which they upload together with their experiment data."*

The translation of this paragraph into a SCY-SE scenario may look like this (Figure 1):

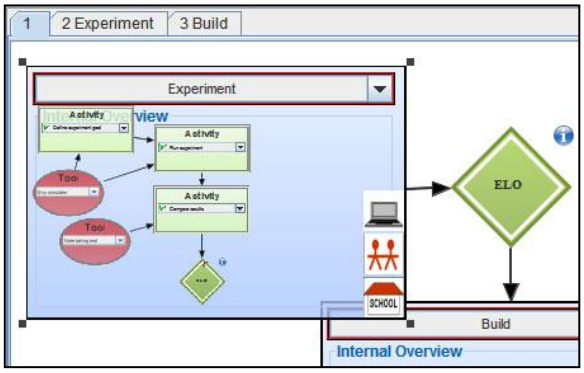


Figure 1. SCY-SE Scenario view

Source of Analysis

Hundred SCY-SE scenario files (four – three unchecked and one checked- from each participant) were collected and analyzed (results with respect to checked scenarios were omitted here due to space

limitations). Similarities were calculated. For answering research question 1, SCY-SE scenarios were compared with corresponding and non-corresponding SCY-SE scenario expert solutions. Concerning question 2, SCY-SE scenarios were compared with SCY-SE scenarios by the same student.

Results

Due to low sample size, descriptive statistics were favoured and non-parametric methods were used. From the questionnaire, we found that most participants (72%) reported that textual scenarios were of similar difficulty level. Some participants (24%) identified one of the three scenarios as most difficult. Most participants (76%) reported that it was most difficult to select the tools (besides LASs and Activities). First, we compared every student's scenario a, b, c with the corresponding expert solution and with the non-corresponding expert solutions. As expected, if student scenarios were compared with the corresponding expert solution, the percentage with respect to similarity was higher (M=81, SD=07) than if student scenarios were compared with the non-corresponding expert solutions (M=55, SD=04). Wilcoxon's Signed-Rank test showed that this difference was statistically significant (z=-4.37, p=.000). Second, we compared student scenarios with student scenarios done by the same student (Sim(a,b); Sim(a,c), Sim(b,c)). As expected, similarity was low (M=53, SD=08) and comparative to similarity between expert solutions A, B, C (M=58, SD=49).

Conclusion and Implications

The results demonstrate that the similarity measure captures well the plausible similarity between graphical scenario designs originating from the same textual source across subjects. We could also show that dissimilarities of scenarios developed by the same person but based on dissimilar textual scenarios were detected (and therefore discriminated). It was somewhat surprising that scenarios based on non-corresponding textual descriptions still resulted in a similarity of over 50%. One reason was that all three textual scenarios (which were the basis for the graphical representations in SCY-SE) had approximately the same length and the same number of LASs. Together with certain tool similarities suggested by an underlying ontology, this resulted in a quite high baseline. Yet, as the similarity of scenarios based on corresponding textual scenarios was over 80% (which results in a statistically significant difference), we were able to reliably discriminate similar scenarios from dissimilar scenarios.

References

Lave, J., Wenger, E. (1991). Situated Learning: Legitimate Peripheral Participation. Cambridge: Cambridge University Press.

De Jong, T., Joolingen van, W. R., Weinberger, A., & the SCY team (2009, June). Learning by design. An example from the SCY-project. *Paper presented at the CSCL 2009*, Rhodes, Greece.

Wichmann, A., Engler, J., Hoppe, H.U. (2010, June): Sharing Educational Scenario Designs in Practitioner Communities. Paper presented at the 9th International Conference of the Learning Sciences ICLS Proceedings 2010, Chicago, USA.

Measuring xenophobic cognitions after intercultural training

Gerhard Schrangl,
Joerg Zumbach
University of Salzburg, Department of E-Learning in Science Education
Hellbrunnerstraße 34, 5020 Salzburg, Austria
gerhard.schrangl@sbg.ac.at ; joerg.zumbach@sbg.ac.at

Abstract. In consideration of increasing xenophobic attacks against immigrants and foreigners and ethnic or religious motivated wars, there is a need to develop educational concepts to combat xenophobia. As part of our study, an intercultural multimedia program was developed. Its target is to discuss various forms of alienation. The computer program is based on research findings, as the symbolic interactionism (Mead, 1978), the symbol-didactics (Biehl, 1991) and other proven intercultural teaching strategies (Grosch, Groß and Leenen, 2000). To evaluate the intercultural training sessions, tools and methods have been developed to measure attitudes toward foreign people. Based on a multimethodal concept an evaluation-tool has been created, which allows proving the effectiveness of long-term intervention programs and short-term intervention effects on an implicit level of awareness. In this case, the used procedure was the implicit association test by Greenwald and Banaji (1995). The applied methods were evaluated in a study with 69 participants (60.7% female) aged between 12 and 16 (M= 13.84, SD= 1.10). Although the t-test did not show a significant result in explicit measures of attitude, there was a significant change in implicit measures.
This result implies that the chosen tutorial methods lead to a verifiable change in attitudes on trait and state-level regarding the xenophobic self-concept.

Keywords: implicit attitude measurement; implicit association test; stereotypes and prejudice; intercultural training.

Summary

The ability to understand others gains more and more importance, not only because of changing demographic circumstances, but also because of the processes of globalization. This is the reason why we are going to come in contact with various types of alieness more often. To ensure a peaceful coexistence of cultures, appropriate educational work is needed. Intercultural education has to take a higher priority to allow a change of perspective in order to reduce prejudice, resentments and unfounded fears of any type of alieness in our society.

The current study was designed to examine a multimedia surface based on different research psychological and pedagogical research findings. The goal was to achieve a change in attitude of students regarding prejudice, stereotypes and alien perception. It had to clear up the question, if a learning environment using a multimedia design can lead to a significant reduction of the xenophobic self-concept.

As part of an empirical study, tools and methods have been developed and used to measure xenophobic attitudes and stereotypes.

Participants

The experiment took place at a High School. There were 61 students (60.7% female) aged between 12 and 16 (M= 13.84, SD= 1.10). Most of the pupils were Austrians, some were German citizens. None of them had a migration background.

Method and instruments

Before and after teaching sequences an IAT (Implicit Association Test) was conducted. The IAT consists of several discrimination tasks. The association strength of several image stimuli and adjectives had been measured. For example, words like “mean” or “nice” had been combined with familiar or foreign images. In further consequence the subject had to sort the words and images according to the categories foreign or familiar and positive or negative.

Explicit measurements for operationalization of emotional and cognitive effects has been used: the scale „Motivation zu vorurteilsfreiem Verhalten“(Motivation to unbiased behavior) by Banse &

Gawronski (2003); the „Skala Ausländerfeindliche Gesinnung“ (scale xenophobic attitude) by Bucher, Göllner & Auer (2001) and the scale „Einstellungen gegen über Fremden“ (attitude towards foreigners) by Frindte (1999). Main target of the multimedia program is the controversy of religious symbols. Symbols play an important role considering communication and identity formation, but also for localization in social space (e.g. Holzwarth 2001). It is based on different theories as the symbolic interactionism (Mead, 1978), the symbol-didactics (Biehl, 1991) but also other proven intercultural teaching strategies (Grosch, Groß and Leenen, 2000), which let the students get into contact with foreign but also familiar symbols. The multimedia program „Intercultural Games“ included seven program parts: „music from all over the world“, „picture observation“, „symbols of alienation“, „making of a crest“, „pictures of strangers“, a short movie and an internet research.

The goal of the program was to initiate an increase of knowledge, but also the ability to question categories such as alienation and familiarity. For example, the pupil had to categorize pictures of everyday objects but also humans into those categories. Using various information the pupils should begin to reflect their views. This should be realized with an examination of cultural and religious symbols, which they should set in relation to their own biography. With the program part „making of a crest” this was implemented. The pupils had to create a crest of their own family with different cultural and religious symbols. This way, an analytic and self-reflective approach to this topic was chosen to permit an ambiguity tolerance. Acceptance of the existence of contradictions, which can be seen as an important factor in intercultural competence (e.g. Makarova, 2010), should be fostered.

Schedule of the experiment

The examination took place in the computer room of an Austrian high-school. The pupils were informed about the schedule of the experiment. Then they got the questionnaire and the IAT was conducted. Afterwards they started the multimedia program “intercultural games“. After two hours (2 x 50 minutes) the results have been discussed together with all pupils. After that the Post-Test was conducted.

Results

The used questionnaires showed no significant difference between the mean values before and after the training sessions. However the t-test for dependent samples reported a significant difference between pre- and posttest on implicit measures $t_{(69)} = 4.23$, $p<.01$, with an effect size of $d= .41$. After the teaching sequence, this result implies that the chosen tutorial methods lead to a verifiable change in attitudes on trait and state-level regarding the xenophobic self-concept. The divergence between implicit and explicit measures was observed in various studies (e.g Greenwald & Nosek, 2001). However, there is a high predictive power of the attitude measurement, which means that there was a change according to the intuitive spontaneous behavior due to the teaching sequence (e.g. Gawronski & Conrey, 2004; Asendorpf, Banse & Mücke, 2002; Egloff & Schmukle, 2002). The divergence can be determined by the possibility for socially desirable answering which is a well known problem in explicit bias measures. Political correctness and social desirability tend to influence explicit answers on issues like race, risky behaviors and much more (e.g. Brunel, Tietje, & Greenwald, 2004). The Implicit Association Test by contrast is nearly immune to social desirable answers.” But considering the findings of Fiedler and Bluemke (2005) the IAT can be manipulated, provided that the pupils understood the operating mode of the IAT. The divergence could also be caused by a measuring problem. On the other hand the result of the IAT could have been generated by measuring another unknown constructs. Regarding the study this result implies that the chosen measuring instruments can verify a change in attitudes on trait and state-level and a change regarding the xenophobic self-concept.

References

Asendorpf, J.B., Banse, R. & Mücke, D. (2002). Double dissociation between implicit and explicit personality self-concept: The case of shy behavior. *Journal of Personality and Social Psychology, 83*, 380-393.

Banse, R. & Gawronski, B. (2003). Die Skala Motivation zu vorurteilsfreiem Verhalten: Psychometrische Eigenschaften und Validität. *Diagnostica, 49*, S. 4-13.

Biehl, P. (1991). *Symbole geben zu lernen.* Neukirchen-Vluyn: Neukirchener Verlag.

Bucher, A. (2001). *Ethikunterricht in Österreich: Bericht der wissenschaftlichen Evaluation der Schulversuche "Ethikunterricht".* Innsbruck - Wien: Tyrolia.

Brunel, F., Tietje, B., & Greenwald, A. (2004). Is the Implicit Association Test a Valid and Valuable Measure of Implicit Consumer Social Cognition. *Journal of Consumer Psychology, 14* (4), S. 385-404.

Egloff, B. & Schmukle, S. C. (2002).Predictive validity of an Implicit Association Test for assessing anxiety. *Journal of Personality and Social Psychology, 83*, 1441-1455.

Fiedler, K., & Bluemke, M. (2005). Faking the IAT: Aided and unaided response control on the implicit association tests. Basic and Applied Social Psychology, 27(4), 307-316.

Frindte, W. (1999). *Fremde Freunde Feindlichkeiten. Sozialpsychologische Untersuchungen.* Opladen: Westdeutscher Verlag.

Gawronski, B. & Conrey, F. R. (2004). Der Implizite Assoziationstest als Maß automatisch aktivierter Assoziationen: Reichweite und Grenzen. *Psychologische Rundschau, 55*, 118-126.

Greenwald, A. G. & Banaji, M. R. (1995). Implicitsocialcognition: Attitudes, self-esteem, and stereotypes. Psychological Review, 102, 4-27.

Greenwald, A. G. & Nosek, B. A. (2001). Health of the Implicit Association Test at age 3. *Zeitschrift für Experimentelle Psychologie, 48*, 85-93.

Grosch, H., Groß, A. & Leenen, W. R. (2000). *Methoden interkulturellen Lernens.* Saarbrücken: AES Methoden für interkulturelle Bildung.

Makarova, E. (2010). Das Fremde im pädagogischen Diskurs des 21.Jahrhunderts. In M. T. Schönbächler, R. Becker, A. Hollenstein, & F. Osterwalder, Die Zeit der Pädagogik: Zeitperspektiven im wissenschaftlichen Diskurs (S. 227-241). Basel: Haupt.

Mead, G. H. (1973). *Geist, Identität und Gesellschaft.* Frankfurt am Main: Suhrkamp Verlag.

Multimedia Learning and the Appraisal Effect

Birgit Reisenhofer,
Joerg Zumbach
University of Salzburg, Department of E-Learning in Science Education
Hellbrunnerstraße 34, 5020 Salzburg, Austria
birgit.reisenhofer@sbg.ac.at; joerg.zumbach@sbg.ac.at

Abstract. In this research, we analyse the influence of media specific appraisal and attribution processes on multimedia learning. In addition, effects of multimodality in multimedia learning material are examined. In a study (n=102), we investigated the influence of attribution and motivation compared to learning outcomes. Two different versions of learning material about data transmission and computer networks were compared: An animation-based version with text and one with audio. A main effect for knowledge acquisition and the type of learning material was found: the animation-based version with audio led to higher learning outcomes than the animation-based version with text. Results reveal that students, who classified their learning condition as difficult, invested more mental effort and achieved a significant better learning outcome and success in learning was attributed to external media in first appraisal. No significant interaction was found between both learning conditions and media specific attribution.

Keywords: modality effect; attribution; multimedia learning; appraisal effect;

Introduction

By using multimedia learning material an optimized use of working memory and its capacity is possible. Several authors state that learning success with audio-visual material is higher than learning success with text-based material (cf. modality effect; Mayer, 2005; Low & Sweller, 2005). Research by Salomon (1984), Field and Anderson (1985) and Krendl and Watkins (1983) prove that learning success is also dependent on additional instructions on how to deal with multimedia teaching material. Apart from this, appraisal and attribution processes play an important role in information processing (cf. Cohen & Salomon, 1979, Salomon & Leigh, 1984). A person's prior expectation about the ease of learning with either text or television influences the amount of invested mental effort and further affects learning outcomes.

The potential of animations used to present information about dynamic processes was confirmed in various studies (cf. Betrancourt, 2005). Nevertheless, again learners' expectations may not be neglected: perception is influenced by previous information and could lead to false or incomplete information processing. Along animated pictures, audio is another important part of multimedia teaching material. Cognitive processes can be supported by multimedia learning material. In case learning material is judged as difficult in media appraisal, more mental effort is invested. Consequently knowledge acquisition is higher and learning performance is to a greater extent attributed to a person's own abilities.

Method

Learning material

Two different versions of teaching material with exactly the same amount of information provided were created. The first version was an animation with auditive information; the second version was the same animation with textual information. Both animations were about data transmission and computer networks.

Participants

One-hundred and two participants took part in this study. They were all recruits of the Austrian Federal Army at an average age of 19.18 years. Assignment to one of the two conditions was random (animation and text with n=45, animation and audio with n=57).

Instruments and Procedure

A multiple-choice test and a test with open questions were designed in order to assess knowledge acquisition. Cognitive load was measured by using the Mental Effort Rating Scale by Paas and van Merrienboer (1994). In order to examine the media-specific attribution we used several items on a five-point Likert-scale derived from Salomon (1984).

First, participants had to complete the pre-test (knowledge acquisition, cognitive load, attribution) and were then randomly assigned to one of the two animation conditions, which lasted 5 minutes each. Afterwards, the post-test (similar to the pre-test) was conducted. Participation in this study was voluntary and took about 35 minutes.

Results

Both animation conditions led to increased performance in the knowledge post test; nevertheless, participants working with the animation condition with audio achieved higher scores in knowledge test performance; whereas cognitive load was lower within this group. A higher amount of invested mental effort in the animation condition with text was reported. Participants, who estimated learning with computers to be easier, did worse in knowledge test performance. Results reveal a main effect on the condition modality; here, knowledge acquisition ($p=0.02$) as well as cognitive load ($p=0.02$) showed significant values.

Participants who expected learning with computers to be easier, did worse in the knowledge post test ($p=0.04$) than participants who expected learning with computers to be more difficult. Though cognitive load was lower, the amount of invested mental effort was higher in case participants judged learning with computers to be difficult ($p=0.008$).

Discussion

Apart from aspects of how to design ideal teaching material, we focused on the students' attribution towards different media, cognitive load and motivational aspects. Participants who assumed learning with computers to be difficult did better in the knowledge post test than participants who assumed it to be easy. It can be derived from these results that appraisal has direct influence on knowledge acquisition as well as on attribution processes. As hypothesized before, learning success was higher with the animation-audio condition. This result can also be explained with the deliberate avoidance of the split-attention effect (Ayres & Sweller, 2005). Due to audio instruction in this learning condition, the focus of learners was on the animation itself while being able to process auditive information. As previously stated by Salomon (1984), students attributed their learning success to using this new technology instead of learning with texts only.

Cognitive load within the animation version with text was, as expected, higher than with the other condition. Students dealing with visual inputs only, apparently have to invest more effort in processing the information. Findings implicate that multimedia learning is influenced by many factors. Impact of unbeneficial appraisal could be compensated by additional instructional aids that foster deeper elaboration processes.

References

Ayres, P. & Sweller, J. (2005). The split-attention principle in multimedia learning. In R.E. Mayer (ed.), *The Cambridge Handbook of Multimedia Learning* (pp. 135-146). New York, NY: Cambridge University Press.

Betrancourt, M. (2005). The Animation and Interactivity Principles in Multimedia Learning. In R.E. Mayer (Ed.), *The Cambridge Handbook of Multimedia Learning.* New York, NY: Cambridge University Press, 287-296.

Cohen, A., & Salomon, G. (1979). Children's literate television viewing: Surprises and possible explanations. *Journal of Communication, 29*(3), 156-163.

Field, D.E. & Anderson, D.R. (1985). Instruction and modality effects on children's television attention and comprehension. *Journal of Educational Psychology*, 77, 91-100.

Krendl, K.A. & Watkins, B. (1983). Understanding television: An exploratory inquiry into the reconstruction of narrative content. *ECTJ*, 31, 201-212.

Low, R. & Sweller, J. (2005). The modality principle in multimedia learning. In R.E. Mayer (Ed.), *The Cambridge Handbook of Multimedia Learning* (pp. 147-158). New York, NY: Cambridge University Press.

Mayer, R.E. (2005). Cognitive Theory of Multimedia Learning. In R.E. Mayer (Ed.), *The Cambridge Handbook of Multimedia Learning* (pp. 31-48). New York, NY: Cambridge University Press.

Paas, F.G.W. & Van Merrienboer, J.G. (1994). Instructional control of cognitive load in the training of complex tasks. *Educational Psychology Review*, 6, 351-372.

Salomon, G. (1984). Television is "easy" and print is "tough": The differential investment of mental effort in learning as a function of perceptions and attributions. *Journal of Educational Psychology, 76*(4), 647-658.

Salomon, G. & Leigh, T. (1984). Predispositions about learning from print and television. *Journal of Communication*, 32, 119-135.

Developing Computer-Based Adaptive Learning Environments: the Role of Learner Characteristics

Mieke Vandewaetere, [a,b]
Geraldine Clarebout [a,b]
[a] *iTEC, Interdisciplinary Research on Technology, Communication and Education, KU Leuven – Campus Kortrijk, E. Sabbelaan 53, 8500 Kortrijk, Belgium*
[b] *CIP&T, Centre for Instructional Psychology and Technology, KU Leuven, Andreas Vesaliusstraat 2, 3000 Leuven, Belgium*
{firstname.lastname}@kuleuven-kortrijk.be

Abstract. Many adaptive learning environments are based on learner models, with the purpose to drive personalization based on learner and learning characteristics. These characteristics, such as cognitive, affective and behavioral variables, are generally considered as important for the learning process. Despite the huge amount of theoretical propositions of learner characteristics considered as eligible for inclusion in learner models, practical payoffs are rather sparse. This study aims to overview the empirical research on the mere value of learner characteristics in the development of adaptive learning environments. The results show that a lot of high-quality studies are situated in a rather shattered research field, building few bridges from theory to practice. We conclude with the call for a theory or framework integrating current and past research results that is able to guide theory-based and systematic empirical research having concrete hypotheses on the merits of learner characteristics in adaptive learning environments.

Keywords: Adaptive learning environments; learner characteristics; learner model; instructional design; effectiveness research.

Introduction

Although any form of instruction can be considered as adaptive if it accommodates different learning needs and abilities of the learners (Lee & Park, 2008), rapid growth in computer technology has influenced the development of computer-based adaptive learning environments. There is a general conclusion of the feasibility of learners achieving learning goals more efficiently, when instructional design is adapted or accommodated to their individual differences (Federico, 1991).

In the development of adaptive learning environments, the construction of learner models takes an active part. Learner models drive the personalization and adaptation based on learner and learning characteristics that are considered as important in learning, such as cognitive, affective and behavioral variables. Despite the huge amount of theoretical propositions of learner and learning characteristics considered as relevant to include in learner models, practical payoffs are rather sparse. And although the different approaches to adaptive instruction offer valuable contributions to the development of adaptive learning environments, a great deal of research on adaptive learning environments stands on its own and is sparsely relied on other research or instructional design theories.

In line with this, the practical outcomes and concrete implementations from research into adaptive instruction is limited (Federico, 1999), partly due to difficulties in the concrete translation of theory into instructional techniques. That general and systematic principles of individualized instruction have not emerged yet (Regian & Shute, 1992) is mainly due to an empirical gap (Gerjets & Hesse, 2004). Indeed, there is still a distance between the expected effect of adaptive and powerful learning environments and their presupposed learning effectiveness.

The goal of this review is threefold: for one thing, we try to elucidate the common grounds of the adaptive systems that have been reported and want to shed light on the underlying building blocks by which these systems have been developed. Secondly, a state of the art is offered of current empirical research on the pedagogical effectiveness of adaptive systems based on learner models and adaptation to learner characteristics; and in closing, we present some possible directions in the form of questions that can be addressed when developing an adaptive learning environment.

Method

The adaptive systems discussed in this review were identified through a comprehensive search of three electronic databases: PsycINFO, ERIC and Web of Science. The following search terms were used: "adaptive learning"+technology|"computer-assisted instruction"|"learner model"|"user model"|"intelligent tutoring system"; "intelligent tutoring system"|"adaptive learning environment"+"learner model"|"user model"|learning; "artificial intelligence"+"adaptive"; "individualized instruction"|"intelligent tutoring system"|"adaptive instruction"+"learner characteristics"|"user characteristics". As a secondary search strategy, reference lists of relevant articles were also reviewed. Also, the journals 'International Journal of Artificial Intelligence in Education (IJAIED)' and 'User Modeling and User-Adapted Interaction (UMUAI)' were searched through, as well as the conference proceedings of the AIED conferences (Artificial Intelligence in Education), UM (User Modeling), AH (Adaptive Hypermedia) and UMAP (User Modeling, Adaptation and Personalization).

The following inclusion criteria were used for article selection: research articles with a focus on empirical research mapping the effectiveness of a computer-based adaptive learning environment. Also, a description of the learning environment of interest should be given. A third criterion is that the research must focus on learner characteristics (e.g., cognition, affect or behavior) as design or modeling variables. Since few research articles were extracted that could be categorized as empirical validation of the effectiveness of adaptive systems, we decided to include also theoretical propositions of such systems, mainly found in conference proceedings, in which it was suggested that further research should focus on empirical effectiveness research. Exclusion criteria included articles published in a language other than English, research studies presented as a book chapter and review articles.

All articles that were considered as relevant after evaluating them according to the criteria were collected and summarized in a database. As a result of the database search, 29 relevant journal articles and 2 relevant excerpts from conference proceedings were listed. This was completed with 17 journal articles and 4 excerpts from conference proceedings, selected by the second search strategy. Each publication was labeled based on following categories: publication date, author(s), selected by first or secondary search strategy, name of learning environment/tutoring system/supporting tool, empirical or theoretical study, and some tags identifying the main concepts of the study.

Results

A major observation that can be put forward is the variability in the research domain of adaptive systems. The fact that building such systems is an interdisciplinary research approach, results in studies with often not attuned approaches according to design, method and evaluation. This in turn leads to difficulties in comparing research studies (e.g., by meta-analysis) on the effectiveness of adaptive systems in general, or difficulties in comparing studies related to the contribution of learner characteristics in learner modeling. However, from the amount of articles that were reviewed, the common grounds of adaptive systems currently developed can be elucidated, and the underlying building blocks of these systems can be uncovered systematically.

Adaptive instruction can be considered as having a tripartite nature, with three components being indicative for the development of adaptive systems. Starting from this tripartite structure, we will discuss in detail the different building blocks of adaptive instruction, all illustrated with empirical research on adaptive learning environments. The first component relates to the source of adaptive instruction (*to what will be adapted?*). Not only learner characteristics (e.g., learning style, working memory capacity, knowledge), but also characteristics of the interaction between learner and environment (e.g., performance, concentration, reading time, help-seeking behavior) are taken into account. The second component of adaptive instruction refers to the target of adaptive instruction (*what will be adapted?*). In the reviewed articles, adaptive instruction was focused on content (e.g.,

advise, guidance, filtering), presentation and instruction (e.g., hints, feedback, pacing), or a combination of both. A last component, the pathways of adaptive instruction (*how to translate source into target?*) links the source(s) and target(s) of adaptive instruction with each other. Rule-based and probability-based techniques were found to be most frequently reported.

Conclusion

The results show an auspicious trend towards more systematic research and more empirical evaluation studies of techniques for learner modeling. This is in line with the review of Chin (2001), who reported an upward trend in the use of empirical evaluations of user-adapted interaction in learner modeling systems. Nonetheless, for the time being, it seems that the practical implementation and empirical evaluation of this techniques and models into adaptive learning systems is still small-scaled, compared with the bunch of theories that has been developed.

We conclude with the call for a bottom-up theory development integrating current and past research results. Providing the adaptive and intelligent learning systems research field with a practice-based framework will engage researchers into more structured en systematic empirical research with concrete hypotheses on the merits of including learner characteristics in adaptive learning environments.

References

Chin, D. N. (2001). Empirical Evaluation of User Models and User-Adapted Systems. *User Modeling and User-Adapted Interaction, 11,* 181-194.

Federico, P-A. (1991). Student cognitive attributes and performance in a computer-managed instructional setting. In R. Dillon & J. Pellegrino (Eds.), *Instruction: Theoretical and applied perspectives* (pp. 16-46). New York: Praeger.

Federico, P-A. (1999). Hypermedia environments and adaptive instruction. *Computers in Human Behavior, 15,* 653-692.

Gerjets, P. H., & Hesse, F. W. (2004). When are powerful learning environments effective? The role of learner activities and of students' conceptions of educational technology. *International Journal of Educational Research, 41,* 445-465.

Lee, J. & Park, O. (2008). Adaptive Instructional Systems. In J. M. Spector, M. D. Merril, & J. J. G. van Merriënboer, & M. Driscoll (Eds.), *Handbook of Research on Educational Communications and Technology (3rd Edition)* (pp. 469-484). New York, NY: Taylor & Francis.

Regian, J. W. & Shute, V. J. (1992). *Cognitive approaches to automated instruction.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Processes Mediating Expertise in Air Traffic Control

Ludo W. van Meeuwen[1,2],*
Halszka Jarodzka[1],
Saskia Brand-Gruwel[1],
Jeroen J.G. van Merriënboer[1,3],
Jeano J.P.R. de Bock[2],
Paul A. Kirschner[1]
[1]Open Univesiteit in The Netherlands; [2]Air Traffic Control The Netherlands; [3]Maastricht University
**ludo.vanmeeuwen@ou.nl*

Abstract. Air traffic control (ATC) involves dealing with complex visualizations. Making decisions based on those visualizations requires not only conceptual but also perceptual skills, like efficient visual search of critical airplane compositions, their quick and correct interpretations, and the appropriate reactions. This study will examine expertise differences in perceiving and interpreting ATC stimuli on a perceptual and conceptual level. Moreover, the potentially mediating influence of spatial abilities will be investigated. ATC Performance, eye movements, verbal reports, and spatial ability will be obtained from experts, intermediates, and novices.

Keywords: expertise; eye tracking; verbal reports; instructional design; air traffic control; spatial ability

Ericsson and Lehman (1996), stated that to understand expertise, instead of proving experts' superior task *performance,* it is important to investigate the mediating *processes* and individual characteristics mediating expertise. This has already been done in detail for conceptual processes, in particular for specific domains like chess (e.g., Charness, Reingold, Pomplunm, & Stampe, 2001) or medical diagnosis (e.g., Boshuizen & Schmidt, 1992). For tasks that involve interpreting visualizations, however, not only the conceptual, but in particular the perceptual processes play a crucial role. In these cases expert performance comprises perceptual skills, that is, the ability to perceive the relevant information in complex, visual stimuli and to draw inferences based upon the perceived information (e.g., diagnosing seizures based on patient videos: Balslev, Jarodzka, Holmqvist, De Grave, Muijtjens, & Eika, in preparation; classification of the locomotion of riff-fish: Jarodzka, Scheiter, Gerjets, & Van Gog, 2010). Furthermore, individual characteristics, like spatial ability have shown to be necessary for expert performance in perceptual tasks (e.g., in chess: Frydman & Lynn, 1992).

Nevertheless, in domains that involve *complex* visual stimuli not much is known about how experts allocate their attention during task performance, how this differs from novices, and how this is related to individual characteristics. Hence, the present study will examine the interplay between perceptual and conceptual processes involved in the interpretation of complex visual stimuli as a function of expertise and its relation to spatial abilities in the domain of air traffic control (ATC).

We hypothesize that experts will perform more accurately and faster than intermediates, which will outperform novices **(**Hypothesis 1**)**. More important, it is hypothesized that novices' perceptual strategies will be guided by the salience of single features (cf. Lowe, 1999), intermediates will follow a text-book strategy, and experts' perceptual strategies are assumed to be characterized by experience- and knowledge-based shortcuts (Hypothesis 2). We assume the same pattern also to be reflected in verbal reports (Hypothesis 3). These task proceedings will result in (Hypothesis 4): an efficient visual search for experts (looking quickly and for a long time on relevant areas), a detailed visual search for intermediates (looking at all potentially relevant areas with many transitions), and an inefficient and course visual search for novices (looking mostly at salient, but irrelevant areas). Moreover, we expect that experts will verbalize less information than novices due to schema automation and, thus, use fewer words in their description of how they accomplish that task (Ericsson & Simon, 1980; Hypothesis 5). In line with Boshuizen and Schmidt (1992) their verbalizations are expected to contain more encapsulating technical terms **(**Hypothesis 6**)**. Finally, we assume that experts' spatial abilities are more pronounced then the other two groups (Hypothesis 7).

Method

Participants in the study will be 31 individuals with three different levels of expertise. Eight of them will be experts, eight intermediates and 15 novices.

Figure 1. ATC radar situation

The experiment will be run in individual sessions of approximately 60 minutes. Participants will receive nine static visualizations of an ATC radar situation (see Figure 1). An ATC radar situation is composed of a number of inbound airplanes towards Amsterdam Airport Schiphol. In ATC the controller has to keep planes separated in a safe and efficient way towards the airport. The controller has to create an optimal line of planes which come from different directions with all different performances. In this study participants will be asked to determine the optimal order of arrival of each plane. The nine trials are composed of three different difficulty levels and will be randomly presented to each participant. The controlled level of difficulty is determined a priori by a domain expert and depends on the number of planes involved in the task and the number of conflicts ahead. During task performance, eye-movements of participants will be recorded with a Tobii 1750 remote eye tracking system with temporal resolution of 50 Hz. After each trial, participants will verbalize the thoughts they had while performing the task. This will be done via cued retrospective reports (CRR). CRR is a think-aloud technique in which participants verbalize their thoughts after completing the task, based on recordings of participants' own eye movements superimposed onto the stimulus (Van Gog, Paas, Van Merriënboer, & Witte, 2005). All participants will be asked to perform a mental rotation task (Vandenberg & Kuse, 1978). Time on task will be measured at all task performances.

Data Analysis

Correctness of Interpreting ATC Situation

The quality of the solutions will be rated by a group of experts. Another dependent variable will be the mean viewing duration per stimulus.

Gaze Data

Dwell time of gazes across different areas of interest (AOIs) will be investigated for an amount of time that every participant will have watched the stimulus. This will be done to make total gaze durations comparable, because participants may watch each still as long as they wanted. Second, time until looking for the first time on the relevant AOIs will be determined. Third, sequence analyses for the different AOIs will be conducted to compare sequences of gazes to each other based on the so-called Levenshtein distance (Levenshtein, 1966). Fourth, we will investigate transitions between AOIs.

Cued retrospective reporting

The cued retrospective reports obtained during the gaze replay will be analyzed with regard to different aspects. First, the *contents* of the participants' initial utterances (i.e., the first term mentioned) of each gaze replay will be analyzed to determine whether they referred to either relevant or irrelevant features in order to investigate participants' initial response to the task. The remaining analyses will

refer to the complete gaze replay. As a second variable, it will be analyzed whether the cued retrospective reporting referred to *features* that are either relevant (e.g., label information, involved planes, initial approach fix) or irrelevant (e.g., not involved planes, irrelevant information). Third, the *total number of words* used during retrospection will be counted. This number will be divided by the time on task, resulting in a number of words per minute. Fourth, *the number of different technical terms*, which were used during retrospection, will be determined.

Discussion

The aim of the study is to investigate mediating factors and development of visual expertise in ATC. Note that this study is work in progress nevertheless, we have preliminary assumptions on the implications of the study. We expect the findings of this study to be usable in structural comparable domains comprising comparable visual complex tasks (e.g. medical specialists, pilots, train traffic controllers). Further research, however, will be needed to investigate the *dynamics* of the domain.

References

Balslev, T., Jarodzka, H., Holmqvist, K., De Grave, W. S., Muijtjens, A., Eika, B., et al. (in prep.). The influence of experience and training on attention and clinical reasoning in pediatrics.

Boshuizen, H. P. A., & Schmidt, H. G. (1992). On the role of biomedical knowledge in clinical reasoning by experts, intermediates, and novices. *Cognitive Science, 16,* 153-184.

Charness, N., Reingold, E. M., Pomplun, M., & Stampe, D. M. (2001). The perceptual aspect of skilled performance in chess: Evidence from eye movements. *Memory and Cognition, 29,* 1146-1152.

Ericsson, K.A., & Lehmann, A. C. (1996). Expert and exceptional performance: Evidence of maximal adaptation to task constraints. *Annual Reviews in Psychology, 47,* 273-305.

Ericsson, K. A., & Simon, H. A. (1980). Verbal reports as data. *Psychological Review, 87*, 215-251.

Frydman, M., & Lynn, R. (1992). The general intelligence and spatial abilities of gifted young Belgian chess players. *British Journal of Psychology, 83,* 233-235.

Jarodzka, H., Scheiter, K., Gerjets, P., & Van Gog, T. (2010). In the eyes of the beholder: How experts and novices interpret dynamic stimuli. *Learning and Instruction, 20*, 146-154.

Levenshtein, V. I. 1966. Binary Codes Capable of Correcting Deletions, Insertions,
and Reversals. *Soviet Phys. Dok. 10*, 707-710.

Lowe, R.K. (1999). Extracting information from an animation during complex visual learning. *European Journal of Psychology Education, 14,* 225-244.

Van Gog, T., Paas, F., Van Merriëboer, J. J. G., & Witte, P. (2005). Uncovering the Problem-Solving Process: Cued Retrospective Reporting Versus Concurrent and Retrospective Reporting. *Journal of Experimental Psychology: Applied, 11,* 237-244.

Vandenberg, S. G. & Kuse, A. R. (1978). Mental rotations, a group test of threedimensional spatial visualization. *Perceptual Motor Skills, 47,* 599-604.

How prior knowledge affects students' representational and experimental competence in middle school physics

Rosa Hettmannsperger,
Wolfgang Schnotz,
Andreas Müller,
Jochen Kuhn,
Wieland Müller and
Sibel Telli
University of Koblenz-Landau
DFG-Graduate School "Processes in Education"
Thomas-Nast-Straße 44, 76829 Landau, Germany
hettmannsperger@uni-landau.de, schnotz@uni-landau.de, muellera@uni-landau.de,
kuhn@uni-landau.de, muellerw@uni-landau.de, telli@uni-landau.de

Abstract. It is a well-known fact in science education that creating multiple representations plays an essential part in understanding science. The special difficulty in physics stems from the fact that students have already developed physical concepts based on everyday experiences. Their common-sense understanding interacts with the new knowledge acquired in school. This research aims to implement instructions, which take into consideration students' prior knowledge, in order to support students in creating "scientifically appropriate" representations in the particular situation of carrying out experiments. The study was designed as pre- and post-test quasi-experimental design. Students of two classes of the 8th grade in a Gymnasium formed real pictures by using a spherical concave mirror. There are some indications that instructions adapted to students' prior knowledge - while operating on representations - improves students' conceptual understanding more than encouraging the use of various representations alone.

Keywords: conceptual change; experimental competence; geometrical optics; multiple representations; prior knowledge; representational competence

Theoretical background

Among researchers who conduct studies of science education it is a well-known fact that using different forms of representations plays an essential part in understanding and practicing science.

According to the theoretical framework for analyzing text and picture comprehension, a student constructs multiple internal representations in the process of knowledge acquisition (Schnotz, 2005). When a learner reads a text, listens to a text or observes a picture, first of all he or she forms a mental representation of the surface structure. After that a verbal or a visual pictorial filter selects the information and forwards them to the working memory. Here the verbal information leads to a propositional representation and later to the construction of a mental model, whereas the visual pictorial information leads directly to the construction of a mental model (Schnotz, 2005; 2006).

Mental models and propositional representations interact continuously with each other. On the one hand, the construction of mental models can be based on propositional representations led by cognitive schemata in the long-term memory. On the other hand new propositional information can be read off mental models in working memory and added to the former propositional representations in the long-term memory (Schnotz, 2006).

A special difficulty in science learning stems from the fact that students' already existing schemata are composed of physical concepts based on everyday experiences. This common-sense understanding of everyday physical phenomena interacts with the new knowledge acquired in school (Goldberg & McDermott, 1987; Wiesner, 1992). Students' existing concepts in long-term memory exert an influence on the construction of mental models, which can influence physical representations in the long-term memory.

The scientific community of educational and cognitive research has been discussing overcoming students' preconceptions for almost 30 years under the topic of conceptual change (Tyson, Venville, Harrison & Treagust, 1997). However, few studies investigated the interplay of preconceptions, external representations, the construction of internal mental models and experiments as a source of real world experiences in physics. This study attempts to shed some light on this relationship. As

students' prior knowledge is reflected in external representations (Cox, 1999), the analysis of students' external representations might be an appropriate instrument to collect and assess students' concepts about physics. Following the research on conceptual change and the research about fostering representational competence in physics education, instructions were developed which take into consideration students' prior knowledge, in order to support students in creating "scientifically appropriate" representations in the particular situation of carrying out experiments.

Research questions

1. Is the analysis of students' external representations an appropriate instrument to collect and assess students' concepts about physics?
2. Which kind of instructions and which kinds of tasks are useful to make students create appropriate representations in the particular situation of carrying out experiments and to foster the skills to operate on them?
3. To what extent do instructions aiming at a reinterpretation of student's prior knowledge, help students to create alternative and new representations?

Research design and methods

The domain of the study is geometrical optics. Students of two classes of the 8th grade in a "Gymnasium" (n=57)[9] formed real pictures by using a spherical concave mirror. The treatment included 3 lessons (135 minutes in total). Furthermore pre- and post-tests demanded one class hour (45 minutes) in each case. Students were taught by the same teacher.

A cognitive task analysis (Gagné, Briggs & Wager, 1988) was prepared to recognize cognitive demands of the experimental design and data analysis procedure in optics. Furthermore, the different forms of required representations were identified such as the sketch of the experimental setup, ray diagrams, table of data, verbal description and equation of magnification and diminution.

The study was designed as quasi-experimental design and two conditions were implemented: the first condition included instructions adapted to students' ideas about picture generation. In contrast, students' ideas about this issue were not addressed in the second condition. In both conditions students were encouraged to use various kinds of representations.

For example, students in the first condition (n=29) were asked to construct the picture of a candle placed before a concave mirror, during the upper half of the concave mirror is covered by an opaque cardboard. A majority of students predict that half the image would disappear. Indeed in this case the entire image remains intact and only its brightness decreases. Since light leaves in all directions from every point on the object, light from every point on the object is reflected by the mirror. Therefore, any portion of the concave mirror suffices to form a complete image.

Parallel to this task students in the second condition students (n=28) had to find out the focal point of a concave mirror by construction (the following quantities were given: the distance from the object to the concave mirror, the distance from the mirror to the real image, the size of the object, the size of the real picture and the radius of the concave mirror).

Two tests were implemented before and after the lessons: a proficiency test to assess knowledge, problem solving and the ability to deal with representations concerning picture formation and a concept test in geometrical optics. Furthermore students' worksheets were collected to assess their use of external representations.

[9] One student was excluded in the analysis, because she had cheated at the pretest. Four students were absent from school in the posttest. The sample included 14 boys and 15 girls in condition1 and 10 boys and 18 girls in condition 2.

Results and discussion

An ANCOVA revealed no significant differences in knowledge and problem-solving between both groups in the post-proficiency test. However, both a repeated measures ANOVA and a t-test indicates that both groups differed in their augmentation of conceptual understanding measured in the concept-test ($p = .004$). Students in the first condition improved more than students in the second condition (Cohen's $d = 0.86$). It has to be noticed though that the informative value is constrained by different levels of prior knowledge between both groups. Especially knowledge and problem solving measured in the pre-proficiency test between both groups varied: Students in the second condition started from better initial conditions than students in the first condition: a t-test showed a highly significant difference of the means in the pre-proficiency test ($p<.000$). A follow up study with a bigger sample size will be performed to prove the main effect and to investigate interdependent effects between variables.

References

Cox, R. (1999). Representation construction, externalized cognition and individual differences. *Learning and Instruction*, 9 (4), 343–363.

Gagné, R. M., Briggs, L. J. & Wager, W. W. (1988). *Principles of Instructional Design*. 3rd ed., New York: Holt, Rinehart and Winston, Inc.

Goldberg, F.M. & McDermott, L. C. (1987). An investigation of student understanding of the real image formed by a converging lens or concave mirror. *American Journal of Physics*, 55 (2). 108-119.

Schnotz, W. (2005). An Integrated Model of Text and Picture Comprehension. In Mayer, R. E. (Ed.). *The Cambridge Handbook of Multimedia Learning*. New York: Cambridge University Press.

Schnotz, W. (2006). Conceptual Change. In *Handwörterbuch pädagogische Psychologie*. Rost, D. H. (Ed.). Weinheim: Beltz PVU.

Tyson, M. L., Venville, G. J., Harrison, A. G. & Treagust, D. F. (1997). A multidimensional framework for interpreting conceptual change events in the classroom. *Science Education*, 81 (4), 387-404.

Wiesner, H. (1992). Verbesserungen des Lernerfolgs im Unterricht über Optik. Schülervorstellungen und Lernschwierigkeiten. *Physik in der Schule*, 30 (9), 286-290.

Can Students Really Multitask? The Case of Mobile Learning

Joke Coens,
Bert Reynvoet,
Geraldine Clarebout
Katholieke Universiteit Leuven
E. Sabbelaan 53, 8500 Kortrijk, Belgium
{Joke.Coens, Bert.Reynvoet, Geraldine.Clarebout}@kuleuven-kortrijk.be

Abstract. The advent of mobile learning offers opportunities to do two things at once in an educational context. When mobile devices are used, students can learn while performing another activity and become real educational "multitaskers". Two experiments were set up to examine the effect of performing a secondary task while learning with a mobile device. The experimental groups had to combine a learning task with a secondary task (screwing). The control group only had to perform a learning task. Additionally, participants of the experimental groups received different instructions ("doing both tasks as good as possible", "learning score is important" or "screwing score is important"). In general, the effect of condition on the learning task was rather limited. Only one significant effect was found: students of the control group outperformed the students focusing on the screwing task while learning.

Keywords: Mobile learning; multitasking.

Introduction

The advent of mobile learning offers opportunities to do two things at once in an educational context. When mobile devices are used, learning can be combined with all kind of activities (e.g., listening to an educational podcast while driving a car or jogging in the park). Students can learn while performing another activity and become real educational "multitaskers".

Within the context of mobile learning research, there is little attention to the multitasking issue (Coens, Clarebout, & Reynvoet, 2009). It seems that although it is recognized that the use of mobile devices offers opportunities for students to study where and whenever they want, the learning effect of learning/studying with a mobile device while performing another activity is actually minimal examined. This is a gap within the domain of mobile learning research and research on what the consequences are of this multitasking for learning is needed. Especially because according to research results in other domains, educational multitasking could have negative consequences for the learning performances. Furthermore, the research on educational multitasking can be important for the design of learning environments.

The main aim of this study is to address the effect of multitasking on mobile learning. Two experiments were set up to examine the effect of performing a secondary task while learning with a mobile device. Additionally, it was examined if the variable "perception of importance" (Schaefer, Krampe, Lindenberget, & Baltes, 2008; Verghese et al., 2007) had a significant effect on the learning performances. Perception of importance is included because it is assumed that what a person attends to in the real world, is largely determined by that persons goals and his/her motivational states (Eysenck, 2005). It is unlikely that within a real context, a person will perceive both tasks as equally important. For example, when someone is learning while sitting on the train, it is assumable that that person will give top priority to the travelling task, simply because he/she want to arrive at his/her destination.

Method

In both studies, participants were randomly divided in four groups. Students of the control group (iPod group) watched videos on an iPod (learning task) and completed a test on the videos afterwards. Students of the experimental groups (iPod+ groups) watched the same videos on the same iPod while they were screwing up nuts and bolts. Afterwards they completed the learning test and received a score for the screwing. Students of the three experimental groups received different instructions

("doing both tasks as good as possible" (iPod+$_{(1)}$), "learning score is important" (iPod+$_{(2)}$) or "screwing score is important" (iPod+$_{(3)}$)).

In study 2 all students additionally performed a single screwing task before they watched the videos (was not the case in study 1). They had to screw up nuts and bolts for one minute long and received a score for this. This score provided an indication for the screwing ability of the participants.

For the analyses, two scores were calculated because the test on the videos consisted of two parts. One by adding the correct answers concerning the first part (study 1: TOT_1, study 2: $TOT_{concept}$) and one by adding the correct answers concerning the second part (study 1: TOT_2, study 2: TOT_{rote}).

Results

The effect of multitasking on the learning results

In study 1, a significant effect for condition on the first part of the test was found. Students who had to combine the learning and the screwing task and who were told that is was important to get a good score on the screwing performed worse on the first part of the test then students who had not to combine the learning with the screwing (ANOVA and post-hoc (Waller Duncan); $F(3,96) = 2.92$; $p = .04$; $\eta^2 = .09$; $M_{iPod} = 11.62$; $SD_{iPod} = 2.22$; $M_{iPod+(3)} = 9.96$; $SD_{iPod+(3)} = 1.94$). For the second part of the test, no significant differences were found (ANOVA; $F(3,93) = .69$; $p = .56$; $\eta^2 = .02$).

In study 2, no significant effect for condition on the learning scores was found. There were no differences between the test scores of participants of the four conditions (MANCOVA for condition on $TOT_{concept}$ and TOT_{rote} and the number of nuts and bolts screwed in the single task condition as covariate; Wilks'$\lambda_{condition} = .87$; $F_{condition}(6,146) = 1.73$; $p_{condition} = .12$; $\eta^2_{condition} = .07$).

The effect of multitasking on the screwing

In study 1, a significant effect for condition on the score that the participants received for the screwing while watching the videos was found. Students who were told to do both tasks as good as possible screwed significant more nuts and bolts then students who were told that it was important to get a good score on the learning test (ANOVA and post-hoc (Waller-Duncan); $F(2,73) = 3.92$; $p = .02$; $\eta^2 = .09$; $M_{iPod+(1)} = 37.52$; $SD_{iPod+(1)} = 7.36$; $M_{iPod+(2)} = 31.52$; $SD_{iPod+(2)} = 7.15$).

In study 2, a significant effect for condition on the score that participants received for the screwing while watching the videos was found (ANCOVA, the number of nuts and bolts screwed in the single task setting is taken as a covariate; $F_{condition}(2,56) = 6.91$; $p_{condition} = .002$; $\eta^2_{condition} = .20$). An ANOVA Waller-Duncan post-hoc test (effect of condition on screwing score while watching the movies) revealed a significant difference between the score for screwing of participants of the iPod+$_{(3)}$ group and the score of participants of the iPod+$_{(1)}$ group and the iPod+$_{(2)}$ group. Students who were told that the screwing score was important screwed significantly more then students who were told that the learning score was important and students who were asked to do both tasks as good as possible ($M_{iPod+(1)} = 32.65$; $SD_{iPod+(1)} = 7.37$; $M_{iPod+(2)} = 31.25$; $SD_{iPod+(2)} = 9.86$; $M_{iPod+(3)} = 40.20$; $SD_{iPod+(3)} = 6.31$). It seems that the instruction that the participants received had an influence on the number of nuts and bolts that they screwed while watching the movies.

Conclusion

Two studies were presented where part of the participants were asked to perform a secondary task (screwing) while studying from an iPod. Furthermore, students of the different conditions received different instructions related to the importance of the different tasks.

In general, the effect of condition on the learning task is rather limited. Only one significant effect was found (study 1, TOT_1) and it was limited to a difference between students of the control group (they did not have to combine the learning and the screwing) and students who focused on the screwing task while learning.

Additionally, both studies reveal significant effects of condition on the secondary task (screwing scores). The effect was limited to some conditions, which means that the instruction that the participants receive influences their screwing performances.

Further research is needed that clearly shows when students are capable of addressing two tasks simultaneously in an efficient and effective way.

References

Clarebout, G., Coens, J., & Elen, J. (2008). The use of ipods in education: The case of multi-tasking. In J. Zumbach, N. Schwartz, T. Seufert, & L. Kester (Eds.), *Beyond knowledge: The legacy of competence* (pp. 75-82). Springer Science+Business Media B.V.

Coens, J., Clarebout, G., & Reynvoet, B. (2009, May). *Mobile learning: een stand van zaken.* Poster presented at the Onderwijsresearchdagen, Leuven, BE.

Eysenck, M. W., & Keane, M. T. (2005). *Cognitive Psychology: A Student's Handbook.* Hove, East Sussex: Psychology Press.

Kenyon, S. (2008). Internet use and time use: The importance of multitasking. *Time & Society, 17,* 283-318.

Lorist, M. M., Kernell, D., Meijman, T. F., & Zijdewind, I. (2002). Motor fatigue and cognitive task performance in humans. *Journal of Physiology,* 313-319.

Schaefer, S., Krampe, R. T., Lindenberger, U., & Baltes, P. B. (2008). Age differences between children and young adults in the dynamics of dual-task prioritization: Body (balance) verus mind (memory). *Developmental Psychology, 44*(3), 747-757.

Verghese, J., Kuslansky, G., Holtzer, R., Katz, M., Xue, X., Buschke, H., & Pahor, M. (2007). Walking while talking: Effect of task prioritization in the elderly. *Archives of Physical Medicine and Rehabilitation, 88,* 50-53.

Zijdewind, I., van Duinen, H., Zielman, R., & Lorist, M. M. (2006). Interaction between force production and cognitive performance in humans. *Clinical Neurophysiology, 117,* 660-667.

Maximizing Discourse in Educational MUVEs

Daniel T. Hickey,
Michael Filsecker,
Ellen Jameson
Indiana University
CRLT, 1900 E 10th St #524, Bloomington, IN 47404,, USA
dthickey@indiana.edu

Abstract. The latest in a series of design studies of *Taiga*, a 20 hour ecological sciences video game in *Quest Atlantis* (QA) explored ways of improving the quality and efficiency of the discourse between students and teachers. In order to facilitate more student agency in the process of drafting and revising in-game texts, we added new reflection questions to the activity. The questions were designed to prompt more sophisticated critical and conceptual engagement, while reducing students' need for individual feedback on each iteration from the teacher. Compared to students in the same teacher's four classes the previous year, the number of submissions was reduced from over three to less than two, gains in conceptual understanding increased slightly, and gains in achievement on externally developed items aligned to targeted standards increased significantly.

Prior Research

Much of the learning in multi-user virtual environments (MUVEs) is due to the added amount of feedback players get because they must coordinate multiple knowledgeable discourses, with the designed game and with each other (Gee, 2008). *Quest Atlantis* (QA) is an educational MUVE (Barab, Warren, & Ingram-Goble, 2008) that engages players in complex narratives involving topics and skills directly related to grades 4-7 schooling. Academic content is organized around written "quests". Players interact with each other, with Non-Player Characters (NPCs), and their teacher.

The project started with a multi-level model of formative and summative assessment from prior studies (Hickey, Zuiker, Taasobshirazi, Schafer, & Michael 2006). Three aligned levels of assessments (*close-level* formative discourse, *proximal-level* performance assessment, and *distal* achievement tests) let us make continual refinements to both the questing process *and* the proximal performance assessment while protecting the validity of the gains on externally developed achievement tests.

As reported in Hickey, Ingram-Goble & Jameson (2009), the first implementation showed that proximal and distal gains were significantly larger in the two Taiga classes than in classes using a comparison curriculum. However, submissions for the Taiga crucial quest were rather poorly done, students rarely received helpful feedback, and that the quality of the submissions did not improve upon resubmission. In the second implementation, we developed a new formative feedback rubric to address this, which led to larger gains in both proximal understanding and distal achievement. However, the formative feedback resources were sparsely utilized.

As reported in Hickey, Filsecker & Kwon (2010), the third cycle found that students receiving in-game incentives and public recognition for high-quality submissions showed significantly larger gains in understanding ($p < .02$) and achievement ($p <= .07$), compared to students in matched classrooms providing more intrinsic incentives. This revealed no evidence of Lepper & Cordova's (1992) "over-justification effect." Rather, students in the public recognition condition (a) enlisted more scientific formalism in their quests, (b) enlisted those formalisms more appropriately, (c) reported slightly *higher* intrinsic motivation towards the questing activity, and (d) slightly more improved interest in solving such scientific problems. However, during the 15-day implementation, our teacher was reviewing roughly *1500* quests. An overwhelming task. This issue constrained the scalability of the curriculum and kept the teacher away from more valuable activities such as whole class discussion.

Current Study

The most recent implementation was completed in Spring 2010. In order further refine the quest submission and revision process, the researchers made intensive refinements to the *reflections* that

accompanied each quest. This was essentially a box included at the bottom of each quest that asked students to reflect on the questing experience. Previously, many students submitted no or minimal responses, and the teachers seldom reviewed.

Refinements

Our refinements to the reflections built on contemporary insights about portfolio assessment (e.g., Habib & Wittek, 2007) that emphasize the need for strategies that help students maintain agency over the artifacts they produce. By inserting carefully crafted reflective questions to each of the quests, we hypothesized that we could cue learners how they should be engaging in the process without directly specifying what to write, avoiding students' tendency to focus in unproductive aspects of the task (i.e., "Is *this* what you want?") instead of the learning process. To capture the impact of these refinements, the open ended performance assessment was modified to provide students opportunities to engage critically and consequentially.

Results

Initial analysis of the quest submissions reveal that the students did indeed reflect more deeply during the questing process and that the questing process was less demanding on the teacher. The videotaped questing process revealed hoped-for instances of students being prompted by the reflections to go back to their quests and to related resources to revise them. The average number of submissions across quests dropped from over three to less than two.

Overall, scores on the proximal performance assessment increased slightly more this year than the previous year (7.0 versus 6.8 points). While the assessment and the scoring rubric changed across years, the relative magnitude of the gains was similar (1.4 vs. 1.5 SD). Scores on the distal achievement measure (unchanged across years) showed that the scores increased substantially more in the most recent implementation, 3.3 points versus 2.2 points. This was the difference between .47 SD and .31 SD, and was unlikely to have occurred by chance [$F(1,144) = 3.8$, $p = .05$].

Conclusion

The analysis so far shows that the inclusion of reflections appears to have resulted in a more manageable number of resubmissions, while supporting a slightly larger gain in understanding and a significantly larger gain in achievement. More interpretive analyses are currently underway to further examine these results and provide additional evidence linking specific design features to specific learning outcomes. At this point we conclude that the focus on reflections is a useful and scalable feature of artifact-intensive learning environments such as Quest Atlantis.

References

Barab, S., Warren, S., & Ingram-Goble, A. (2008). Conceptual play spaces.. In R. Ferdig (Ed.), *Handbook of research on effective electronic gaming in education* (pp. 1-20). Hershey, Pennsylvania: IGI Global publications.

Gee, J. P. (2003). What video games have to teach us about learning and literacy (1st ed.). New York; Houndmills, England: Palgrave Macmillan.

Gee, J.P. (2008). Game-Like learning: an example of situated learning and implications for opportunity to learn. In Moss et al. (eds.), *Assessment, Equity, and opportunity to learn*. Cambridge University Press. 200-221.

Habib, L., & Wittek, L. (2007). The portfolio as artifact and actor. *Mind, Culture, and Activity*, *14*(4), 266-282.

Hickey, D. T., Filsecker, M. K., Kwon, E. J. (2010). Situative consideration of incentives and competition in a multi user videogame environment. Paper presented at annual meeting of the American Educational Research Association, Denver.

Hickey, D. T., Ingram-Goble, A. A., Jameson, E. M. (2009) Designing assessments and assessing designs in virtual educational environments. *Journal of Science Education and Technology*, 18,187–208.

Hickey, D. T., Zuiker, S. J., Taasobshirazi, G., Schafer, N. J., & Michael, M. A., (2006). Three is the magic number: A design-based framework for balancing formative and summative functions of assessment. *Studies in Educational Evaluation, 32* (180-201).

Lepper, M. R., & Cordova, D. I. (1992). A desire to be taught: Instructional consequences of intrinsic motivation. *Motivation and Emotion*, *16*(3), 187-208.

Signaling and Reading Direction in a simple Computer Simulation

Günter Daniel Rey
Institute for Psychology, Department Psychology IV, Julius-Maximilians-Universität Würzburg
Röntgenring 10, 97070 Würzburg, Germany
rey@psychologie.uni-wuerzburg.de

Abstract. The experiment investigated whether layout of cause and effect affects learning for causal connections in a simple computer simulation. Students (N = 113) used an introductory text and a simulation to learn central concepts about neural networks and then took a retention and transfer test. Each learner was randomly assigned to one cell of a 2 (compliance with reading direction or not) x 2 (with or without signaling) between subjects factorial design. Students who obtained the causal connection in reading direction (the cause is positioned on the left side, the effect is placed on the right side) performed better on transfer than did students, for whom the reading direction was reversed (from right to left). Furthermore, signals that indicated the layout of the causal connection fostered transfer performance and reduced time spent with the simulation. These results are consistent with the signaling principle and the cognitive theory of multimedia learning.

Keywords: computer simulation; multimedia learning; signaling; causal connection; reading direction

Introduction

Computer simulations can be defined as programs where the user can perform experiments in controlled settings to understand how the underlying mathematical model of the simulation works. Learners can explore this model by manipulating values of (input) variables and observing the behavior of other (output) variables (de Jong, 2006). For example, a simple computer simulation can display the causal connection between net input (cause), activity function (moderator) and activity level (effect). This connection is of basic importance for neural networks, which is an interdisciplinary and mathematically challenging topic. The purpose of the present study was to investigate how such a computer simulation should be designed to optimize its instructional effectiveness.

There are several ways to present a causal connection in a computer simulation. One option is to display the causal connection in reading direction, which means that the cause is positioned on the left side while the effect is placed on the right side in the simulation. Several experiments exist for written or spoken presented text, which show that the compliance with reading direction of a causal connection improves retention and/or transfer performance (e.g., Bebout, Segalowitz, & White, 1980) and facilitates cognitive processing (e.g., Evans & Beck, 1981). However, only a few studies exist for visualizations (Hegarty, 1992; Tversky, Kugelmass, & Winter, 1991; Winn, 1982).

While all these studies, which investigated reading direction in visualizations, used non-interactive visualizations, the presented experiment utilizes a computer simulation. Presenting a computer simulation in reading direction should facilitate organizing selected images into a coherent pictorial model in the learner's working memory representing a causal connection. Therefore, learners who obtain the causal connection in a computer simulation in reading direction should perform better on retention and transfer than do students for whom the reading direction is reversed (from right to left).

The signaling principle is that people learn more deeply from a multimedia message when cues are added that highlight the organization of the essential material (Mayer, 2005b). The theoretical rationale is that working memory is limited and can be easily overloaded by additional multimedia instructional messages, which contain too much detail, embellishment or gratuitous information. Signaling directs the learner's attention toward essential material, thereby enabling the learner to ignore extraneous material and use all available cognitive capacity to process essential material (Mayer, 2005b).

For multimedia messages and scientific graphs, empirical evidence for the signaling principle is partly or entirely supported by experimental studies (e.g.,Boucheix & Guignard, 2005; Mautone & Mayer, 2001, 2007; Shah, Mayer, & Hegarty, 1999). Given that the effects are not strong and are based on only a few experiments, Mayer (2005b) concluded that the signaling principle should be

considered preliminary. The presented experiment investigates the principle in a simulation, which presents a causal connection. It is hypothesized that signals facilitate selecting and organizing relevant information into a coherent representation in working memory. It is predicted that signals, which indicate the layout of the causal connection, foster retention and transfer performance in simulations.

Method

Participants and Design

The participants were 113 undergraduate freshmen (91 women and 22 men). All students indicated that they lacked experience in neural networks. The mean age of the participants was 22.04 (*SD* = 3.63). Each student served in one cell of a 2 x 2 between subjects factorial design. The first factor was the direction of the causal connection (left to right vs. right to left), the second factor was the presence of static signals (with signals vs. without signals) about the direction of the causal connection.

Instrument and Materials – Tasks

For each participant, the computerized materials consisted of an introductory text about neural networks, a computer simulation, and a retention and transfer test. The introductory text contained approximately 900 words and two figures about neural networks. The four experimental conditions only differed in compliance with reading direction and the existence of signals in the simulation. The first condition "left to right" adhered to reading direction and contained static signals. So, the net input (cause) was placed on the left side of the illustration, while the activity level (effect) was positioned to the right side. Signals were added in terms of labels and arrows, which indicated the compliance with reading direction. The labels "Netto-Input" (net input) and "Aktivitätslevel" (activity level) above their numerical values specified the thermometers. Two arrows points to compliance with reading direction. The second condition also received the causal connection in reading direction, but without signals. The third and fourth groups received the causation in opposition to reading direction. In these conditions, the net input was displayed on the right side, while the activity level was placed on the left. The third condition contained signals (labels and two arrows from right to left), while the fourth group did not.

The retention test consisted of ten multiple choice questions. Each question included between two and five response options where only one answer was correct. Retention questions could be answered with the given information without additional inference information. The transfer test consisted of seven multiple choice questions and three questions in open response format. The multiple choice questions included between two and five response options and the open response format contained text boxes. In all transfer questions inferences had to be drawn from the presented information.

Procedure

The participants completed the entire experiment at their own rate and without any time limit. On average they spent about 20-30 minutes with the instructional text and computer simulation. First, subjects received the introductory text followed by the simulation. While working with the computer simulation students no longer had access to the introductory text. After finishing the simulation participants answered the retention and transfer questions.

Results and Discussion

Students who received the causal connection in reading direction did not remember significantly more concepts on the retention test than did students who received the causal connection from right to left, $F(1, 109) = 3.67$, $p = .06$. Students who received the causal connection in reading direction scored significantly better on the transfer test, $F(1, 109) = 7.73$, $p < .01$. The effect sizes (Cohen's d) were 0.36 on retention and 0.53 on transfer. Students who received the causal connection in reading direction, did not spend significantly more time with the simulation, $F(1, 109) = 0.09$, $p = .77$, $d = 0.05$. Students who received signals did not remember significantly more concepts on the retention test

than did students who did not receive signals, $F(1, 109) = 0.04$, $p = .85$. Students who received signals scored significantly better on the transfer test, $F(1, 109) = 4.61$, $p < .05$. The effect sizes were 0.04 on retention and 0.41 on transfer. Students who received signals spent significantly less time in the simulation than did students who did not receive signals, $F(1, 109) = 7.23$, $p < .01$, $d = 0.51$.

Overall, learners who obtained the causal connection in reading direction performed better on transfer than did students for whom the reading direction was reversed. Signals, which indicated the layout of the causal connection, fostered transfer performance and reduced time spent with the computer simulation. On the practical side, causal connections in computer simulations should be presented in reading direction. Furthermore, static signals like labels and arrows should be added that highlight the organization of the essential material to improve learning outcome and reduce time spent with the computer simulation. On the theoretical side, the present results are consistent with the Cognitive Theory of Multimedia Learning (Mayer, 2005a), particularly with the signaling principle.

References

Bebout, L. J., Segalowitz, S. J., & White, G. J. (1980). Children's comprehension of causal constructions with "because" and "so". *Child Development, 51*, 565-568.

Boucheix, J.-M., & Guignard, H. (2005). What animated illustrations conditions can improve technical document comprehension in young students? Format, signaling and control of the presentation. *European Journal of Psychology of Education, 20*, 369-388.

de Jong, T. (2006). Computer simulations - Technological advances in inquiry learning. *Science, 312*, 532-533.

Evans, J. S. B., & Beck, M. A. (1981). Directionality and temporal factors in conditional reasoning. *Current Psychological Research, 1*, 111-120.

Hegarty, M. (1992). Mental animation: Inferring motion from static displays of mechanical systems. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18*(5), 1084-1102.

Mautone, P. D., & Mayer, R. E. (2001). Signaling as a cognitive guide in multimedia learning. *Journal of Educational Psychology, 93*, 377-389.

Mautone, P. D., & Mayer, R. E. (2007). Cognitive aids for guiding graph comprehension. [Journal; Peer Reviewed Journal]. *Journal of Educational Psychology, 99*, 640-652.

Mayer, R. E. (2005a). Cognitive theory of multimedia learning. In R. E. Mayer (Ed.), *The Cambridge Handbook of Multimedia Learning* (pp. 31-48). Cambridge, MA: Cambridge University Press.

Mayer, R. E. (2005b). Principles for reducing extraneous processing in multimedia learning: Coherence, signaling, redundancy, spatial contiguity, and temporal contiguity principles. In R. E. Mayer (Ed.), *The Cambridge Handbook of Multimedia Learning* (pp. 183-200). Cambridge, MA: Cambridge University Press.

Shah, P., Mayer, R. E., & Hegarty, M. (1999). Graphs as aids to knowledge construction. *Journal of Educational Psychology, 91*, 690-702.

Tversky, B., Kugelmass, S., & Winter, A. (1991). Cross-cultural and developmental trends in graphic productions. *Cognitive Psychology, 23*, 515-557.

Winn, W. (1982). The role of diagrammatic representation in learning sequences, identification and classification as a function of verbal and spatial ability. *Journal of Research in Science Teaching, 19*, 78-89.

More than Fun and Games: Using Computer-based Simulations to Enhance Change Management Competencies

Sabine Seufert
Tanja Fandel-Meyer
Swiss Centre for Innovations in Learning (scil), University of St. Gallen
Dufourstr. 40a, 9000 St.Gallen, Switzerland
sabine.seufert@unisg.ch; tanja.fandel@unisg.ch

Abstract. This paper presents and discusses a computer-based simulation to improve change management competencies. In light of the continuous changes today, the competencies to deal and cope with change is a major topic in management education. Although, simulations are widely used in the field, to determine the potential for learning and building competencies through simulations still remains an open question. In the following paper, the simulation "EduChallenge" will be introduced. This simulation follows a design-based research methodology and demonstrates the use of simulations to develop competencies in the field of management education. The focus of the research study is to evaluate the transfer impact of the simulation-based training on the learning outcomes which are defined as changes in knowledge, beliefs/attitudes, and skills to successfully implement and execute change management initiatives. Based upon a transfer evaluation the potential and limitations of using computer-based simulations to enhance change management competencies will be discussed.

Keywords: Computer-based simulation; Game-based Learning; Change Management, Management Education.

Introduction: The Role of Simulations in Management Education

Simulations have been used to bring to the classroom various aspects of the business world and have been becoming increasingly more prevalent in the education system (Salas, Wildman & Piccolo 2009, p. 559; Zantow, Knowlton, Sharp 2005, p. 451). Simulations are used widely in management education to provide a "real-world" perspective. According to Bell, Kanar & Kozlowski (Salas & Wildman, 2008, p. 560) a simulation can be defined as "any artificial or synthetic environment that is created to manage an individual's (or team's) experiences with reality". Consequently, simulations can provide various potential benefits for learning and competence development. Simulations can demonstrate the application of theory and provide learners with a risk-free environment in which to explore roles, make mistakes and learn from them. Furthermore, it allows for learning in an environment similar to the one in which the learner works. This eases the process of transferring knowledge and competencies gained to other situations (see Schönwald et al., 2006). Due to the gaming element and the dynamics of the simulation, it can be assumed that students are more likely appreciative of the course content. As a consequence, they participate more actively in the training than they would with other teaching methods (Zantow, Knowlton, Sharp 2005, p. 451).

Even though simulations are already used widely in the field of management education, it is seldom used for developing so called "soft-skills" such as change management competencies (Angehrn et al., 2009). Furthermore, the majority of the literature focusing on simulation in management education describes the current state of simulation technology, but does not provide enough guidance as to how to effectively utilize simulations to develop competencies of management students in order to support long-lasting learning effects (Salas, Wildman & Piccolo 2009, p. 560). As a consequence, the following paper adresses this gap by introducing the computer-based simulation "EduChallenge" to demonstrate how a simulation can be of use in the development of change management competencies.

The Simulation "EduChallenge": A Learning Environment for Change Management

The EduChallenge Simulation is the key component of a learning experience designed for a facilitated group of participants interested in extending their understanding of change management processes in educational institutions such as universities, training departments or learning organizations in general. The simulation was developed as a joint project of two universities and can be classified as a simulation exercise even though it includes some "game-like elements" such as a competitive factor. Within the simulation, participants working in groups are challenged to introduce a new quality

management system in one university department. They have up to 6 months of (simulated) time to convince as many as possible, of the 22 members of the division's management team, to adopt this innovation. During the simulation, the 'change agents' can choose among many different initiatives and change management tactics to meet their goal. As participants implement a tactic, they immediately receive feedback about the impact of their decisions. The objective is to get as many adopters as possible. A number of models and insights from the literature on change management, as well as more generally from social psychology, organizational behavior, social network analysis, and higher education research, have been integrated in the simulation in order to reflect specific organizational dynamics of higher education to increase the realism of the individual or collective behaviors displayed by the simulated agents. The following graph illustrates the dynamics of the simulation.

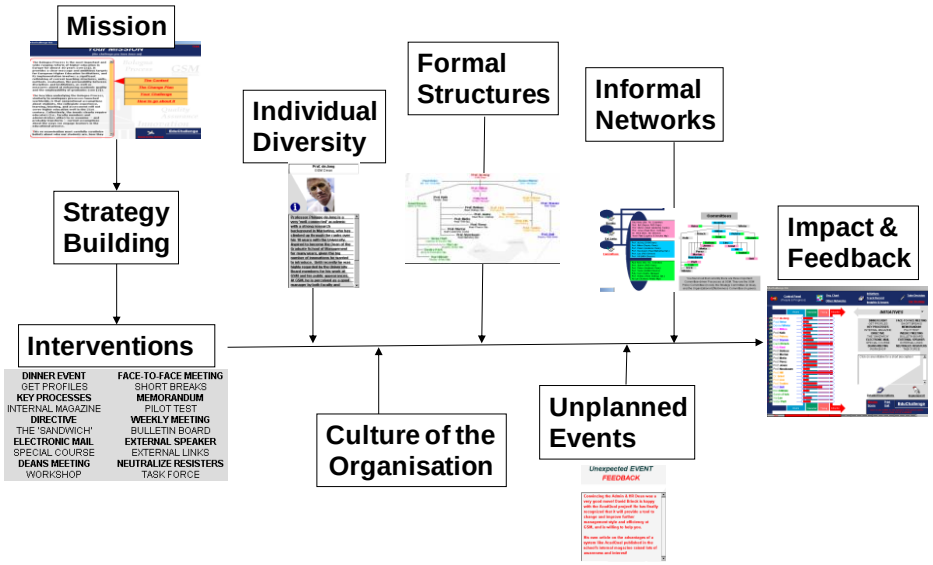


Figure 1: The underlying dynamics of the simulation "EduChallenge"

The primary objective of EduChallenge is to provide participants a rich and realistic experience in a change management project. It helps learners to broaden their understanding of change management processes in various ways. This `hands-on experience´ as a change agent will serve as motivation and starting point for the participants to discuss and learn about a number of specific theories of change. It consolidates and builds upon their understanding of the underlying complexity of change management in areas such as acknowledging individual diversity, understanding and dealing with resistance, and selecting effective interventions. The aim of the simulation is primarily to help players become more aware of their own models and of their own limitations (see Argyris, 1982 for a distinction between 'espoused theory' and 'theory-in-use'). This was the main reason for designing the simulation particularly 'challenging' in terms of succeeding with the assigned mission. Participants should become frustrated from the result of not succeeding in persuading enough individuals modeled in the simulation. It is assumed that this experience of frustration reflects the real practice of change management and also to gain the awareness of the complexity for the learners. However, the transfer from playing to learning does not happen automatically. In order to help participants to derive meaningful insights from the simulation experience, the simulation gaming phase should be followed by a reflection phase. Starting the debriefing session after the teams have completed the simulation experience is an important moment from a pedagogical perspective. Within this stage, the participants have to switch back from an 'action' into a 'reflection' mode.

Research Study: Research questions, methodology and findings

The development and implementation of EduChallenge follows a designed-based research approach. Based on this paradigm (Euler & Sloane, 1989; Design-Based Research Collective, 2003; Reinmann, 2005; Peterson, & Herrington, 2005) and according to Reeves (2000, p. 26) research should address complex problems, in real life contexts, in collaboration with practitioners. For practical

meaningfulness, research and related designs should integrate design principles with technological affordances to render plausible solutions to these complex problems and conduct rigorous and reflective inquiry to test and refine innovative learning environments as well as to define new design principles. In the frame of a design-based research approach, EduChallenge has been formatively evaluated in the development process several times (Schönwald et al., 2006). The leading research question on developing the simulation is: "How to build and develop competencies of learners to successfully lead and execute change initiatives?"

According to the competence matrix of Euler & Hahn (2004), competencies are activity-based and consist of knowledge, beliefs/attitudes, and skills. Learning outcomes can be regarded as changes in these activity fields. Thus, learning can be defined as an active process in which learners engage in activities that lead to changes in knowledge, beliefs and/or change practices (skills). In research studies it is common to categorize learning outcomes according to this threefold distinction. Since the emotional aspects and dealing with resistance of involved stakeholders is a major issue in change management, a particular focus is set on attitudes as learning outcomes. Subsequently, the research study addresses the following research questions:

- What impact does the simulation-based training with EduChallenge have on learning transfer outcomes in general (transfer competencies)? In particular, how can learners overcome emotional barriers to successfully implement change management initiatives (transfer attitudes)?
- Which learning outcomes in relation to individual change and organizational change do learners report (transfer behaviour)?

For that reason, a transfer evaluation has been conducted with 20 participants of a designed change management program. To assess the impact of learning activities on individual and organizational change (Kirkpatrick, 1996) framework is applied. In order to get significant results, the involved respondents have to give concrete examples of individual learning outcomes as well as of organizational change as done by the research study of Tushman et al. (2007). The results demonstrate that using a computer-based simulation helps to sensibilize learners for possible upcoming problems and also support the competencies of reflection on how to manage change. Within the paper the results will be further discussed. The paper closes with a discussion of potentials and limitations for the effective use of the simulation techniques to promote change management competencies in organizations.

References

Angehrn, A.; Maxwell, K. & Luccini, M. & Rajola, F. (2009). Designing Effective Collaboration, Learning and Innovation Systems for Education Professionals. International Journal of Knowledge and Learning (IJKL), Vol. 5, No.3/4 pp. 193 - 206.

Argyris, C. (1982). Reasoning, Learning and Action. Individual and Organizational. San Francisco: Jossey-Bass.

Design-Based Research Collective (2003) Design-Based Research: An Emerging Paradigm for Educational Inquiry. Educational Researcher, Vol. 32, No. 1, 5-18.

Euler, D. & Sloane, P. (1994). Aktuelles Stichwort „Organisationsentwicklung". Kölner Zeitschrift für „Wirtschaft und Pädagogik", 6, 123-141.

Euler, D., & Hahn, A. (2004). Wirtschaftsdidaktik. Bern: Haupt.

Kirkpatrick, D. L. (1996). Evaluating training programs. The four levels. San Francisco: Berrett-Koehler.

Peterson, R., R. & Herrington, J. (2005). The State of the Art of Design-Based Research. In G. Richards (Ed.), Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2005 (pp. 2302-2307). Chesapeake, VA: AACE

Reeves, T. C. (2006). Design research from the technology perspective. In J. V. Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), Educational design research (pp. 86-109). London: Routledge.

Reinmann, G. (2005). Innovation ohne Forschung? Ein Plädoyer für den Design-Based Research-Ansatz in der Lehr-Lernforschung. Unterrichtswissenschaft, 33(1), 52–69.

Salas, E., Wildman, J., & Piccolo, R. (2009). Using Simulation-Based Training to Enhance Management Education. Academy of Management Learning & Education, 8(4), 559-573.

Schönwald, I., Euler, D., Angehrn, A., & Seufert, S. (2006). Educhallenge learning scenarios designing and evaluating learning scenarios with a team-based simulation on change management. SCIL Report (Bd. 8). St. Gallen: Swiss Centre for Innovations in Learning (SCIL), University of St. Gallen.

Tushman, M. L., Fenollosa, A., McGrath, D. N., O'Reilly, C. & Kleinbaum, A. M. (2007). Relevance and Rigor: Executive Education as a Lever in Shaping Practice and Research. Academy of Management Learning & Education, 6(3), 345-362.

Zantow, K., Knowlton, D.S. & Sharp, D. (2005). "More Fun and Games: Reconsidering the virtues of strategic management simulations", Academy of Management Learning and Education, 4(4): 451-458.

Defining Game-Based Learning: A Review on Gaming Elements in Computer-Based Learning Environments

Sylke Vandercruysse[a,b]
Mieke Vandewaetere[ab,]
Geraldine Clarebout[a,b]
[a] *iTEC, Interdisciplinary Research on Technology, Communication and Education, KU Leuven – Campus Kortrijk, E. Sabbelaan 53, 8500 Kortrijk, Belgium*
[b] *CIP&T, Centre for Instructional Psychology and Technology, KU Leuven, Andreas Vesaliusstraat 2, 3000 Leuven, Belgium*
{firstname.lastname}@kuleuven-kortrijk.be

Abstract. According to Bergeron (2006), recently, a new interest in the use of video games for learning has emerged. Video games are considered as a means to enhance knowledge, skills and attitudes and are thus considered as a new instructional technology with great potential. However, effectiveness research on game-based learning is highly susceptible to a muddle of approaches, methodologies and descriptions of gaming for educational purposes. Therefore, we will first deal with the question how games can be defined. To do so, game elements will be brought into focus. Additionally, we will present a review of effectiveness studies in game-based learning research, and discuss their strengths and weaknesses.

Keywords: Game-based learning, game elements, instructional design; effectiveness research.

Introduction

Games as learning environments are considered as a new instructional technology with great potential (Becker, 2007). Video games are considered as a means to enhance knowledge, skills and attitudes, which is shown in the increased attention that has been given by different scholars to games (Akilli, 2007; Gee, 2003; Hayes & Games, 2008; Ke, 2009; Papastergiou, 2009a).

From this conceptual viewpoint, a lot of effectiveness is claimed about the use of games. Notwithstanding the large amount of research on (educational) games, no univocal and generic definition has arisen. Also, even in defining the characteristics of a game, no general descriptions have emerged. In defining games, the common approach is to list the game elements one considers as essential. Since not all authors emphasize the same features and give them the same relevance, an extensive and detailed description of game and its elements is necessary and should be common in every research article related to educational gaming. For now, comparing the effectiveness of educational or serious games as such is not possible, as no studies are referring to similar descriptions and categorization of games.

In this review, we want to sketch the empirical research on the effectiveness of game elements, rather than for games as a whole. Defining the educationally effective parts of a game might be a first step towards a conceptual research framework for educational gaming. As Aldrich (2005, p. 80) stated, "*Rather than thinking about games and simulations, it is more productive to think about the distinct elements.*".

What makes a game a game?

In this part we will give an overview of the different games elements retrieved in literature. In our discussion of the elements, it will become clear that in the same way as there is not a clear definition on what a game is, there is a fair amount of discussion on what elements are crucial to constitute a game. In Table 1, an overview is given of the elements constituting a game, as reported in literature (e.g., Akilli, 2007; Alessi & Trollip, 2007; Bergeron, 2006). Also, the presupposed benefits for learners and the learning process are listed.

Table 1: Gaming elements

Possible elements of a game	Presupposed benefits of the element
1. Fun	enjoyment, pleasure, motivation
2. Play	intense involvement, absorbing
3. Rules	Structure
4. Goals and objectives	Motivation
5. Interactive	Doing
6. Adaptive	Flow
7. Outcomes & feedback	Learning
8. Win states	ego gratification
9. Conflict/competition/challenge	Adrenaline
10. Problem solving	Creativity
11. Interaction	social groups
12. Representation & story	Emotion

This research

Although research on educational games is flourishing as a research field and numerous studies have been published, the empirical evidence to support this assumptions is still limited and conflicting (Kashibuchi & Sakamoto, 2001; Ke, 2008; Ke, 2009; Papastergiou, 2009b). So the educational effectiveness of the games, or specific elements of these games is unclear. Hence, our review aims to answer the question whether there is any empirical evidence that specific educational game elements are beneficial for motivation or can enhance learning processes.

Method

A literature search was performed in 3 databases, namely ERIC (EBSCOhost), PsycINfo (OvdiSP), and Web of Science (SSCI). The following descriptors were used: "educational game*", "serious game*", "game-based learning", "game* AND education*" and "gaming AND education*. The terms "learning" and "research" were respectively used to focus the search. Only peer-reviewed articles were included in this review and no date limits were set. This search resulted in 464 articles.

The abstracts of the articles were read independently by three researchers and were scored 1, 2 or 3 according to their relevance with 1 being strongly relevant, 2 as case of doubt and 3 as not relevant. These scores were based on different criteria: the article must describe (quasi-) experimental research that made use of a computer based game in an educational setting. Ideally, it describes an effectiveness research. Articles that complied to all the above mentioned criteria received a 1-score.

In total, from the 464 abstracts, only 38 got score 1 by at least two raters, 357 abstracts were excluded because they got twice or three times a 3 score, 54 abstracts were kept in doubt and 15 articles received 3 different scores from the 3 researchers. Of the 38 approved articles, 33 were read through completely and summarized in a table. In sum, only 19 articles reported on empirical evidence of the use of computer based educational games in an educational setting and were therefore considered as eligible for discussion.

Results and Conclusion

After scoring the abstracts it was remarkable that the articles resulting from the search strips with "serious game*" did not remain. This means that most of the researchers use the notion 'educational game' and that the notion of 'serious game' is not often applied in research on effectiveness of game-based learning. This is not the case for all the thematic relevant literature, but it concerns the results of the search on empirical research conducted in this review.

For our discussion of the outcomes of our literature search, we start from the assumption that three key factors are indispensable in research focusing on the implementation of games in educational

settings. Firstly, there is the environment in which the content (e.g., science, history, geography) and form (e.g., multiplayer games, virtual reality games) is taken into consideration, and the game with gaming elements as well. Secondly, the mediating variables are discussed, being among other things, learner characteristics such as gender, prior knowledge and motivation. Third, the learning results (e.g., learning outcomes, attitude change, engagement, acceptance) will come up for discussion. Next to the key factors, the relations between these three factors are considered. In our review, we discuss these three key factors thoroughly and refer to work that does or does not supports the positive claims that have been made related to game-based learning.

References

Akilli, G.K. (2007). Games and simulations: A new approach in education? In D.G Gibson, C.A. Aldrich, & M. Prensky (Eds.), *Games and simulations in online learning: Research and development frameworks.* Hershey, PA: Information Science Publishing.

Aldrich, C. (2005). *Learning by doing: The comprehensive guide to simulations, computer games, and pedagogy in e-learning and other educational experiences.* San Francisco: Pfeiffer.

Becker, K. (2007). Pedagogy in commercial video games. In D.G Gibson, C.A. Aldrich, & M. Prensky (Eds.), *Games and simulations in online learning: Research and development frameworks.* Hershey, PA: Information Science Publishing.

Gee, J.P. (2003). *What video games have to teach us about learning and literacy.* New York, NY: Palgrave Macmillan.

Hayes, E.R., & Games, I.A. (2008). Making computer games and design thinking. A review of current software and strategies. *Games and Culture, 3*(3-4), 309-332.

Kashibuchi, M., & Sakamoto, A. (2001). The educational effectiveness of a simulation/game in sex education. *Simulation Gaming, 32,* 331-343.

Ke, F. (2008). Computer games application within alternative classroom goal structures: cognitive, metacognitive, and affective evaluation. *Educational Technology Research and Development, 56,* 539-556.

Ke, F. (2009). A qualitative meta-analysis of computer games as learning tools. In R.E. Ferdig (Ed.), *Handbook of research on effective electronic gaming in education (pp. 1-32).* Kent state: Information Science Reference.

Papastergiou, M. (2009a). Online computer games as collaborative learning environments prospects and challenges for tertiary education. *Journal of Educational Systems, 37*(1), 19-38.

Papastergiou, M. (2009b). Digital game-based learning in high school computer science education: impact on educational effectiveness and school motivation. *Computer & Education, 5*(1)2, 1-12.

Students' navigation in a Wikipedia reading task

Ladislao Salmerón [1],
Raquel Cerdán [1],
Pilar García-Carrión [1],
Johannes Naumann [2],
Gema Tavares [1]
[1] University of Valencia - Avd. Blasco Ibáñez, 21, 46010, Valencia, Spain
[2] German Institute for International Educational Research - Schloßstraße 29
60486 Frankfurt am Main, Germany
lasalgon@uv.es, raquel.cerdan@uv.es, magarca3@alumni.uv.es, naumann@dipf.de,
getasan@alumni.uv.es

Abstract. This study explored the strategies that students use to select hyperlinks during task oriented reading in a Wikipedia document. We tested current models of hyperlink navigation that propose that students always assess the semantic relation between their goal and the existing hyperlinks in a document. Our study investigated eight-graders' navigation while they were reading a Wikipedia document to answer a set of questions. The results challenge the core assumption of current navigation models, and suggest that young students select hyperlinks based on a strategy of word matching: they select a hyperlink if it contains similar words as those included in their study goal (i.e. a particular question), independently of the semantic relevance of it.

Keywords: hyperlink navigation; matching strategy.

Introduction

In task-oriented reading students are provided with a set of questions and they are instructed to use a document, such a Wikipedia page, to answer them. While reading and searching for answers, students must evaluate the multiple embedded hyperlinks that are usually included in Wikipedia documents. Some of the links may be highly relevant for students' goals (i.e. answer a particular question), and many other might be totally irrelevant.

Current models such as the SNIF-ACT (Fu & Pirolli, 2007) propose that students assess the semantic relationship between their goal and the existing hyperlinks in the document (see also the CoLiDeS model (Blackmon et al., 2005; Kitajima et al., 2005) and CoLiDeS+ (Juvina & Van Oostendorp, 2008). These models consider that students read the document hyperlinks and decide which one contains more relevant information for them after a semantic comparison between the links and their particular goal. Evidence for these models comes mostly from simple fact searching tasks (i.e. selecting a page to buy a flight ticket), and mostly from university students.

An alternative model, the Matching strategy, proposes that readers may select a hyperlink provided that it includes a word match which is also literally present in the question, independently of the semantic relationship between them (Cerdán, Gilabert & Vidal-Abarca, in press). For example, imagine that while learning about the French Revolution, the readers saw a question such as "Why did peasants benefit from the popular revolts during the French Revolution, after they took the Novelty castles around France?" The Wikipedia document may include two embedded links: "Live conditions in the country-side after the Revolution" and "The Novelty castles in France". Although only the first link would certainly include relevant information to answer the question, some students may decide first to select the second link because is the only one that includes a positive word matching with parts of the question. Younger students may be more inclined to use this matching strategy, because they often guide their selection of hyperlinks by salient superficial cues, such as word typography (Rouet et al, in press).

Our aim was to test the semantic and matching models of hyperlinks selection in a sample of young students. To answer this question we performed an experiment in which eight-graders answered a set of questions about the French Revolution using a Wikipedia document, while their navigation paths were recorded.

Method

FirstFifty-five eight-grade students from a private school participated in the experiment (mean age 14.2 years, 51% female, mostly Caucasian). 4 participants were excluded from the analyses because they fail to follow the instructions. Participants' task was to navigate through a Wikipedia document about 'The French Revolution' to answer a series of questions. The main document was an adapted version of an on-line document developed by a professional teacher, and distributed by the Spanish Minister of Education. The main document was composed of 1559 words, and was organized in three main sections (Causes, development and consequences of the Revolution), and 10 subsections. Eight sections included 3 embedded hyperlinks to additional 24 Wikipedia documents.

We constructed two types of questions following the PISA framework (OECD, 2002): retrieving and interpreting. Retrieving questions required participants to select and extract specific pieces of information from a linked document. On the other hand, interpreting questions demanded students to connect several pieces of information through inferences within the main document and a linked document. After being presented with a question (e.g. "Why does the King defeat the new revolutionary laws emerged in the National Assembly, after the Storming of the Bastille?"), participants were told to go to a specific subsection of the main Wikipedia document to answer that question. In each subsection there were three links: 1) a relevant hyperlink that was signaled in the question (either explicitly [e.g. "New revolutionary laws"] or thorough a paraphrase [e.g. "Novel legal order"]), and that pointed to a document that included information necessary to answer that particular question, 2) a irrelevant-signaled link that was always explicitly signaled in the question (e.g. "Storming of the Bastille"), and that pointed to a document with irrelevant information for that question, and 3) an irrelevant-non signaled link that was not included in the question.

Students were presented with one question at a time, and were guided to the main subsection of the main document that included information relevant for that question

Results

We focused in students' navigation data in two sets of analyses: first we explored students' initial hyperlink selection, and second we checked students' hyperlink selection pattern for those questions in which they had initially selected the irrelevant-signaled link.

With regard to students' initial selections (i.e. just after reading a particular question), an ANOVA with type of hyperlink (relevant and irrelevant) and matching condition (explicit and paraphrase), showed an effect of type of hyperlink (F (1,50)=19.37, p=.001, η^2=.28). Participants initially accessed the relevant link more often (M= 30.63%; SD = 22.69) than the irrelevant-signaled link (M= 19.44%; SD = 19.01). We found no effect of matching condition, F(1,50)=3.48, p=.07, η^2= .06. Finally, the interaction between the variables reached significance levels, F(1,50) = 16.36, p= .00, η^2= .25. LSD post-hoc analyses showed that students first accessed the relevant link more often than the irrelevant-signaled link (M= 38.91, SD=25.30; M= 14.77, SD=15.91, respectively) in the explicit condition (i.e. when the question included the exact wording of the relevant link), but their selection did not differ in the paraphrase condition (M= 22.35; SD=20.08; M= 24.11; SD=22.11) (i.e. when the question included the paraphrase of the relevant hyperlink). In addition, post-hoc analyses showed that the students in the explicit condition accessed first the relevant link more often than those in the paraphrase condition. The opposite was found for the irrelevant-signaled link.

We further explored students' navigation behavior only for the questions in which they had first accessed the irrelevant-signaled link. For these, we computed if students just afterwards selected the relevant link or not. In the explicit condition, students either always accessed the relevant link afterwards (M=35.71% of participants) or always ignored the relevant link afterwards (M= 57.14%), χ^2 (9, N=28) =84.00, p<.00. By contrast, in the paraphrase condition, most students ignored the relevant link afterwards (M= 48.57%), other accessed the relevant link just in some cases (M= 28.50%), and few always accessed the relevant link afterwards (M= 22.85%), χ^2 (9, N=35) = 105.00, p<.00.

Conclusions

Our results concur with the matching strategy model, and challenge current models that conceive students' hyperlink selection only as a semantic process. Although students clearly identified and selected the relevant hyperlinks when the question included the very same words of a relevant link (i.e. word-matching), they were equally inclined to select either a relevant or irrelevant hyperlink if the question only included a word-match to the irrelevant link (i.e. paraphrase condition). These results suggest that students may find it difficult to decide which link to select when the relevant one for a specific task requires a semantic conversion (i.e., paraphrase) and there is simultaneously a competing link that shares superficial features with the original task, either words such as in the present experiment (Cerdán, et al., in press) or typography distracters (Rouet et al., in press). In such cases, the simple overlapping of words between the task and a specific link may be equally salient than performing a more demanding semantic analysis, at least for younger students.

In the explicit condition, in which were present both word-matching-based cues to both the relevant and the signaled-irrelevant link, students were more prone to choose the relevant link. This result may indicate that both a matching-based and a semantic-based analysis guided students to selecting the relevant link. By contrast, in the paraphrase condition, in which we suppressed the word-based superficial cues for the relevant link, the competing word-based irrelevant cues gained over a semantic-based analysis and students tended to select more often the irrelevant but signaled hyperlinks. Therefore, in the absence of word-based superficial indicators to relevant links, and in the competing presence of similar cues to irrelevant information, the matching model may be more explicative of students' hyperlink selection.

Data from students' navigation after having discarded an initially selected irrelevant link also point in this direction. In those cases, students selected afterwards the relevant link more often in the explicit condition, in which there was a word-matching with the relevant link. This result may support the previous interpretation that, when both word-based matching and semantic relevant cues compete, students may guide their selections on a combination of superficial and semantic-based indicators. In the absence of word-based cues for relevant information, students' decision to select a link may mostly depend on other word-based cues, even if they point to irrelevant hyperlinks.

In further analyses we will explore the influence of individual differences, such as comprehension and navigation skills, in students' navigation behavior. Also, we will test the extent to which individual factors and navigation impact students' performance.

References

OECD (2003). The PISA 2003 assessment framework. Mathematics, reading, science and problem solving knowledge and skills. Paris, France: OECD.

Rouet, J.-F., Ros, C., Goumi, A., Macedo-Rouet, M. & Dinet, J. (in press). The influence of surface and deep cues on primary and secondary school students' assessment of relevance in Web menus. *Learning and Instruction.*

Effects of Self-Explanation Scaffolds in Video-Based Worked-Out Examples on Emotions and the Acquisition of Complex Skills in Medical Education

Lena Hofmann,
Karsten Stegmann,
Frank Fischer,
Matthias Siebeck
University of Munich
Leopoldstraße 13, 80802 München, Germany
lena.hofmann@psy.lmu.de, karsten.stegmann@psy.lmu.de,frank.fischer@psy.lmu.de,
matthias.siebeck@med.uni-muenchen.de

Abstract. Emotions play an important role in learning processes and outcomes. When fostering complex skills linked to negative emotions worked-out examples combined with self-explanation scaffolds could be helpful to enhance learning by enhancing self-efficacy through planning how to act. Videos can be used as worked-out examples especially when no predetermined solution is available because demonstrating content in context. In our study 152 medical students learned the complex skill of delivering a cancer diagnosis which is linked to coping with negative emotions. We examined the effects of video-based worked-out examples with a) principle-based scaffolds, b) reasoning scaffolds, and their interaction on negative emotions and acquisition of delivering a cancer diagnosis. We found a positive effect of the reasoning scaffolds on complex skills. Furthermore, negative emotions regarding breaking bad news (BBN) were lower after learning with worked-out examples than before. No effects of the scaffolding types on emotions were found.

Keywords: video-based worked-out examples, self-explanation; medical education

In medical education learning goals are on the one hand medical factual knowledge, on the other hand advanced complex skills like communication. However, some skills in medical education like breaking bad news (BBN) are connected with negative emotions. Acquisition of communication skills in conjunction with self-efficacy regarding BBN may support medical students also to cope with these negative emotions (Hojat, Gonnella, Erdmann, & Vogel, 2003). Protocols like SPIKES (Baile et al., 2000) provide steps how to appropriately communicate BBN situations. Worked-out examples have been broadly applied to support skill acquisition. There is a huge body of evidence that worked-out examples enhance skill acquisition and self-efficacy under certain conditions (Renkl, 1997; Schworm & Renkl, 2007), especially if self-explanations are scaffolded. Our question is, to what extend worked-out examples affect skill acquisition and emotions and to what extend specific self-explanation scaffolds may moderate the effects on skill acquisition and emotions.

Worked-out examples. Worked-out examples can serve as expert models and are especially helpful to enhance performance, problem solving skill, and self-efficacy when combined with self-explanations (Crippen & Earl, 2007). Two successful self-explanation styles can be distinguished (Renkl, 1997): Reasoning and principle-based explanation. Reasoning self-explanations comprise (a) that a learner tries to develop an own solution including reasons and (b) compares them afterwards with the solution provided in the worked-out example. Principle-based explanations comprehend that learners refer to a principle behind the goal structure and elaborate on it.

Video-based worked-out examples. Scaffolding to support these self-explanation styles to foster complex skills have hardly been investigated in video-based worked-out examples. The advantage of using videos as worked-out examples is the demonstration of content within an authentic context (Ertelt, 2007). Especially in ill-structured domains without "prepackaged prescriptions" videos can foster deep learning and prepare for later professional performance (Spiro, Collins, & Ramchandran, 2007). McLaren, Lim, Gagnon, Yaron and Koedinger (2006) successfully implemented video-based worked-out examples, but did not include the support of self-explanation activities.

Worked-out examples and emotions. Worked-out examples have been broadly used in domains, like math, where negative emotions like anxiety occur because learners do not know how to act, may negatively affect the acquisition of complex skills (Atkinson, Sharon, Renkl, & Wortham, 2000). However, effects of worked-out examples on emotions were usually not reported. Worked-out examples may reduce negative emotions by supporting coping strategies like planning how to act (Baile et al., 2000). Against this background, learning with worked-out examples may reduce negative emotions mediated through skill acquisition.

Research question

To what extent do principle-based scaffolds, reasoning scaffolds and the interaction thereof affect negative emotions and the acquisition of complex skills when learning with video-based worked-out examples?

Method

In a 2X2 pre-post design we implemented a video-based worked-out example and varied principle-based scaffolding (without vs. with) and reasoning scaffolding (without vs. with). 152 medical students at the LMU Munich were randomly assigned to one of the four conditions. The learning session on breaking bad news (BBN) is a mandatory module of the Medical Curriculum Munich (MeCuM). After a short introduction, learners were asked to read a 2000 words summary on the SPIKES (15 minutes). Negative emotions regarding BBN situations were measured before and after the worked-out example using four items with a 5-point Likert scale (25 minutes). The questions addressed to what extent learners feel anxiety and inhibition regarding BBN situations. The reliability of the scales were sufficiently high (pre-test: Cronbach's alpha = .75; post-test: Cronbach's alpha = .76). The skills regarding the BBN were measured before and after the worked-out example with a video-based test. The learners watched three single video-based examples without instructional explanations from two different simulated BBN situations per test. The order of the two situations was balanced, i.e. both served randomly for 50% of the students as pre-test or as post-test (and vice versa). The learners were asked to describe how they would act after each episode. The answers were coded with a coding scheme based on SPIKES (Baile et al., 2000). The amount of steps listed according to the SPIKES served as measure for the skill regarding BBN. To exclude effects of the different simulated BBN situations we z-standardised the scores for each situation separately. A question-based skill test asked four open questions about the SPIKES before and after the worked-out example. 30 minutes were given for the video-based worked-out example that lasts 11 minutes. This video showed a simulated BBN situation where a medical student in the role of the doctor delivers a cancer diagnosis to a standardized patient. It was segmented into 11 episodes. For each episode, learners could open an analyses of the acting of the doctor according to the SPIKES and suggestions how to do better (comment of an expert). In addition, three episodes were stopped before the doctor took action. Learners were asked how they would proceed. These gaps were implemented to trigger self-explanations before comparison with the comment of the expert. The principle-based scaffolds asked learners explicitly to apply the SPIKES protocol when they were asked to fill a gap. The reasoning scaffolds asked learners to elaborate on their solution.

Results and Discussion

We found a positive effect of the video-based worked-out example on skill acquisition and negative emotions regarding BBN. They were lower after learning with the worked-out examples than before, but no effects of the scaffolding types on emotions were found. No effect of the principle-based scaffolds was found.

Our assumption that video-based worked-out examples can reduce negative emotions is supported by these results. Further analyses have to show to what extend the effect on negative emotion is mediated by the skill acquisition and self-efficacy. In addition, the role of negative emotions on skill acquisition has to be revealed. Process analyses may allow answering why the self-explanation scaffolds had not the expected effects on skills and negative emotions. Maybe the prior knowledge of the learners plays an important role: Renkl's (1997) observation that principle-based explanations are preferably created by learners with low prior knowledge may be tested in further analyses.

Overall, video-based worked-out examples seem to be an effective means to facilitate the acquisition of communication skills and reduction of negative emotions in medical education.

References

Atkinson, R. K., Sharon, J. D., Renkl, A., & Wortham, D. (2000). Learning from Examples: Instructional Principles from the Worked Examples Research. *Review of Educational Research, 70*(2), 181-214.

Baile, W. F., Buckman, R., Lenzi, R., Glober, G., Beale, E. A., & Kudelka, A. P. (2000). SPIKES-A six-step protocol for delivering bad news: application to the patient with cancer. *The Oncologist, 5*(4), 302-311.

Crippen, K. J., & Earl, B. L. (2007). The impact of web-based worked examples and self-explanation on performance, problem solving, and self-efficacy. *Computers & Education, 49*(3), 809-821.

Ertelt, A. (2007). *On-Screen Videos as an Effective Learning Tool. The Effect of Instructional Design Variants and Practice on Learning Achievements, Retention, Transfer, and Motivation.* Albert-Ludwigs Universität, Freiburg im Breisgau.

Hojat, M., Gonnella, J. S., Erdmann, J. B., & Vogel, W. H. (2003). Medical students' cognitive appraisal of stressful life events as related to personality, physical well-being, and academic performance: A longitudinal study. *Personality and Individual Differences, 35*(1), 219-235.

McLaren, B. M., Lim, S.-J., Gagnon, F., Yaron, D., & Koedinger, K. R. (2006, June 26-30). *Studying the effects of personalized language and worked examples in the context of a web-based intelligent tutor.* Paper presented at the 8th International Conference on Intelligent Tutoring Systems, Jhongli, Taiwan.

Renkl, A. (1997). Learning from worked-out examples: A study on interindividual differences. *Cognitive Science, 21*, 1-29.

Schworm, S., & Renkl, A. (2007). Learning argumentation skills through the use of prompts for self-explaining examples. *Journal of Educational Psychology, 99*(2), 285-296.

Spiro, R. J., Collins, B. P., & Ramchandran, A. (2007). Reflections upon a Post-Guttenberg Epistemology for Video Use in Ill-Structured Domains: Fostering Complex Learning and Cognitive Flexibility. In R. Goldman, R. D. Pea, B. Barron & S. Derry (Eds.), *Video research in the learning sciences*. Mahwah, NJ: Lawrence Erlbaum Associates.

The use of interactive learning tasks in a computer-based self-regulated learning environment

Felix Kapp,
Susanne Narciss,
Hermann Körndle
TU Dresden
Dresden, Germany
kapp@psychologie.tu-dresden.de

Abstract. Web-based learning requires a high grade of self-regulation. One possibility to support learners in coping with these challenges is to provide them with interactive learning tasks. Learning tasks have been proved to be an effective support for learners (Hamaker, 1986). This explorative study reports findings on the use of interactive learning tasks in a computer-based learning environment on intellectual property. 39 learners participated in the study. Based on a significant pre-post learning effect follow-up analysis were conducted for low and high achievers regarding their learning activities before and after working on the learning tasks. Results reveal different learning paths and patterns concerning the use of text and interactive learning tasks. High achievers had text study phases and massed work on learning tasks. In contrast low achievers tended to switch immediately between text and learning tasks.

Keywords: interactive learning tasks, Self-Regulated Learning, computer-based learning environment (CBLE)

Introduction

Web-based learning requires a high level of self-regulation (Azevedo & Cromley, 2004; Narciss, Proske & Körndle, 2007). One possibility to support learners in coping with these challenges of self-regulated web-based learning is to provide them with interactive learning tasks. Interactive learning tasks permit multiple-try solution possibilities and include informative tutoring feedback (Körndle, Narciss & Proske, 2009). Working on learning tasks can facilitate the learner's retention and understanding of learning material, the learner's knowledge organization and application, as well as the learner's assessment of his progress of knowledge and skill acquisition (Narciss, Proske & Körndle, 2004).

Based on a review Hamaker (1986) reported that learning tasks have an effect on learning achievement. This review excluded learning tasks with informative feedback and studies from the field of computer-based instruction. Yet, it is a widely acknowledged assumption in educational research that learning tasks are useful in CBLEs as well. The purpose of the study was to identify effects of systematically constructed interactive learning tasks on the process of self-regulated learning in CBLEs.

Method

Participants and Procedure: 39 students and research assistants of the Dresden University of Technology, Germany were invited to a 90 minute learning session about intellectual property. In the first 15 minutes they were asked to draw a mind map concerning all their knowledge about intellectual property. Afterwards they worked 50 minutes with the CBLE and finished the session drawing another mind map and answering the multiple choice knowledge test (25 minutes).

Design and Material: A pre-posttest design was used. Learners navigated in an environment with a horizontal menu of four main chapters and a vertical menu of the related subchapters. The subject of the CBLE was intellectual property. Material contained 17 subchapters with advanced organizers, content related pictures, examples, short summary sentences and 17 interactive learning tasks with informative tutoring feedback (Narciss, 2006). Each interactive learning task was constructed based on the content of one specific subchapter. All 17 interactive learning tasks were multiple choice questions in a single-best choice format. The informative tutoring feedback consisted of knowledge of result, specific information about why it was correct or wrong and in case of a wrong answer additional

information which supports the learner to find the correct solution on his/her own. After the second incorrect trial the learning environment presents the correct solution.

Achievement measures: Learner's achievement in the pre- and post-test was assessed by a) a mind map test consisting of drawing all their knowledge about intellectual property using squares to picture concepts and lines to indicate relationships between concepts and b) a post-knowledge test consisting of 25 multiple choice items. Mind maps were analyzed using a rubric with four categories.

Learning activities: To gain information about the learning process the logfiles were analysed with regard to a) the use of interactive learning tasks, b) study time of the several sub-chapters and c) learning sequence. Time on tasks and the correct and incorrect attempts of answering the interactive learning tasks were also recorded in the data base and included in statistical analyses.

Results and conclusion

Achievement: 39 persons participated in the pre-, post - mind map and in the multiple choice knowledge tests. Data analysis of pre- and post-tests revealed a significant learning effect (M_{pre} = 0.18, SD_{pre}=0.51, M_{post}=2.21, SD_{post}=1.15, $t(38)=2.21$; $p<.05$).

Learning activities - Log files: Learners worked on M=15.26 interactive learning tasks (*SD* = 3.26). An average of 10.38 (*SD* = 2.79) was solved correctly in the first attempt, 2.44 (*SD* = 1.67) in the second trial and 1.62 (*SD*= 1.48) were answered incorrectly. The average study time in the learning environment was 53.87 minutes (*SD*= 8.89). This time was invested in text pages and interactive learning tasks. Mean time on learning tasks was 9.24 minutes (*SD* = 3.89). The number of accessed subchapters was *M*=25.54 (*SD* = 11.25). Several subchapters were accessed more than once. For more information explorative analysis of learning path and use of learning tasks for low (the 10 lowest testscores) and high achievers (the 10 highest testscores) were conducted. Figure 1 shows the learning behaviour of a low achiever, Figure 2 the one of a high achiever. In both figures the cumulative learning time is shown on the y-coordinate, the accessed subchapters are indicated with the numbers 1 to 17 on the x-coordinate. The corresponding interactive learning tasks are marked with the numbers -1 to -17. The learning environment suggested a sequence from subchapter 1 to 17 dividing the 17 pages in 4 main chapters (subchapter 1 to 6, 7 to 10, 11 to 13 and 14 to 17).

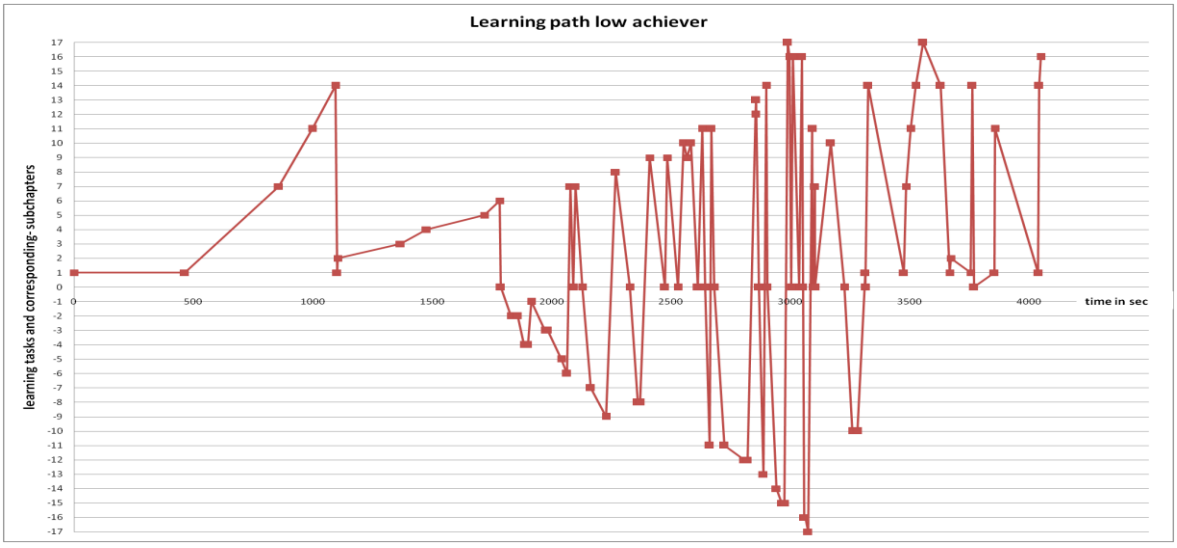


Figure 1. Learning path of a low achiever.

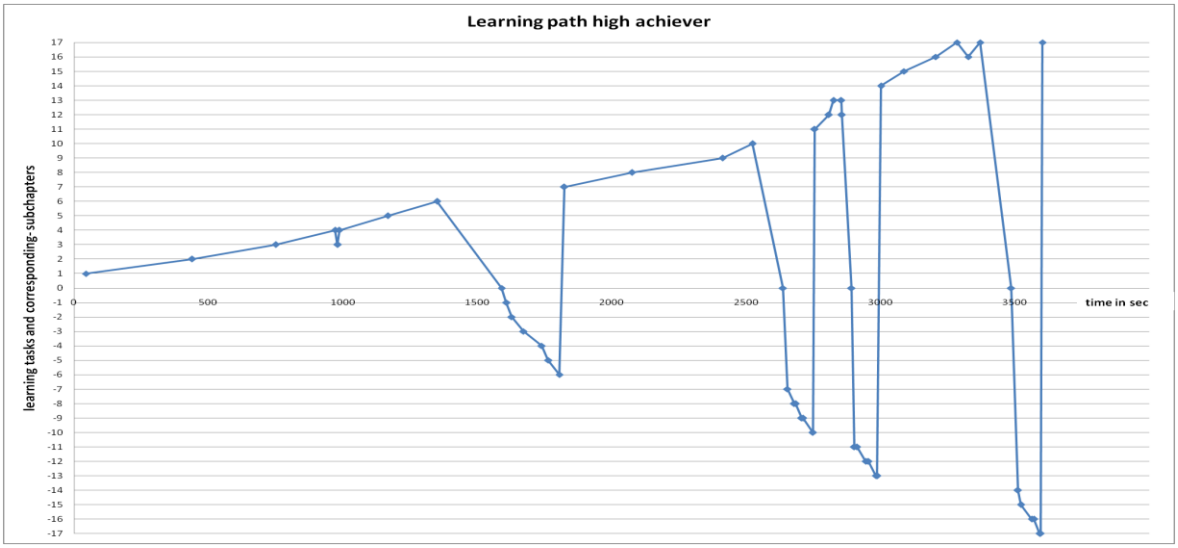


Figure 2. Learning path of a high achiever.

Explorative data analyses of learning sequences and the interaction between text studying periods and interactive learning tasks show different use of the provided material between low and high achievers. Whereas high achievers used a straight study strategy following the suggested sequence and only interrupt in a few cases to go back to previous subchapters, low achievers seem to skip around from one subchapter to the next without a straight plan. Furthermore high achievers used the learning tasks in a kind of blocked study schedule consisting of text study phases followed by phases in which they answered the learning tasks relating to these texts of the four main chapters. In contrast, low achievers tended to switch immediately between studying text pages and the work on learning tasks. In some cases high achievers went back to a previous subchapter after getting feedback in the corresponding learning tasks. Revision in case of incorrect answers on the one hand and a straight learning strategy on the other hand is behaviour associated with successful learning. This provides first empirical support for different regulation behaviour concerning the use of learning tasks within CBLE.

Further research with an experimental paradigm is necessary. A special focus should be on the use of interactive learning tasks in self-regulated learning environments and the question of how the learning process is affected by them.

References

Azevedo, R., & Cromley, J. G. (2004). Does Training on Self-Regulated Learning Facilitate Students' Learning With Hypermedia? *Journal of Educational Psychology, 96*(3), 523-535.

Hamaker, C. (1986). The effects of adjunct questions on prose learning. *Review of Educational Research, 56,* 212-242.

Körndle, H., Narciss, S., & Proske, A. (2009). Developing and evaluating tools for web-based learning and instruction. In M. W. Greenlee (Ed.), *New issues in experimental and applied psychology. A Festschrift for Alf Zimmer* (pp. 127-164). Lengerich: Pabst Science.

Narciss, S. (2006). Informatives tutorielles Feedback. Entwicklungs- und Evaluationsprinzipien auf der Basis instruktionspsychologischer Erkenntnisse. *Reihe Pädagogische Psychologie und Entwicklungspsychologie* (Band 56). Münster: Waxmann.

Narciss, S., Proske, A., & Körndle, H. (2007). Promoting self-regulated learning in web-based learning environments. *Computers in Human Behavior, 23*(3), 1126-1144.

Narciss, S., Proske, A., & Körndle, H. (2004). Interaktive Aufgaben für das computergestützte Lernen. Vom ersten Entwurf bis zur technischen Realisierung. In U. Schmitz (Hrsg.*), Linguistik lernen im Internet. Das Lehr-/Lernportal PortaLingua* (S. 193-206). Tübingen: Gunter Narr.

The Impact of a Training of Questioning on Transfer

Frauke Kämmerer,
Helmut M. Niegemann
University of Erfurt
Nordhäuser Straße 63, 99089 Erfurt, Germany
frauke.kaemmerer@uni-erfurt.de
Preference: Poster presentation

Abstract. Questioning as a learning strategy can improve text understanding and learning outcomes because it stimulates elaborations. In this research project we compare two forms of training (question stems vs. question prompts) experimentally. We aim at empirically based statements about the effectiveness of a computer-based training of questioning. We consider the number and quality of questions according to the PREG model asked by students. Results of the pre-test with 37 students from grades 8 and 9 show that there is an advantage of question prompts concerning near transfer ($t(32)=2.719$; $p=.01$). Effect size $d=.85$ reveals a high effect for the whole number of questions.

Keywords: Questioning; computer-supported learning; text understanding; evaluation

Need for the Study

There are two main reasons why it is important to pay attention to the questions of students: the fact, that students rarely ask questions in lessons and the shortcomings in previous training studies.

Questions in lessons

Questioning as a learning strategy can contribute to text understanding and learning outcome (e.g. Graesser & Person, 1994; Neber, 2004). Students, however, rarely ask questions in lessons and teachers normally do not support questioning of students. One student asks 1.3 to 4 questions on average in one lesson. However, these questions are usually not so called deep-reasoning questions (Graesser & Person, 1994; Niegemann & Stadler, 2001). Therefore, there is a need for training students in questioning.

Shortcomings of previous studies

Previous studies have shown that some trainings of questioning can result in higher level questions and better learning outcomes (e.g. Graesser & Person, 1994). However, these studies have some shortcomings, e.g. (a) different forms of training (e.g. question prompts and question stems) have not yet been examined experimentally and (b) the quality of questions has not yet been considered appropriately.

Theoretical background

The PREG model (Spanish "pregunta" means question) predicts the occurrence of questions during text understanding on three different cognitive levels (Otero & Graesser, 2001): text surface, text base and situation model. Students received training on these three levels of understanding.

(a) Text surface: learners seek to understand the meaning of a certain word. An example for question prompts is "What is the meaning of "industrialization"?". An example for question stems is "What is the meaning of …?".

(b) Text base: learners seek to understand the relation of propositions in a text. An example for question prompts is "What is the reason for the industrialization in the 18th and 19th century Europe?". An example for question prompts is "What is the reason for …?".

(c) Situation model: learners seek to construct relations between propositions in a text and their prior knowledge. An example for question prompts is "How is the development of trains related to the introduction of standard time zones?". An example for question stems is "How is … related to …?".

Research question and hypotheses

This paper deals with one of our research questions concerning transfer: Are there any differences between the two forms of training (question prompts, question stems) concerning near transfer? We expect students receiving training with question prompts to show better transfer to a topic from the same subject (history) compared to students receiving training with question stems (near transfer). We suppose modeling to be responsible for this effect (Bandura, 1977). That is, students learn better how to ask questions with the help of fully formulated question prompts instead of question stems. From this research question we derived three hypotheses:

Hypothesis 1: We expect students receiving training with question prompts to ask more questions in the post-test on near transfer. Hypothesis 2: We expect students receiving the training with question prompts to ask more questions on a low cognitive level (text surface). Hypothesis 3: We expect students receiving training with questions prompts to ask more questions on a high cognitive level (text base and situation model).

Method

37 students (23 girls, 14 boys; mean age: 14.16 years) of two grammar schools participated in this study. The training consisted of six sessions. In the first session students read a history text about the Roman Empire and were asked to formulate all the questions they have (pre-test). In the 2nd, 3rd and 4th session students received the training with question stems and question prompts. In these sessions students read texts about the industrialization. Students in the "question prompts" condition were asked to choose the questions while reading the text. Students in the "question stems" condition were asked to complete the question stems while reading the text. Students in both conditions were also able to formulate questions themselves. In the fifth session students read a history text about the crusades in the Middle Ages. They were again asked to formulate questions on their own (post-test on near transfer). In the sixth session students received a biology text about antibiotics. While reading they were again asked to formulate all the questions they have (post-test on far transfer).

To test our hypotheses we considered the number and quality of questions. First of all, we counted the whole number of questions asked by students in the post-test on near transfer. After that, we judged the quality of questions according to the PREG model. Then we counted the number of questions on each of the three levels of understanding. We considered questions on text surface to have a low cognitive level and questions on text base and situation model to have a high cognitive level.

Analyses and Findings

To test our hypotheses we conducted t-tests. Table 1 shows the results of the t-tests.

Table 1: Results of the t-tests

	H1: whole number			H2: text surface			H3: text base + situation model		
	Question prompts	Question stems		Question prompts	Question stems		Question prompts	Question stems	
N	17	17		17	17		17	17	
M	7.12	4.18	sig.	4.47	2.47	sig.	2.65	1.71	n.s.
SD	3.407	2.877	d=.85	2.672	2.095	d=.78	2.234	1.649	
	t-test for independent samples								
	t(32)=2.719; p=.01			t(32)=2.429; p=.02			t(32)=1.397; p=.172		

Hypothesis 1: The conducted t-test shows a higher number of questions for the question prompt condition with a high effect size for the whole number of questions. That is, we can accept our first hypothesis. Hypothesis 2: The conducted t-test shows a higher number of questions for the question prompt condition with a median effect size for the number of questions on text surface. Therefore, we can also accept our second hypothesis. Hypothesis 3: The conducted t-test shows no significant difference in the number of questions on a high cognitive level between the two conditions. Therefore, we have to reject our third hypothesis.

Discussion

Considering the quality of questions, the results revealed that the higher number of questions in the question prompt condition was due to the higher number of questions on the low cognitive level (text surface). The desired increase in questions on a high cognitive level, however, could not be shown. There seems to be a need for training on a high cognitive level.

Future research and practical implications

The results of the presented study indicate that students may need further assistance for the formulation of questions on a high cognitive level. In a next step, we therefore modify the training: first, we will concentrate on training on high cognitive levels, i.e. we plan to eliminate training on text surface. Results of the pre-test have shown that students are able to formulate questions on this level. Second, we will integrate two different forms of feedback into the training: students will receive answers to their questions and they will also receive feedback on the quality of their questions. Furthermore, we have to test if there is a difference between question prompt and question stem condition in the test on far transfer.

References

Bandura, A. (1977). *Social learning theory*. Eaglewood Cliffs, NJ: Prentice-Hall.

Graesser, A. C., & Person, N. K. (1994). Question asking during tutoring. *American Educational Research Journal, 31*(1), 104-137.

Neber, H. (2004). Förderung epistemischen Fragens im Religionsunterricht. *Unterrichtswissenschaft, 32*(4), 308-320.

Niegemann, H. M., & Stadler, S. (2001). Hat noch jemand eine Frage? Systematische Unterrichtsbeobachtung zu Häufigkeit und kognitivem Niveau von Fragen im Unterricht. *Unterrichtswissenschaft, 29*(2), 171-192.

Otero, J., & Graesser, A. C. (2001). PREG: Elements of a Model of Question Asking. *Cognition and Instruction, 19*(2), 143-175.

Designing Multimedia for Effective Self-Regulated Learning

Tatjana Ruf,
Cornelia Hauss,
Rolf Ploetzner
University of Education
Kunzenweg 21, 79117 Freiburg, Germany
tatjana.ruf@ph-freiburg.de

Abstract. This paper describes research in progress on how to avoid structural and conceptual disorientation by means of self-regulated learning in multimedia learning environments. Multimedia systems offer many possibilities for self-regulated learning yet at the same time place high demands on the learners' self-regulatory skills. The focus of this research project is on how self-regulated learning in multimedia learning environments can be supported through (a) an innovative design of the multimedia system and (b) the encouragement of appropriate self-regulatory activities by the students. In order to examine these research questions, we are designing a multimedia learning environment which is both adaptable and adaptive. The subject matter is cell biology and genetics. The multimedia system serves as a test bed for empirical studies.

Keywords: Self-regulated learning; multimedia; usability.

Multimedia learning environments are commonplace in today's society. And while they promise to support learning in many different ways, they do not always exploit their full potential. On the one hand, a multimedia system offers the user the possibility to engage in more self-regulated learning. For example, learners might decide what topic they want to learn and which kind of representation to use. Learners might also be able to choose between different pathways and retrieve information in an order that seems most appropriate to their learning needs. On the other hand, flexible multimedia systems often place high demands on the learners' cognitive systems. For instance, in order to determine which information to search for and process next, learners require self-regulatory skills (Bannert, 2007). A prerequisite for accomplishing this task is that the learner has gained knowledge about the structure of the information space as well as about the navigation possibilities available. Furthermore, the learner has to evaluate to what extent the information that they have found conforms to their informational needs. Finally, the learner has to integrate the information into a coherent knowledge structure. It is assumed that students differ in their willingness and ability to engage in self-regulated learning and therefore require varying degrees of support (Brockett & Hiemstra, 1991).

One essential problem often observed in multimedia learning is disorientation of the learners. Two forms of disorientation are distinguished: structural and conceptual disorientation (e.g. Conklin, 1987; Ploetzner & Härder, 2001; Heiß, 2007). Problems concerning structural disorientation are known as the "lost in hyperspace" phenomenon. Structural disorientation is related to the physical space of a multimedia or hypermedia system and denotes a missing or incorrect idea about the system's structure. Conceptual disorientation is related to the *conceptual* space of a multimedia system and characterizes a missing or incorrect representation of the subject matter and its relationships. This project focuses on two main research questions: (1) How can structural disorientation be avoided through the design of the learning environment? and (2) how can conceptual disorientation be avoided by inducing appropriate self-regulatory activities of the students through the use of adaptable prompts?

In order to examine these questions, we are designing an adaptable and adaptive multimedia learning environment in cooperation with other computer scientists and psychologists. The learning material is made up of various representations of cell biology and genetics. The multimedia environment is based on ILIAS, an open source learning management system. From the perspective of the learner, the most important component is the user interface; it provides an interaction model that supports self-regulated as well as system-controlled learning.

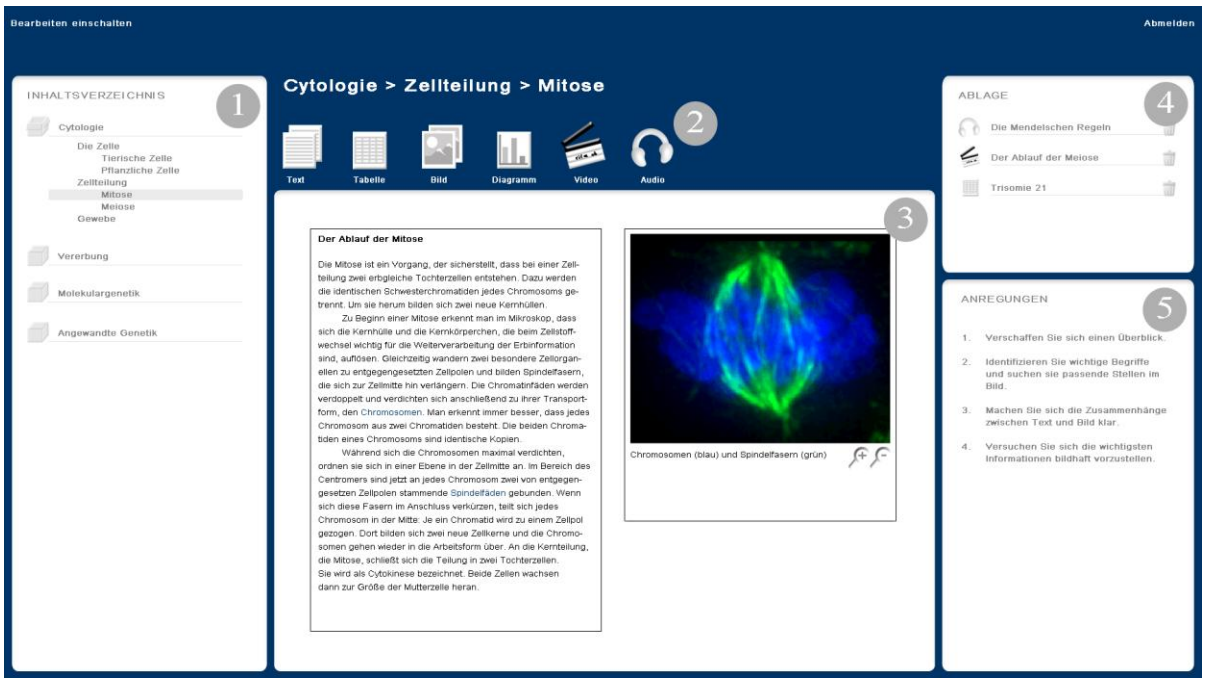


Figure 2: The user interface of the multimedia learning environment

As shown in Figure 1, the user interface comprises five main areas. The navigation area (1) organizes the learning units into courses, chapters and sections. Each learning unit consists of several re-presentations such as texts, tables, pictures or animations. While some of theses representations might be redundant, others might complement each other. The different representations in a learning unit are available to the learners by means of the media shelf (2). The content area (3) displays those representations which are currently being viewed. Stored representations of previous learning units are listed in the tray (4). The prompting area (5) shows prompts which induce self-regulatory activities.

In the self-regulated mode, the learner navigates freely through the learning units, drags the preferred representations from the media shelf and drops them into the content area. He or she may use different representations at the same time and store representations in the tray for later use. Specific combinations of representations trigger adaptable prompts which encourage self-regulatory activities as well as the use of representation-specific learning techniques (Kombartzky et al., in press). In the system-controlled mode, the learner has to follow a pre-specified path and utilize the pre-selected representations. Prompts are not adaptable in this mode.

Three empirical studies are currently in progress. The first study is a usability test. Although usability is often mentioned as a prerequisite for effective learning with multimedia (e.g. Harms, 2005), very few learning environments employed in studies of human learning are actually designed according to the principles and guidelines of usability research, much less do they follow the process of user centered design. Yet this approach may help to reduce structural disorientation in a multimedia environment thus enabling the student to focus on learning the subject matter. Results of the first study will be presented at the conference.

In the second study, system-controlled learning is compared to user-controlled learning. This study will primarily investigate how different levels of self-regulatory skills interact with system- and user-controlled learning. The observations made in this study will form the basis for the development of prompts that aim at encouraging self-regulatory activities. Both the content of the prompts, namely how to formulate differently specific prompts that correspond to the self-regulatory skills of the learners, as well as the way they are presented to the learners, i.e. how to make sure that the learners notice and take advantage of them, are of importance.

The third study examines whether the developed support measures improve learning. User-controlled learning will be observed in three different experimental conditions. The first group will be

provided with the prompts but can decide independently whether or not to make use of them. The second group will also be provided with the prompts and will be strongly encouraged to process them. The third (control) group will not be given the prompts. We expect that learners who receive the prompts and process them as a function of their self-regulatory skills will show minimal conceptual disorientation and therefore exhibit the largest learning gains.

Thus, with respect to the learning environment envisioned, adaptability has two different meanings. The first meaning denotes the possibility to adapt learning contents, external representations and learning paths to one's informational needs. The second meaning is related to the possibility to adapt system-provided learning assistance to one's self-regulatory abilities.

Acknowledgements

This research project is part of the cluster "Adaptable and adaptive multimedia systems" within the WissenschaftsCampus Tübingen, Germany. It is supported by the State of Baden-Württemberg and related to cooperating projects conducted by Alexander Renkl (University of Freiburg), Katharina Scheiter (Knowledge Media Research Center) and Gottfried Zimmermann (University of Tübingen).

References

Bannert, M. (2007). Metakognition beim Lernen mit Hypermedien: Erfassung, Beschreibung und Vermittlung wirksamer metakognitiver Strategien und Regulationsaktivitäten. [Metacognition in learning with hypermedia: Collection, description and mediation of effective metacognitive strategies and regulatory activities]. Münster: Waxmann

Brockett, R. G. & Hiemstra, R. (1991). Self-direction in adult learning: Perspectives on theory, research and practice. New York: Routledge.

Conklin, J. (1987). Hypertext: An introduction and survey. *IEEE Computer*, *20*, 17-41.

Harms, I. (2005). Usability-Engineering: Theoretische Implikationen und praktische Umsetzung. [Usability-Engineering: Theoretical implications and practical implementation]. In C. Igel & T. Abel (Hrsg.), *Handbuch eLearning* (S. 129-153). Schorndorf: Hofmann.

Heiß, A. (2007): Desorientierung beim Lernen mit Hypermedien. Förderung struktureller und konzeptueller Orientierung. [Disorientation when learning with hypermedia. Promotion of structural and conceptual orientation]. Münster: Waxmann

Kombartzky, U., Ploetzner, R., Schlag, S., & Metz, B. (in press). Developing and evaluating a strategy for learning from animation. Learning and Instruction.

Ploetzner, R. & Härder, J. (2001). Unterstützung der Verarbeitung externer Repräsentationen am Beispiel des Lernens mit Hypertexten. [Support of processing external representations on the example of learning with hypertexts]. *Unterrichtswissenschaft*, *29* (4), 367-384.

Participation under Compulsion

Petra Grell, Prof. Dr.,
Franco Rau
University of Potsdam, Department Educational Science
Karl-Liebknecht-Str. 24-25, 14476 Potsdam, Germany
petra.grell@uni-potsdam.de; franco.rau@uni-potsdam.de

Abstract. Benefits of Social Software in teaching and learning are a research subject of great interest, especially in higher education. The possibilities to encourage students' participation are promising, but there is a neglected area we intend to point out: heteronomy. Compulsion and external control are used to enhance participation. In our study we examined international evaluation and research papers, where Social Software was implemented to engage students' participation within courses. We identified several contradictions within these descriptions. Few authors consider that students might pretend to "play the game" due to assessment regulations. The tension between students' self-responsibility and external control in education needs to be reflected systematically.

Keywords: Participation; Heteronomy; Resistance; Social Software; Higher Education.

Tremendous opportunities and hidden heteronomy

Benefits of Social Software in teaching and learning are a topic of great interest, especially in higher education. It would be "foolish to ignore the tremendous opportunities" (Wheeler 2009, p. 4). The possibilities to encourage students' participation are promising: enhancing autonomy and collaboration, sharing experiences, higher grades of participation, learning through peer review, instant feedback. (Hardy, Pinto & Wei 2008, Grosseck 2009)

Even though these possibilities appear to be promising to encourage students' participation, there is a neglected area we intend to point out: the tension between heteronomy and self-determination in a course. Often assigned collaboration becomes part of assessment. Teachers initiate the collaborative learning process by setting the rules. Due to the assessment criteria external control and compulsion become part of the learning environment. Theses (hidden) elements of external control within innovative and cooperative learning settings are neglected. Anderson & Lin (2009) reported that blogs helped "with resource sharing, aided in learning course concepts, and encouraged the creation of a strong collaborative community" (p. 246). But the issue of heteronomy within their participatory setting is not mentioned. We think it is important to focus on the autonomy-heteronomy-dilemma within courses using Social Software. The core of this study is an analysis and discussion of research and evaluation papers.

A Lack of Participation

1. *Participation on a voluntary base (with sweetener)*

There are case studies on the topic of voluntary participation (Safran 2008, Cole 2009). Explicit precondition in Safran's case study was the voluntary basis of blogging. Safran explains the low engagement of student: "The low rate of 30% of the students who engaged in the blogging activity, and the results of the pre- and post-study surveys both hint on a relatively low knowledge and level of experience with weblogs." (p. 135). Safran discusses no other explanations. One may assume that the students act self-determined and that the blogging didn't make sense from their subjective point of view.

Cole (2009) determines whether a wiki environment supports student engagement to create a module-level knowledge repository for undergraduates (Cole 2009, p. 143). Several pedagogical changes were made to integrate the wiki activity. The assessment structure was modified to encourage them. But the students' wiki-activity was low. "After 5 weeks (halfway through the teaching term) there had been zero posts to the wiki. [...] students were only interested in participating with the pre-set learning activities" (p. 144). From our point of view this lack of participation on a voluntary basis indicates that within an informal setting Social Software based collaboration is really different from collaboration in formal teaching and learning settings.

2. *Mandatory collaboration and peer feedback*

Some teachers/researchers try to enhance participation and collaboration through obligatory interactive parts of coursework. For example: Student groups were obliged to communicate with other groups about same topics via Wiki, in order to overcome learning/working in small groups and create an atmosphere of collaboration (Jadin 2007). The results were not promising. Blogs and Microblogs were offered by Ebner & Maurer (2009) to enhance reflection, discussion and quality. Ebner & Maurer found out that weblog-communication and peer feedback did not happen in the intended way, "... the most positive effect of weblogs usage was that the students wrote about a topic over a longer period of time" (p. 56). The missing communication was "...maybe a fact of the learning behavior – Learners are doing mainly what teachers want to" (p. 54). They knew from similar experiments in former years: "Mandatory discussion contributions lead to no increasing lecture outcome" (p. 55). In these papers the approach to enhance participation under compulsion partly fails. On the other hand, Xiao & Lucking (2008) describe a wiki-book-setting with obligatory peer feedback (at two predetermined dates instead of continuity), which seemed to work. Thus, there are promising results and descriptions of failure related to mandatory collaboration.

Contradictions and Questions

Nevertheless in several papers (e.g. Ehlers, Adelsberger, & Teschler 2009; Ebner, Lienhardt, Rohs, & Meyer 2010) conclusions and recommendations appear to be unfounded or at least questionable. If there is a learning environment or setting with a lot of external control (Pauschenwein, Jandl, & Sifri 2009; **Ebner & Maurer 2009,** Lopez-Fernandez & Rodriguez-Illera 2009) it is, at least from our point of view, nearly impossible to find out anything about students' participation or self-responsibility or autonomous learning. Because participation is not fulfilling assignments, but taking part in decisions and expressing own interests.

According to the papers the necessity of incentives or assessment sometimes seems inevitable in formal settings. Xie, Ke & Sharma (2008) investigate the interaction effects of peer feedback and blogging on reflective thinking skills. There was a high drop-out rate (38.6%) - a limitation of their study - although blogging was mandatory. They suggest: *"... writing might not be a natural approach of conducting reflection for all students, or 10% of the final grades may not be a strong enough incentive for all students to keep blogging for a semester."* (Xie, Ke, & Sharma 2008, p.24) By focusing closely on external control or extrinsic motivation the essential basis for participation i.e. meaning and usefulness is neglected. Only few papers (Hall & Davison 2007) include students' points of view or reflect the balance between effort and benefits (Cole 2009, p.144).

As an alternative we would like to offer a subject-scientific perspective on the lack of participation (Grell 2005). We focus on the learner as a social individual, his situation and the meaning of the (assigned or freely chosen) objects from his point of view. A student's decision to ignore assignments, incentives or to pretend to "play the game" is his choice, if teachers like it or not. Teaching autonomy through heteronomy is problematic. Therefore it is necessary to reflect the tension between students' self-responsibility and external control in education systematically, especially in participatory settings.

References

Anderson, N., & Lin, C., (2009). Exploring technologies for building collaborative learning communities among diverse student populations. In *Proceedings of the 14th Annual ACM SIGCSE Conference on innovation and Technology in Computer Science Education.* ITiCSE '09 (pp. 243-247). New York, NY: ACM.

Cole M. (2009). Using Wiki technology to support student engagement: Lessons from the trenches. *Computers & Education. 52*(1), 141-146.

Ebner M., & Maurer H. (2009). Can Weblogs and Microblogs Change Traditional Scientific Writing?. *Future Internet*. *1*(1), 47-58.

Ebner, M., Lienhardt, C., Rohs, M., & Meyer, I. (2010) Microblogs in Higher Education - A chance to facilitate informal and process-oriented learning?. *Computers & Education. 55*(1), 92-100.

Ehlers, U.-D., Adelsberger, H.H., & Teschler, S. (2009). Reflexion im Netz: Auf dem Weg zur Employability im Studium. In N. Apostolopoulos, H. Hoffmann, V. Mansmann & A. Schwill (Hrsg.), *E-Learning 2009. Lernen im digitalen Zeitalter* (pp. 15-29). Münster: Waxmann Verlag.

Grell, P. (2005): Forschende Lernwerkstatt. Lernwiderstände in der Weiterbildung. Münster. Waxmann.

Grosseck, G. (2009). To use or not to use web 2.0 in higher education?. Procedia Social and Behavioral Sciences. 1, 478–482.

Hall, H., & Davison, B. (2007). Social software as support in hybrid learning environments: The value of the blog as a tool for reflective learning and peer support. *Library & Information Science Research.* 29(2), 163-187.

Hardy, N., Pinto, M., & Wei, H. (2008). The Impact of Collaborative Technology in IT and Computer Science Education: Harnessing the Power of Web 2.0. *In Proceedings of the 9th ACM SIGITE conference on Information technology education* (pp. 63-64). New York, NY: ACM.

Jadin, T. (2007). Social Software für kollaboratives Lernen. In B. Batinic, A. Koller & H. Sikora (Hrsg.), *E-Learning, digitale Medien und lebenslanges Lernen* (pp. 23 - 35). Linz: Trauner.

Lopez-Fernandez O., & Rodriguez-Illera, J.L. (2009). Investigating university students' adaptation to a digital learner course portfolio. *Computers & Education. 52* (3), 608-616.

Meyer, K.A. (2010). A comparison of Web 2.0 tools in a doctoral course. *The Internet and Higher Education*, In Press, Corrected Proof, Available online 11 February 2010, DOI: 10.1016/j.iheduc.2010.02.002.

Öner, D. (2009). Pre-service teachers' experiences with Wiki: challenges of asynchronous collaboration. In *Proceedings of the 5th international Symposium on Wikis and Open*. WikiSym '09 (pp. 1-2). New York, NY: ACM. DOI= http://doi.acm.org/10.1145/1641309.1641353

Pauschenwein, J., Jandl, M., & Sifri, A. (2009). Untersuchung zur Lernkultur in Online-Kursen. In N. Apostolopoulos, H. Hoffmann, V. Mansmann & A. Schwill (Hrsg.), *E-Learning 2009. Lernen im digitalen Zeitalter* (pp. 15-29). Münster: Waxmann Verlag.

Safran, C. (2008). Blogging in higher education programming lectures: an empirical study. In *Proceedings of the 12th international Conference on Entertainment and Media in the Ubiquitous.* MindTrek '08 (pp. 131-135). New York, NY: ACM.

Sim, J.W.S., & Hew, K.F. (2010). The use of weblogs in higher education settings: A review of empirical research. *Educational Research Review*, In Press, Corrected Proof, Available online 18 January 2010, DOI: 10.1016/j.edurev.2010.01.001.

Wheeler S (2009). Learning Space Mashups: Combining Web 2.0 Tools to Create Collaborative and Reflective Learning Spaces. *Future Internet*. *1*(1), 3-13.

Xiao, Y., & Lucking R. (2008). The impact of two types of peer assessment on students' performance and satisfaction within a Wiki environment. *The Internet and Higher Education*. 11(3-4), 186-193.

Xie, Y., Ke, F., & Sharma, P. (2008) The effect of peer feedback for blogging on college students' reflective learning processes. *The Internet and Higher Education*. 11(1), 18-25.

Developing competences in VET through e-writing activities

Alberto Cattaneo,
Elena Boldrini,
Elisa Motta,
Christoph Arn
Swiss Federal Institute for Vocational Education and Training
Via Besso, 84 – 6900 Lugano, Switzerland
{alberto.cattaneo, elena.boldrini, elisa.motta, christoph.arn}@iuffp-svizzera.ch

Abstract. Computer-supported collaborative writing modality can be used in order to design some learning activities which constitute a means for reducing the gap existing in the context of the dual-track school/work based Vocational Education and Training Swiss programmes and therefore for better and effectively connecting the different learning locations. Besides, this approach can foster in apprentices the awareness of their professional identity, the propensity to reflect on what experienced at the workplace and finally their motivation and competence. A study conducted with commercial employee apprentices – in the framework of the Dual-T project led by the "Technologies for Vocational Training" leading house and funded by the Federal Office for Professional Education and Technology – is presented here, considering the effects of the writing activities on the capacity of describing professional procedures and on the above mentioned dimensions.

Keywords: Computer-Supported Collaborative Writing; professional identity; reflective thinking; Vocational Education and Training.

Introduction

The challenge of using technologies to motivate learners includes an additional key implication when dealing with dual-track Vocational Education and Training (VET). In this case, in fact, the contextual effects on learners' motivation (Volet & Järvelä, 2001) have to take into consideration the fact that for apprentices learning is supposed to emerge from the interaction of multiple contexts regularly co-occurring (Gurtner, Monnard & Genoud, 2001; Horn, Nolen, Ward & Campbell, 2008).

In Switzerland, the VET system foresees three different learning locations: the school, the workplace, and the additional training segment – known as "intercompany courses" or "industry courses" – in virtue of which we speak about a "trial system". In this dynamics, the workplace often plays a crucial role, directly influencing learning when apprentices find those affordances that allow them to personally engage (Billett, 2001; Eteläpelto, 2008).

Against this background, the potential benefits of technologies may be twofold, namely 1. as a tool to capture, to document and to store authentic professional situations experienced at the workplace, and 2. as a means to exploit and expand these experiences at school, thus fostering the connection between contexts. However, it is rarely the experience in itself that induces learning but additional and profound reflection on this experience is indispensably needed. In other words, it's by reflecting on the activities performed at the workplace that apprentices can become more aware of their activities and competences, thus developing self-regulation as well as a grounded professional identity (Schön, 1983; Wenger, 1998).

These considerations establish the point of departure of Dual-T, a Swiss research project managed by the "Technologies for Vocational Training" leading house[10], whose main aim is the design of learning activities to bridge the gap - and better articulate the relationship - among the different learning locations in VET.

[10] The leading house – funded by the Federal Office for Professional Education and Technology (OPET) under the contract #BB.2006.0023 – gathers up 4 main partners: École Polytechnique Fédérale de Lausanne (EPFL)/CRAFT, coordinator; University of Geneva, TECFA; University of Fribourg, Psychology Dept., Swiss Federal Institute for Vocational Education and Training (SFIVET). Each partner, in collaboration with the other, focuses on some specific questions applied to different projects. This paper deals with a project jointly conducted by SFIVET and University of Geneva teams.

Commercial employees and collaborative writing

Using a Design-Based Research approach (DBR – Collins, 1992; Brown, 1992; DBRC, 2003), we developed and designed several computer-supported collaborative writing activities in collaboration with teachers and instructors.

In designing these activities, we departed from teachers' observation that the apprentices' often face difficulties in a. reflecting on their professional experiences and b. consequently developing a personal professional identity. These difficulties are strikingly mirrored in the so called "Process Unit" (PU), an official and rated document that commercial employees are required to produce in all the three years of apprenticeship. In particular, they have to provide a description of a professional procedure which they had faced at the workplace (1), a corresponding flowchart depicting this procedure (2) and possibly some examples to corroborate their experience (3). The PU is part of the final exam which provides the Federal VET Certificate, and it is rated both by the course supervisor in the business training company and by the representatives of the professional associations and instructors in the intercompany courses.

On the basis of a writing-to-learn perspective (Flower & Hayes, 1980; Hayes, 1996; Galbraith, 1999), as well as a Computer Supported Collaborative Learning frame, we designed peer-tutoring and peer-commenting activities to promote reflection, confrontation, professional competence acquisition, and finally professional identity development. All the activities were supported by ELGG, an e-portfolio learning environment (of which we especially exploited the weblog and a wiki tool directly integrated), and were implemented during the last school year (from October 2009 to March 2010) in two classes of commercial employees in Canton Ticino, Switzerland.

The study

The rationale of the project may be summarized as follows: commercial employees often experience workplace situations that differ among companies: the same professional procedure takes place in a slightly different way even in the same domain. However, this difference can be exploited to foster both professional competence development and the awareness of personal (and collective) professional identity. Collaborative writing on these experiences can be a useful means in this respect, as well as for encouraging confrontation, discussion, comparison, and collaboration dynamics among the apprentices. Additionally, in asking apprentices to describe what experienced on the job, we can further that reflective attitude the teachers complain to be not usual in apprentices.

Some preliminary experiences at this regard have already been conducted in the last school year (2008-2009) with about 60 commercial employee apprentices, revealing that in the collaborative writing activities, foreseeing the collaboration among apprentices and a peer-to-peer commenting and revising modality, the professional quality (in terms of exactness) of the apprentices' texts increased and comparison and discussion were fostered (Motta, Arn, Cattaneo & Boldrini, 2009).

Refining the design already implemented, we had the chance to collect more data on the process: we developed a pre-post questionnaire investigating aspects like apprentices' (i) perceived self-efficacy at school and at the workplace (Bandura, 1990), (ii) reflective thinking capacity (Kember et al., 2000), (iii) professional commitment and identification (Heinmann & Rauner, 2008). In this contribution we will focus on the quality of the descriptions the members of the two experimental classes included in the PUs – and the related obtained ratings –, comparing them with the PUs of all the other commercial employee classes in Ticino, which have not experienced any computer-supported peer-to-peer writing activity. The quality of the text in this case is considered as the operational indicator revealing professional awareness and competence. Additionally, we will also consider the results on the above mentioned dimensions of the questionnaires analysis, which will be conducted after having submitted the post-test at the end of April.

References

Bandura, A. (1990). *Multidimensional scales of perceived academic efficacy*. Stanford University, Stanford, CA, 326-327.

Billett, S. (2001). Learning through work: Workplace affordances and individual engagement. *Journal of workplace learning, 13*, 209-214.

Brown, A. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of the Learning Sciences, 2*(2), 141-178.

Collins, A. (1992). Towards a design science of education. In E. Scanlon & T. O'Shea (Eds.), *New directions in educational technology* (pp. 15-22). Berlin: Springer.

DBRC. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher, 32*(1), 5-8.

Eteläpelto, A. (2008). Perspectives, prospects and progress in work-related learning. In S. Billett, C. Harteis & A. Eteläpelto (Eds.), *Emerging perspectives of workplace learning* (pp. 233-247). Rotterdam: Sense Publishers.

Flower, L. S., & Hayes, J. R. (1980). *The dynamics of composing: making plans and juggling constraints*. In L. W. Gregg & e. R. Steinberg (Eds.), Cognitive Processes in Writing (pp. 31-50). Hillsdale (NJ): Erlbaum.

Galbraith, D. (1999). *Writing as a knowledge-constituting process*. In M. Torrance & D. Galbraith (Eds.), Knowing what to write: conceptual processes in text production (pp. 139-160). Amsterdam: Amsterdam University Press.

Gurtner, J.-L., Monnard, & Genoud, P. A. (2001). Towards a Multilayer Model of Context and its Impact on Motivation. In S. Volet & S. Järvelä (Eds.), *Motivation in learning contexts: theoretical and methodological implications* (pp. 189-208). Amsterdam: Pergamon.

Hayes, J. R. (1996). *A new model of cognition and affect in writing*. In C. M. Levy & S. Ransdell (Eds.), The Science of Writing (pp. 1-30). Hillsdale, NJ: Erlbaum.

Horn, I.S., Nolen, S.B., Ward, C., & Campbell, S.S. (2008). Developing practices in multiple worlds: The role of identity in learning to teach. *Teacher Education Quarterly,35*(3) 61-72.

Kember, D., Leung, D.Y.P., Jones, A., Yuen Loke, A., McKay, J., Sinclair, K., Tse, H., Webb, C., Wong, F.K.Y., Wong, M. & Yeung. E. (2000) "development of a questionnaire to measure the level of reflective thinking", assessment & evaluation in higher education, 25(a), 381-395.

Heinemann, L. & Rauner, F. (2008). *Identität und Engagement: Konstruktion eines Instruments zur Beschreibung der Entwicklung beruflichen Engagements und beruflicher Identität.* Hrsg. Berufsbildungsforschung (IBB): Universität Bremen.

Motta, E., Arn, C., Cattaneo, A., & Boldrini, E. (2009). *Using e-Portfolio Actitivies to Work on Professional Identity.* Paper presented at the ePortfolio 2009 - Innovation, Creativity and Accountability themes, London, June 22nd–24th, 2009.

Schön, D. A. (1983). *The Reflective Practitioner*. New York: Basic Books.

Volet, S., & Järvelä, S. (Eds.). (2001). *Motivation in Learning Contexts. Theoretical Advances and Methodological Implications*. Amsterdam: Pergamon.

Wenger, E. (1998). *Communities of Practice: Learning, Meaning and Identity*. New York: Cambridge University Press.

Collaborative and Constructive Participation: a model for blended courses

M. Beatrice Ligorio
University of Bari
Palazzo Ateneo, Via Crisanzio 1 70100, Italy
Bealigorio@hotmail.com

Roberto Cordeschi
University of Rome "Sapienza"
Via Carlo Fea, 2
I-00161 ROMA, Italy
roberto.cordeschi@uniroma1.it

Abstract. Socio-constructivist framework can be used to exploit the educational potentialities of web-based environments. Based on this framework a pedagogical method called Collaborative and Constructive Participation (CCP) was designed for blended courses. The CCP capitalizes several pedagogical ideas already used in face to face contexts – such as Reciprocal Teaching, Jisgaw, Community of learners and of practices. Many blended activities are included into the CCP model and they will be here described. The CCP model was tested on many courses for higher education and professional development. The efficacy of the model was established by looking at: a) qualitative changes of both the individual and group products; b) qualitative changes of the web-forum discussions; c) content of students' e-portfoli. Results show that the CCP model has an impact not only on learning strategies but also on participation to group work and on the capability of self-assessment.

Keywords: Collaboration online; participation; blended learning; socio-constructivism

Introduction

Socio-constructivist framework can be used to exploit the educational potentialities of web-based environments. Based on this framework a pedagogical method called Collaborative and Constructive Participation (CCP) it has been designed and it will be here presented. CCP is particularly suitable for blended courses where not only online and face to face are mixed but also several pedagogical suggestions. Individual study is proposed as starting point for dyads collaboration and for small-group activity as well as tasks to be performed by the whole community (Brown, & Campione, 1990; Koschmann, 1996; Scardamalia & Bereiter, 2007). Students are also required to work on a variety of tasks and end-products, using different formats (asynchronous web-forums, synchronous chats, texts, maps, tables). Students' effective participation (Anderson, 2007) is sustained by offering several activities and formats and by a repeated routine, in order to allow many occasions to try out the tasks, every time with a slight increase of complexity.

Setting-up the context

The CCP model requires a radical re-organization of the context. We propose a four-step strategy to set it up. The first step is to group the students. As we know (Dillenbourg, 1999) small groups are the engine for collaborative learning. During the second step the course is structured into units. The number of units depends on the time available and on the general aims of the course. At the third step an agenda to schedule the face-to-face meetings is outlined. In between face-to-face meetings, students are required to perform a set of online activities, hosted on a platform. The fourth step comprises a training to familiarize students with the platform used for the course.

The blended activities

The CCP model includes a set of online and offline activities; some of them mainly take place face to face, others are mainly online.

Two types of face to face meetings are planned: (1) *standard* meetings and (2) *discussion* meetings. The *standard* meetings are considered as the starting point for the unit and are anchored into the

teacher's lecture. The *discussion* meetings are a consolidation of the unit and it could be a group discussion - the group members compare their points of view– or a plenary discussion, involving all the students aimed at defining the main points of the unit. In between the face-to-face meetings, students perform the following activities:

1) Reading and writing. Students read individually the educational material the teacher assigns to each of them (Raimes, 1991). Once the material has been read, students have to write a short critical review –following suggestions and hints given by the teachers - and post it on the platform. All the group members have to read and comment on all the reviews. The bulk of reviews is the starting-point for the online discussions.

2) Discussing. The discussions are guided by the Progressive Inquiry Model (PIM) (Hakkarainen, Lipponen & Järvela, 2002). Students try to answer a research question by contributing with concepts and ideas taken from the educational material read and from the review written by the colleagues. This discussion is best hosted in a asynchronous web-forum.

3) Searching for new materials. Students are encouraged to be active (Brown & Campione, 1990) by searching new material to better address the unit. This material should be posted online accompanied by a short justification.

4) Building collaborative products. According to socio-constructivism (Scardamalia & Bereiter, 2007) participants should collaboratively build meaningful material. CCP requires students, before moving to a new unit, to build three products: a) a synthesis describing how much the discussion fits into the PIM; for this product a collaborative writing tool such as wiki should be used; b) a conceptual map containing the answer to the research question of the unit - any shared online white board provided by a synchronous chat is adequate; c) a checklist – in the format of a table or a grid - of important points emerged during the discussion.

5) Role-taking. In the CCP model, a number of roles are proposed and all of them imply the responsibility of one of activities proposed (Schellens, Van Keer & Valcke, 2005). Ideally, each student should always play a role strictly connected to a task or a product.

6) *E-portfolio and self-assessment*. In order to support self-evaluation and meta-cognitive reflection about the activities performed, students are required to maintain personal folders and complete a sheet of self-assessment at the end of each unit.

Results

The CCP model was tested on many courses for higher education and professional development. The efficacy of the model was established by looking at a:

a) qualitative changes of both the individual and group products. These products can be qualitatively compared because each of them is produced as many times as many units compose the course. Such comparison will give the sense of both individual and group changes and progresses. Some analysis run on these products will be presented.

b) qualitative changes of the web-forum discussions. Again, each course will allow a number of discussions equal to the number of units. These discussions can be analyzed in many ways: i) looking at the references to the educational material; ii) analyzing the dialogical dimension by checking references to previous notes; iii) examining how students go from simple evidences to the construction of theories. Some of these analysis will also be reported.

c) content of students' e-portfoli. The e-portfoli are individual spaces where students: i) state their expectations at the start of the course; ii) compare their initial expectations with final comments; iii) self monitor their performance by filling in a self-assessment sheet and by selecting their best product/note at the end of each unit.

Final comments

In general our results are very encouraging: the quality of the products improves and students report to be very enthusiastic about this learning experience.

The weak point of this model is the great work needed from the teacher's side and the need to have support from a staff specifically trained.

References

Anderson, P. (2007). What is Web 2.0? Ideas, technologies and implications for educations, *JISC Technology & Standard Watch.* URL: http://www.jisc.ac.uk/publications/publications/twweb2.aspx

Aronson, E., & Patnoe, S. (1997). *The jigsaw classroom: Building cooperation in the classroom (2nd ed.)*. New York: Longman.

Brown, A. L., & Campione, J. C. (1990). Communities of learning and thinking: Or a context by any other name.Contributions to Human Development, 21, 108-125. Basel,CH: Karger.

Dillenbourg, P. (1999). What do you mean by collaborative learning?. In P. Dillenbourg (Ed), Collaborative-learning: Cognitive and Computational Approaches (pp.1-19). Oxford: Elsevier.

Hakkarainen, K., Lipponen, L., & Järvela, S. (2002). Epistemology of inquiry and computer-supported collaborative learning. In T.D. Koshmann et al (Eds), *CSCL 2: Carrying Forward the Conversation* (pp. 129-156). Mahwah, N.J.: Laurence Erlbaum Associates.

Koschmann, T. (1996). Paradigm shifts and instructional technology. In T. Koschmann (Ed.), *CSCL: Theory and practice of an emerging paradigm* (pp. 1-23). Mahwah, NJ: LEA

Raimes, A. (1991). Out of the Woods: Emerging Traditions in the Teaching of Writing. *TESOL Quarterly*, 25, 3, pp. 407-430.

Scardamalia, M., & Bereiter, C. (2007). Fostering communities of learners and knowledge building: An interrupted dialogue. In J. C. Campione, K. E. Metz, & A. S. Palincsar (Eds.), *Children's learning in the laboratory and in the classroom: Essays in honor of Ann Brown* (pp. 197-212). Mahwah, NJ: Erlbaum.

Schellens, T., Van Keer, H. and Valcke, M. (2005). The impact of role assignment on knowledge construction in asynchronous discussion groups: a multilevel analysis. *Small Group Research* 36, 704–745.

Collaborative Creation of Shared Knowledge Objects in Higher Education

Crina Damsa,
Sten Ludvigsen
Intermedia, University of Oslo
P.O. Box 1161 Blindern, NO-0318 Oslo, Norway
crina.damsa@intermedia.uio.no

Patrick Sins
Utrecht University, the Netherlands

Bert Reijnen
STOAS, the Netherlands

Abstract. Knowledge creation approach depicts learning as a collaborative activity aimed at the creation and development of shared knowledge objects. Knowledge objects can be approached in terms of acquiring particular content but also with respect to the nature of the activities and interactions they elicit and support. This study seeks to understand how students in higher education collaborate on developing shared knowledge objects in a virtual environment that supports collaborative learning. This design-based study was conducted in an applied science university that prepares teachers for lower secondary education. Small groups of students conducted collaborative projects that involved the design of educational material for authentic use. Preliminary results indicate that productive interactions occurred in groups' collaboration and led to object advancement, and that object elaboration took place both at individual and at collective level. The findings also provide insight into the way technology supported this process. Several implications for pedagogical and technological development are drawn based on these findings.

Keywords: knowledge creation, object-oriented collaboration, shared spaces

Learning through collaborative creation of knowledge objects

Recent studies of collaboration demonstrate that simply bringing people together in groups with some task, or pooling the group's knowledge, are insufficient conditions for productive collaboration (Barron, 2003; Salas, Shawn, & Burke, 2005). One recent approach to learning called Knowledge Creation (Paavola & Hakkarainen, 2005) depicts learning as a collaborative activity aimed at creating new knowledge, through the creation and development of shared knowledge objects (e.g., research reports, instructional material, scientific models, etc.). According to this approach, collaborative learning does not serve only individual learning or social interaction, but is organized around common knowledge objects whose creation and development defines their purpose. According to Van Aalst (2009), this perspective emphasizes that understanding and knowing are mediated by the objects that are created and shared by a community. Rather than residing inside individual minds, ideas and knowledge are regarded as cultural objects that mediate learning and understanding.

Based on this perspective, pedagogical designs should explicitly scaffold learning through incorporating collaborative co-construction activities revolving around authentic knowledge objects. Knowledge objects can be approached in terms of acquiring particular content but also with respect to the nature of the activities and interactions they support; that collaborative processes shape the knowledge objects constructed, but are also shaped by the actions taken upon these objects (Stahl, 2003). One of the prominent approaches to such innovative designs is technological support of object-mediated collaboration, in the form of virtual collaboration spaces. However, such designs are often undermined by the fact that little is known about how to analyze processes of object-mediated collaboration and the resulting objects. This paper makes an attempt to examine the mechanisms of collaborative creation of knowledge objects and of object evolution, and seeks to understand how a virtual environment designed from the knowledge creation perspective supports object-mediated collaborative learning. Our assumption is that particular types of interactions, namely productive interactions, lead to the emergence and development of knowledge objects worked upon by the participating groups.

Settings and method

The research was conducted in an University of Applied Sciences and Teacher Education in the Netherlands. This university prepares pre- and in-service teachers for lower secondary education. The curriculum is based on Professional Situations (PS), where students are stimulated to mobilize knowledge and skills during projects in authentic work environments. Three different PS's were randomly selected to be part of the research study. Throughout the entire project period (September 2009 to July 2010), a group of 8 teachers and 73 mixed-age students, enrolled the three PS's, participated in the study.

In this project, we actively engaged both teachers and students in object-oriented processes. We have introduced interventions to foster transformations of teachers' coaching practices, and to stimulate students' knowledge creation processes. The teachers and 2 researchers participated in project meetings, reflecting on their experiences in the PS's and designing coaching and assessment instruments. Groups of students were required to design, develop, and report on authentic knowledge objects (didactic materials, support material, guidelines and manuals, etc.). Various scaffolding activities and artefacts were provided, such as workshops, templates for work plans, and tool training sessions. Student groups had coaching hour every second week. Collaboration took place f2f, through the online environment and e-mail.

The activities were supported by Knowledge Practices Environment (KPE) (see www.knowledgepractices.info). In KPE, individual and collective shared (work) spaces can be created. Each shared space encompasses a workplace with three views: a Process view (which supports planning and organizing the process), a Content item view (which allows creating, sharing and collaboratively editing versions – document, wiki pages, notes, comments, etc.), and a Community view. The tools specifically employed to support object-bound collaboration were document versioning and wiki for collaborative text production.

Data collection and analytic approach

We collected a rich set of data, categorized as: a) interaction data; b) knowledge objects, both produced in KPE or during fieldwork; c) reflection data. For examining the interaction process and how objects emerge from interactions we used a qualitative analysis framework which comprised three discrete processes: analyses of groups' (f2f and online) interactions, of idea uptake based on interactions and of object evolution. To unveil the way technology contributed to the process we analyzed both observations and reflection data, using a grounded theory approach.

Preliminary results

The analyzed *interaction*s proved to be of heterogeneous nature. We identified productive interactions that explicitly contributed to the conceptual enrichment and development of the shared knowledge object. The interactive actions that contributed directly to the conceptual development of the knowledge object were labelled as 'creating shared understanding' and 'collaborative generative'. However, other types of actions were identified, which had different purposes (e.g., establishing the focus or sharing information). The analyses of the interactions also yielded *sets of relevant concepts*, considered by the group as more or less relevant for the knowledge objects to be developed and indicated that groups had elaborated strategies in dealing with these concepts. From the perspective of concept and idea *elaboration* the findings reveal that elaborations led to the materialization of the group's shared views and stance. However, the work of expanding these common views took place individually and led to, at times, lower levels of elaboration. Further, analyses of object versions indicated that a gradual expansion of the analyzed concepts was registered. Finally, findings concerning *contributions and participation* of individual group members to the elaboration process show that individual ideas and textual versions were discussed and commented upon in the group,

plans for action were joint and integration of materials occurred both at textual and at conceptual level. However, the elaboration of concepts and ideas into the object versions was done individually. The findings indicate that the sections that were discussed within the group and provided with feedback more than once showed a higher degree of elaboration.

Tool support was experienced as helpful by participants in contributed to increased awareness during the process, and in supporting them to create a structure and to organize the group work, to organize the process visually, to create versions and to comment on each others work inside the space. The tool was considered less useful in supporting communication.

Conclusion

This paper focussed on understanding the mechanisms of collaborative creation of knowledge objects, by analyzing interactions of students engaged in an authentic project and by tracing the development process of the knowledge objects they worked on. Also, technological tools designed to support object-bound collaboration was examined. The study shows how interactions between learners contribute to object progression and how this process feeds into the collaboration strategies employed. Based on our findings, we contemplate that shared knowledge expressed in objects stimulates collaborative reflection and analysis of limitations in existing practices which may lead to new collaboration strategies.

From a pedagogical design and didactic perspective, this study indicated that introducing elements of the knowledge creation approach in the institutionalized structures and practices works better and has more impact than renewing entirely the existing structure. With respect to tool support, we have seen that some KPE functionalities are key in creating awareness of the collaborative work and in supporting iterative object development. Based on the findings we also conclude that organizing training sessions are essential for both teachers and students emphasizing the aspects of the tools which are new to the participants, in comparison to other tools they already know.

References

Barron, B. (2003). When smart groups fail. The Journal of the Learning Sciences, 12, 307-359.

Paavola, S. & Hakkarainen, K.: The Knowledge Creation Metaphor – An Emergent Epistemological Approach to Learning. Science & Education, 14(6), 535--557 (2005)

Salas, E., Sims, S., & Burke, C. S. (2005). Is there a “Big Five” in teamwork? Small Group Research, 36, 555-599

Stahl, G. (2003). Meaning and interpretation in collaboration. In B. Wasson, S.Ludvigsen & U. Hoppe (Eds.), *Designing for change in networked learning environments: Proceedings of the international conference on computer for collaborative learning* (CSCL '03) (pp. 523-532). Bergen, Norway: Kluwer Publishers.

van Aalst, J. (2009). Distinguishing knowledge-sharing, knowledge-construction, and knowledge-creation discourses. Computer-Supported Collaborative Learning, 4, 259-287.

Feedback Mediated Adaptive Learning with Texts and Pictures

Christiane Baadte &
Wolfgang Schnotz
University of Koblenz-Landau
Fortstr. 7
D-76 829 Landau
baadte@uni-landau.de; schnotz@uni-landau.de

Abstract Although the facilitating effects of feedback on self-regulated learning are often accentuated some meta-analytical studies point out that under some conditions feedback either has no effect on learning outcomes or it even depletes performance. This may particularly be the case if the feedback overstrains the learners with reference to cognitive and affective aspects, or when it decreases motivation. Thus, the present study examined the effects of different types of feedback on self-regulated learning with reference to these three aspects and with reference to the learners' self-concept. For this purpose a web-based interactive learning environment for self-regulated learning in the domain of text-picture comprehension was developed. Seventy-eight sixth-graders from a German grammar school completed the program, with half of the sample receiving feedback and the other half receiving no feedback. Results point out to differential feedback effects on various aspects of self-regulated learning.

Summary

In educational contexts feedback is regarded as a powerful tool to promote learning processes in various ways (e.g. Narciss & Huth, 2006; Krause, Stark & Mandl, 2009). As Hattie and Timperley (2007) assume this may be the case because of the effects that feedback takes on motivational, emotional and cognitive aspects of learning. As, according to current definitions of self-regulated learning (e.g. Zimmerman, 2000) motivation, emotion and cognition constitute the stages on which self-regulation occurs, feedback is a tool that supports the learners' self-regulation with respect to these three aspects. In order to accomplish a given task, learners have to keep themselves in a task-oriented, motivated condition, they have to deal with various emotions that accompany their learning process, and they have to tackle the task-inherent demands on a cognitive as well as on a meta-cognitive level. In this vein, feedback should support self-regulation with reference to these three pivotal aspects. However, in their meta-analysis concerning the effects of feedback in different learning domains, Kluger and DeNisi (1996) found that in at least one third of the studies incorporated in the analysis, feedback either had no effect on the learning outcome or, under some conditions, it even decreased performance. According to Kluger and DeNisi's Feedback Intervention Theory, this may be the case if feedback directs the learner's attention away from the task level to the self-regulation level when feedback-standard gaps are detected at the level of the self. Assuming that individuals only have a limited amount of cognitive resources at their disposal the regulation on the task level and the regulation on the level of the self may lead to a competition for cognitive resources which can be allocated within and across levels of the hierarchy as needed. The more resources are allocated towards the performance of a certain task on a superordinate level (e.g. the self), the less will be available for the completion of a secondary task on a subordinate level (eg. the task) which results in a decreased performance in this task (see also Vancouver & Tischner, 2004). Thus, in providing feedback that actually supports the performance in self-regulated learning, teachers should pay attention to the cognitive as well as to the affective effects that feedback may elicit, by giving the 'right' feedback at the 'right' time.

But, *which* feedback is most beneficial and *when* is the appropriate time to provide feedback in the self-regulated learning cycle? According to Zimmerman (2000) each self-regulated learning cycle comprises three phases: forethought, performance, and self-reflection. The forethought phase refers to the goal oriented planning of actions or action steps and the selection of adequate strategies. In the

performance phase the selected strategies are applied in order to complete the task at hand. Self-reflection refers to the evaluation of the learning outcome. Hence, it encompasses attributional processes, self-evaluation and reactions to these evaluations but also adaptive processes that help learners to improve their self-regulatory skills. In addition, a pivotal assumption of the cyclical model is that the outcome of each preceding phase influences the accomplishment of the subsequent phase. Hence, in our research we assume, that cognitive, affective and motivational self-regulation in each one of these three phases can be supported by particular feedback. In the forethought phase *goal-setting feedback* should be provided that helps students to set adequate goals. *Process feedback* should be given during the performance phase in oder to support task completion whereas *outcome feedback* should be provided right after the completion of the task in order to inform the student about the quality of her/his learning outcome. However, up to now, little is known (a) about the effects of these three feedback types on cyclical self-regulated learning processes in general, (b) about the supportive effects of these three feedback types on cognitive, motivational and affective aspects of self-regulated learning processes in the domain of text-picture comprehension, and (c) how this feedback types interact with the self-concept of the learners.

To assess the impact of goal-setting feedback, process feedback and outcome feedback on self-regulated learning with texts and pictures a web-based, interactive feedback-mediated learning environment (*Feedback Mediated Adaptive Learning Environment*) was developed. This program provided students (5th graders of German grammar schools) with a pool of text-picture comprehension tasks on various levels of difficulty. In addition, computer-based feedback was given according to the three feedback types. In a first step, students were asked to choose a task at a certain level (easy, medium or difficult) and to accomplish this task. The completion of each sub-task was then supported by specific bug-related process feedback. After the completion of each task, outcome feedback informed the students about the quality of their performance. In the subsequent self-reflection phase the students' affective state was assessed. In the following goal-setting phase, students were asked to choose the task they wanted to complete next on the basis of difficulty indexes. The adequacy of the task selection was commented by the goal-setting feedback and subjects were given the opportunity to revise their choice. After this, the second learning cycle proceeded with the completion of the selected task.

In the present study, 78 fifth-graders from a German grammar school were tested. Half of the sample completed a version of the program in which all three feedback types were implemented whereas the other half received an alternative version, in which no feedback was provided. All participants completed six learning cycles. As a moderating variable the students' academic self-concept (SC) was assessed. The dependent variables were the performance score, the goal setting behavior and the mental effort that was invested in the task, and the affective state in the self-reflection phase of each cycle. The results of the cross-sectional analyses revealed consistent effects of the participants' self-concept on cognitive, motivational and affective variables. Students with a higher academic self-concept were better in the completion of the text-picture comprehension tasks (R^2=.10; F(3,73)=2.63; p=.056; SC: B=-.18; β=.28; t=2.49; p=.015), they selected more difficult tasks (R^2=.15; F(3,72)=4.10; p=.010; SC: B=-.02; β=.38; t=3.44; p=.001), and they were in a better affective state during the completion of the tasks (R^2=.16; F(3,72)=4.53; p=.006; SC: B=-2.32; β=.36; t=3.33; p=.001) compared to students with a lower academic self-concept. However, the relation between feedback and performance was moderated by the provison of feedback with reference to high SC students (R^2=.42; F(3,15)=3.54; p=.04; SC x FB: B=-.97; β=1.16; t=2.39; p=.031). If these students received feedback, their overall performance score decreased although they invested more mental effort in the task (SC x FB: F(3,68)=2.88; p=.042; η^2=.113). In addition their alertness and their mood decreased significantly

during the completion of the six learning tasks (alertness t_1 vs. t_6: $t(8)=3.05$; $p=.016$; mood t_1 vs. t_6: $t(8)=3.62$; $p=.007$). No such interaction effects were detected with reference to low SC students.

The results provide evidence for an expertise reversal effect which was discussed for example by Schnotz (2010). On this note, feedback provided an additional information for the high SC learners which they actually did not need to complete the task. Hence, these learners had to process learning-irrelevant information. That is, they invested more 'mental energy' (Schnotz, 2010) which resulted in a greater exhaustion, and, hence, in a decline in alertness, in mood and in performance.

References

Hattie, J., & Timperley, H. (2007).The power of feedback. *Review of Educational Research,* 77(1), 81-112.

Kluger, A. N. & DeNisi, A. (1996). The Effects of Feedback Interventions on Performance: A Historical Review, a Meta-Analysis, and a Preliminary Feedback Intervention Theory. *Psychological Bulletin*, Vol. 119, No. 2, pp. 254-284.

Krause, U.-M., Stark, R. & Mandl, H. (2009). The effects of cooperative learning and feedback on e-learning in statistics. *Learning and Instruction*, *19*, 158-170.

Narciss, S. & Huth, K. (2006). Fostering achievement and motivation with bug-related tutoring feedback in a computer-based training on written subtraction. *Learning and Instruction*, *16*, 310-322.

Schnotz, W. (2010). Reanalyzing the expertise revearsal effect. *Instructional Science*, 38, 315-323.

Vancouver, J. B., & Tischner, E. C. (2004). The Effect of Feedback Sign on Task Performance Depends on Self Concept Discrepancies. *Journal of Applied Psychology, 89,* 1092-1098.

Zimmerman, B.J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P.R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 451-502). San Diego, CA: Academic Press.

Effects of support for Coherence Formation in Computer Science education

Ingmar Baetge & Tina Seufert
Ulm University, Institute of Psychology and Education
Albert-Einstein-Allee 47, 89081 Ulm, Germany
Ingmar.Baetge@uni-ulm.de; Tina.Seufert@uni-ulm.de

Abstract. As graphical representations are used heavily in computer science education when teaching the concepts of programming languages, students often struggle with the complexities arising from the need to create a coherent mental model from both textual representations (informative texts or programming examples) and graphical representations (diagrams). A study was conducted to investigate the effects of various support types on cognitive load during learning and on learning outcomes. Results show, that support for coherence formation can be used to reduce extraneous cognitive load when instructing students with computer science learning material using multiple representations, leading to more successful learning.

Keywords: multiple representations, coherence formation, multimedia instruction

Introduction and Theoretical Background

In Computer Science education, multiple representations are used to help learners to understand computer science concepts – a vast number of diagram types and notational formats can be found when opening a contemporary text book on topics in computer science and programming languages. The *multimedia effect* (Mayer, 2005) shows that graphical representations often help learners to understand difficult texts and increase their learning outcomes.

However, learners in computer science often struggle with the complexities when studying with learning materials including additional diagrams or programming examples, and there is empirical evidence for decreased learning outcomes when using multiple representations (Ainsworth, 1999). Learners have to perform various mapping activities to identify corresponding elements in different representations to form a coherent mental model – this is a difficult task and it can lead to increased cognitive load and lower learning outcomes. A solution to this problem can be offered by giving support to the learner when performing the coherence formation process (Seufert & Brünken, 2004). On the surface level, the correspondence of elements can be highlighted using color coding or *inter-representational hyperlinks* (for an overview see Seufert & Brünken, 2006), and on a deep structure level, additional verbal information can explain interrelations between different representations.

Due to the multimedia effect, we expect that adding graphical representations to textual representations can be helpful for learners in computer science. It can also be proposed that the application of the different support methods for coherence formation to computer science learning material should improve learning outcomes, even more so when the amount of representations is increased. A study was conducted to investigate these hypotheses.

Method

An experimental study was conducted to analyze the impact of support for coherence formation on cognitive load and learning outcomes of computer science students when using learning material with multiple representations. The study was embedded as an additional seminar into the syllabus of a regular university lecture for undergraduate students in computer science to provide a realistic learning environment. In total, 120 students participated in the study. Students were given a ten-page training material on two computer science topics: an introduction of classes and objects in Java and an introduction of a data structure called linear lists.

The participants of the study were grouped using a 2x2-factorial design: the first factor was whether the students would get 2 textual representations only (instructional text and programming examples) or a graphical representation in addition to the textual representations. The second factor was the inclusion of support for coherence formation into the learning material. Students with support

had an enhanced version of the learning material with additional support for coherence formation. To foster mapping between the two textual representations, color coding was added to important textual elements to signal correspondences, inter-representational hyperlinks marked corresponding elements between graphical and textual information, and additional textual explanations supported the learner in understanding the graphical representations and their relation to the textual representations. Students were asked to work with the material for two weeks.

As dependent variables, learning outcomes were measured using a post test consisting of 11 small exercises ($\alpha = .72$; range from 1 to 11). Additionally, we measured cognitive load after the first part of the learning material (about classes and objects), after the second part of the learning material (about linear lists), as well as after the test. Cognitive load was subjectively rated; it was assessed on a 7-point likert-scale that ranged from very low to very high mental effort (adapted from Paas, 1992). In a pretest, various control variables were analyzed: We conducted tests for prior knowledge, spatial abilities, memory performance, motivation, and learners' confidence in their abilities in computer science in general. After post test, students were also asked to report on their actual learning time.

Results

To analyze the effects of the two factors on learning outcomes, we performed a 2x2 ANOVA with the factors additional graphical representations (2 versus 3 representations) and inclusion of support (with versus without support for coherence formation) with the learning outcomes. There was neither a statistical significant main effect for support, nor for additional representations. However, a significant interaction effect was found for the two factors ($F(1,116) = 4.11$, $p < .05$, $\eta^2 = .03$): The group with both graphical representations and support for coherence formation had better results than groups with only additional representation or only additional support.

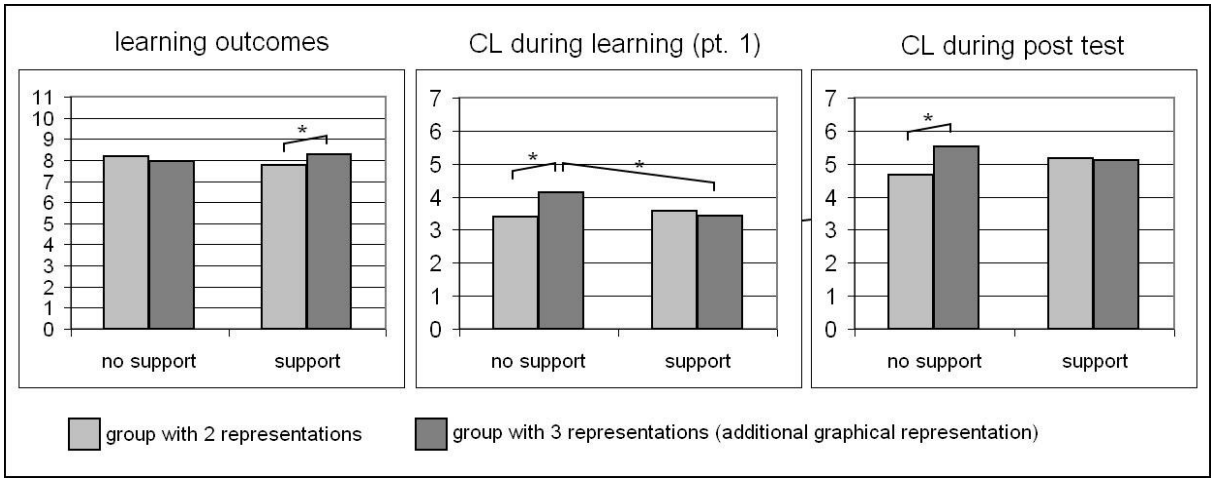


Figure 1. Results for learning outcomes, cognitive load (CL) during learning of part one and during post test; * significant, $p < .05$

For the first part of the learning material, we found a significant interaction effect for cognitive load between the two factors ($F(1,118) = 4.46$, $p < .05$, $\eta^2 = .04$), but also no main effects. For the second part of the learning material, no significant effects could be found for cognitive load, although the pattern of the groups is similar to the cognitive load in the first part. As the second part of the learning material was significantly more difficult, the effect disappeared due to a ceiling effect.

For cognitive load during the post test, again no main effects could be found. An interaction effect was found ($F(1,119) = 4.93$, $p < .05$, $\eta^2 = .04$): the highest load scores could be revealed for the group with additional graphs but without help – although no graphical representations or support for coherence formation were used in the test.

Summary and Discussion

As opposed to the expectation of a positive influence of additional graphical representations (multimedia effect), no main effects for these supporting representations could be found – additional graphical representations per se do not help the learner in achieving higher learning outcomes. The same result can be reported for the support of coherence formation: no main effect was found; neither for learning outcomes nor for cognitive load. The contrary can be seen in the interaction effects: Both additional representations and support for coherence formation even lower learning outcomes if used exclusively. The control group shows very good learning outcomes, so students are able to create a mental model using only the textual representations and don't depend on coherence formation support or additional representations. However, if the two factors are combined, learners show better learning outcomes and reported lower cognitive load during test. The conclusion to be drawn from these results is that additional representations are not necessary in computer science learning material – but if they are to be used, support for coherence formation is important. As most computer science learning material does use lots of graphical representations, we advise to include support for coherence formation more often.

From an instructional point of view, the inclusion of additional representations and coherence formation support is not the final answer to increase learning outcomes for computer science students – future work will also include research on training learners' abilities in dealing with different representations in computer science learning material, rather than concentrating on the design of the learning material itself.

References

Ainsworth, S. (1999). The functions of multiple representations. *Computers and Education, 33*, 131–152.

Mayer, R. E. (Ed.). (2005). *The Cambridge Handbook of Multimedia Learning.* New York: Cambridge University Press.

Paas, F. (1992). Training strategies for attaining transfer of problem-solving skill in statistics: A cognitive-load approach. *Journal of Educational Psychology, 84*, 429–434.

Seufert, T., & Brünken, R. (2004). Supporting coherence formation in multimedia learning. In P. Gerjets, P. Kirschner, J. Elen, & R. Joiner (Eds.), *Instructional design for effective and enjoyable computer-supported learning. Proceedings of the first joint meeting of the EARLI SIGs Instructional Design and Learning and Instruction with Computers (CD-ROM)* (pp. 138–147). Tübingen: Knowledge Media Research Center.

Seufert, T., & Brünken, R. (2006). Cognitive load and the format of instructional aids for coherence formation. *Applied Cognitive Psychology, 20*, 321–331.

Supporting Learning with Multiple Graphical Representations with Intelligent Tutoring Technology

Martina Rau[1],
Vincent Aleven[1], *and*
Nikol Rummel[2]
[1]*Human-Computer Interaction Institute, Carnegie Mellon University, USA*
{marau, aleven} @cs.cmu.edu
[2]*Institute of Education, Ruhr-Universität Bochum, Germany*
Nikol.Rummel@ruhr-uni-bochum.de

Abstract. Fractions are challenging for middle-school students. Research shows that multiple representations can enhance students' understanding of fractions, but provides little guidance as to *how* they should be used. The goal of our research is to investigate how learning with multiple representations of fractions can best be promoted using a successful intelligent tutoring system technology: Cognitive Tutors. We report the results from two recent *in vivo* experiments. Study 1 demonstrates that learning with multiple graphical representations of fractions leads to better learning outcomes than learning with a single graphical representation, provided that students are prompted to self-explain. Study 2 shows that blocking practice with multiple representations presented one-at-a-time leads to better learning outcomes than interleaving practice with the representations. We conclude that Cognitive Tutors can support learning with multiple graphical representations and that they provide a useful platform to research how learning with the representations can be optimized.

Keywords: Intelligent tutoring systems; multiple representations; fractions; classroom evaluation

Introduction

Several studies have demonstrated that multiple representations can enhance robust learning (Ainsworth, 2006), yet it is still open how to best capitalize on their use in realistic curricula. The goal of our research is to generate principles about how multiple representations best support robust learning in a real-world domain, and to build an intelligent tutoring system (ITS) that reflects these principles. We report on two studies that we have conducted in order to reach this goal.

We focus on a domain in which multiple graphical representations (MGRs) are often used: fractions (Cramer, Wyberg, & Leavitt, 2008). Understanding fractions is foundational for more advanced mathematics (NMAP, 2008), yet they pose a significant challenge for students. We investigate ways in which MGRs can support students' understanding of fractions. As platform for this research, we use a successful learning technology, namely, Cognitive Tutors. The design of Cognitive Tutors follows a set of research-based principles. They provide immediate feedback on errors and help on demand, which makes learning more efficient (Koedinger & Corbett, 2006). More specifically, we are using example-tracing tutors, which are behaviorally similar to Cognitive Tutors, but substantially easier to build (Aleven, McLaren, Sewall, & Koedinger, 2009). A key advantage of using computer-based tutors is that they allow for the use of *interactive* representations. Representations with interactive features have been shown to enhance students' learning compared to physical representations (Moyer, Niezgoda, & Stanley, 2005).

We have used different versions of our fractions tutor in two *in vivo* experiments to investigate how to support learning with MGRs of fractions in an ITS. The current version of the fractions tutor includes circles, rectangles, and numberlines (see Figure 1).

Study 1

Although previous research suggests that MGRs (e.g., circles, numberlines, etc.) may promote fractions learning, this notion is mostly based on observational studies. We therefore investigated the effects of providing students with MGRs of fractions, presented one-at-a-time, compared to providing students with only a single graphical representation (SGR), in addition to the symbolic representation (e.g., ½). Research has shown that students benefit from MGRs only if they link the representations

and distill from them a common concept or principle. Therefore, we hypothesized further that self-explanation (SE) prompts would help students benefit from working with MGRs. 112 6th-graders were randomly assigned to work with one of four versions of our fractions tutor which varied on two experimental factors: Whether the tutor incorporated (1) only a SGR or MGRs, and (2) whether or not students were prompted to self-explain how the graphical representations relate to the symbolic notations. Students' performance on an immediate and a delayed posttest demonstrated an advantage for learning with MGRs over learning with a SGR, provided that students were prompted to self-explain (Rau, Aleven, & Rummel, 2009).

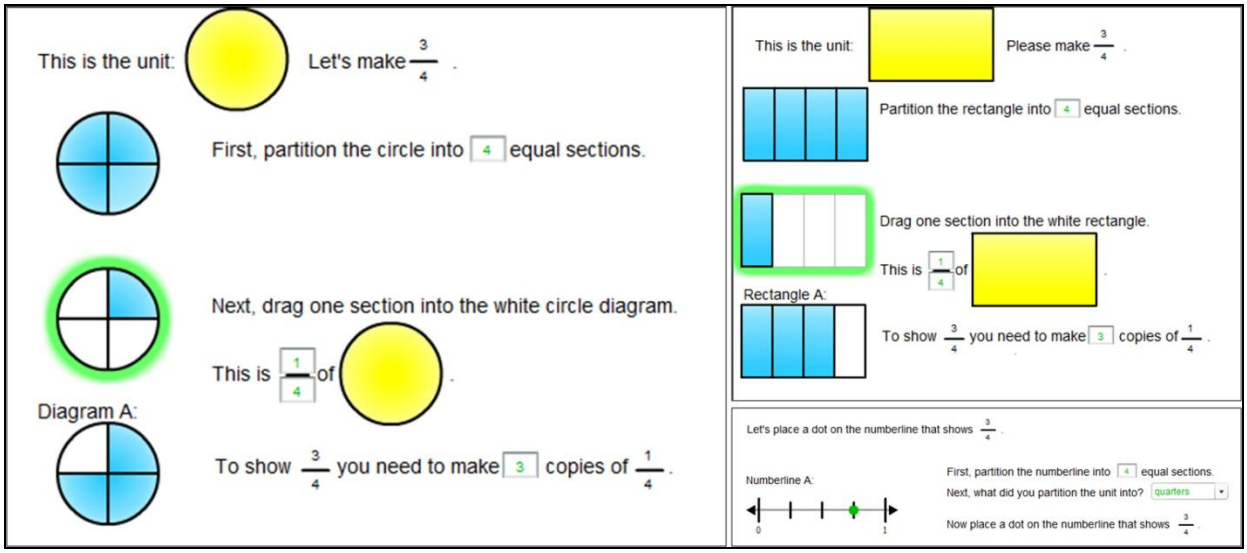


Figure 3. Three separate instances of a problem dealing with equivalent fractions, each with its own graphical representation: circles (left), rectangles (top right), and numberlines (bottom right).

Study 2

When learning with MGRs, students need to acquire representational fluency with each of the representations. In order to benefit from *multiple* representations, students need to flexibly switch between the different representations and make comparisons between them. However, it is yet unclear to what extent the acquisition of each of these cognitive competencies facilitates the acquisition of the other, and consequently, whether representational fluency or representational flexibility should be supported first in order to achieve optimal learning from MGRs. In a second study, we therefore investigated different modes of temporal sequencing of representations when students work with MGRs one-at-a-time. Specifically, we contrast blocking representations (e.g., AAABBBCCC, where A may be a circle, B a numberline, and C a set representation), versus interleaving them (e.g., ABCABCABC). When practice with representations is blocked, students have the opportunity to develop fluency with one representation before the next one is introduced. When practice with different representations is interleaved, students may have greater opportunity to (spontaneously) make comparisons between representations and develop representational flexibility along with fluency. To investigate which temporal sequence leads to the best learning outcomes, we compared four versions of our fractions tutor which differed regarding the temporal sequence in which representations were presented: in a blocked, moderately blocked, interleaved, or increasingly interleaved manner. Results of a recent *in vivo* experiment with 296 5th- and 6th-grade students show an advantage at an immediate and a delayed posttest for the blocked and the increasingly interleaved designs, especially for students with low prior knowledge (Rau, Aleven, & Rummel, 2010). The results thus point toward the conclusion that initially providing opportunities to build up

representational fluency with each representation is more important than initially providing opportunities for spontaneous comparison making between representations.

Discussion and Conclusion

The results from studies 1 and 2 show that an ITS with MGRs can promote students' learning of fractions. Study 1 demonstrates the importance of supporting students' reflecting on connections between graphical and symbolic representations; study 2 supports the notion that the development of representational fluency should be supported before providing students with opportunities for cross-representational comparison making. Open questions remain regarding how we can support students' explicit connection-making between MRGs. In fact, the educational psychology literature indicates that students have difficulty in spontaneously integrating information from different representations, even though connection making is crucial for students' benefit from multiple representations. In our experiments so far, we have relied on spontaneous cross-representational comparison making as we have presented graphical representations one-at-a-time. Our next step will be to experimentally investigate different forms of explicit scaffolding for students to make connections between simultaneously presented MGRs, while building upon our findings from studies 1 and 2.

References

Aleven, V., McLaren, B. M., Sewall, J., & Koedinger, K. R. (2009). A new paradigm for intelligent tutoring systems: Example-tracing tutors. *International Journal of Artificial Intelligence in Education, 19*(2), 105-154.

Ainsworth, S. (2006). DeFT: A conceptual framework for considering learning with multiple representations. *Learning and Instruction, 16*(3), 183-198.

Cramer, K., Wyberg, T., & Leavitt, S. (2008). The role of representations in fraction addition and subtraction. *Mathematics teaching in the middle school, 13*(8), 490-496.

Koedinger, K. R., & Corbett, A. (2006). *Cognitive Tutors: Technology Bringing Learning Sciences to the Classroom.* New York, NY, US: Cambridge University Press.

Moyer, M., Niezgoda, D., & Stanley, J. (2005). Young children's use of virtual manipulatives and other forms of mathematical representations. In W. J. Masalski & P. C. Elliott (Eds.), *Technology-supported mathematics learning environments, 67th yearbook* (pp. 17-34). Reston, VA: National Council of Teachers of Mathematics.

NMAP. (2008). *Foundations for Success: Report of the National Mathematics Advisory Board Panel*: U.S. Government Printing Office.

Rau, M., Aleven, V., & Rummel, N. (2009). Intelligent tutoring systems with multiple representations and self-explanation prompts support learning of fractions. In V. Dimitrova, R. Mizoguchi, B. du Boulay, & A. Graesser (Eds.), *Proceedings of the 14th International Conference on Artificial Intelligence in Education, AIED 2009* (pp. 441-448). Amsterdam: IOS Press, best student paper award.

Rau, M. A., Aleven, V., & Rummel, N. (2010). Blocked versus interleaved practice with multiple representations in an intelligent tutoring system for fractions. A. Aleven, J. Kay, J. Mostow (Eds.), *Proceedings of the 10th International Conference on Intelligent Tutoring Systems, ITS 2010* (pp. 413-422). Berlin/Heidelberg: Springer.

Effects of paper and navigational overviews on sixth-graders' comprehension

Victoria García & Ladislao Salmerón
University of Valencia - Avd. Blasco Ibáñez, 21, 46010, Spain
victoria.garcia-cuenca@uv.es, lasalgon@uv.es

Abstract. Few studies have studied the effect of navigational overviews on children's comprehension. Existing evidence suggest that navigational overviews improve comprehension and navigation control of young students. Nevertheless, current studies can't help to clarify to what extent overviews affect children comprehension because they allow students a) to easily visualize the hypertext macrostructure or b) to easily navigate across information nodes. We describe the results from a study with sixth-graders which support the hypothesis that navigational overviews enhance inferential comprehension by providing students with navigation control over their reading.

Keywords: hypertext comprehension; graphical overviews; sixth-graders.

Introduction

Graphical overviews are textual devices that convey hypertext structure to students by displaying section titles and their relations. In educational hypertext, graphical overviews are intended to serve two purposes: a) to improve students' visualization of the hypertext macrostructure, and b) to support navigation across the hypertext nodes.

A bulk of evidence shows that graphical overviews support students' comprehension in traditional printed texts to both children and adult students (e.g. Assimilation Theory, Mayer, 1979). This theory states that graphical overviews help readers to emphasize the relevant characteristics of the text organization and make more accessible the relations between relevant ideas. The usefulness of graphical overviews in hypertext, by contrast, is currently a controversial issue (Salmerón et al., 2005). Few studies have tried to clarify this issue with regards to children's comprehension (Puntambekar & Goldstein, 2007). The authors provided sixth-grade students with two versions of real class documents. These included either a navigation overview or a list of concepts for navigation. Navigational overviews had no effect on factual comprehension, but they improved children's inferential understanding. In addition, data revealed that students using the navigational overview navigated better the system, i.e. visited more relevant sections for the students' objectives.

Although this study stresses the relevance of navigational overviews on children's learning, it can not help to clarify to what extent students comprehend better because these overviews allow them a) to easily visualize the hypertext macrostructure (Mayer, 1979) or b) to control their navigation in relation to their reading objectives (Scheiter & Gerjets, 2007). Our study aims to answer this question. We provided a group of sixth-graders with two versions of a text-book excerpt: a hypermedia system which forced them to use a navigational overview to read through the sections, or a paper version of the materials, which included the same graphical overview.

Method

Sixty-six sixth-grade students from a midsize Spanish school participated in the study. Mean age was 11 years old, most students were Caucasian, and the percentage of girls was of 51.6%. Each participant was randomly assigned to one of the groups: paper vs. navigable overview. We controlled for several individual variables which could influence children's comprehension: sustained attention, visuo-spatial skills, lexical access and general reading comprehension ability.

Materials consisted of an adapted version of a chapter on "Ancient Rome daily life" from a text-book. This topic is introduced in the Spanish curricula in the seventh grade, thus most students had no much prior knowledge on it. The text included 2332 words, divided into 20 sections, and included a graphical overview, which signaled the structure of the sections (see Figure 1). The hierarchical structure started with a main section, "The origins of Rome". The hierarchy also included five second-

level sections, eleven third-level sections, and three four-level sections. Second level nodes introduced the information with rhetorical questions such as "How was the Roman society?" Students were provided with twelve questions (6 true-false and 6 multiple-choice format). Six questions evaluated factual comprehension by requesting information that was stated in a single section (e.g. Slaves in Ancient Rome were born and died being slaves, so they could not change their social status). Other six questions evaluated inferential comprehension by requesting students to integrate information that appeared in at least two different sections (e.g. 'The social status of women in Ancient Rome was similar to that of slaves, because they could not vote nor have a job as politician', referring to information on 'Women' and 'Slaves' sections). Questions were moderately reliable: Cronbach alpha = .52 and .49 for factual and inferential questions respectively.

In a first session we assessed students in several variables related to reading (attentional abilities, visuo-spatial reasoning, lexical access and reading comprehension ability). In a second session, students were instructed to read the (hyper)text with the aim of answering some questions about the contents. They were told to check thoroughly the graphical overview provided with the text, because it could help their comprehension. After reading the (hyper)text, they were provided with the comprehension questions. Students could go back to the (hyper)text if needed.

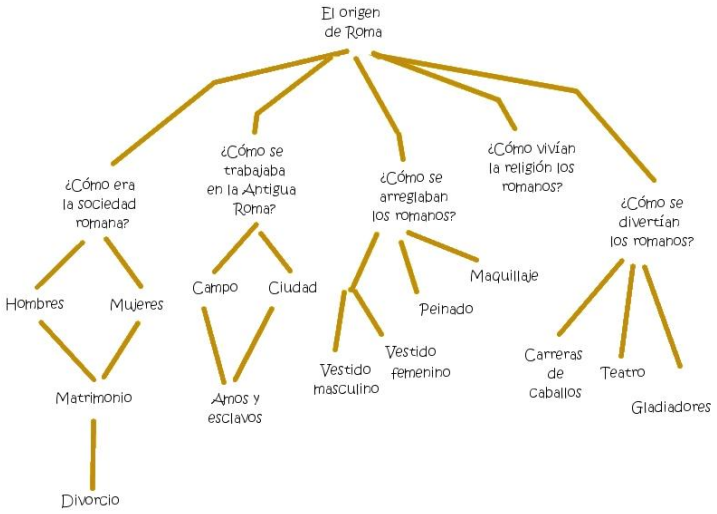


Figure 1. Graphical overview used in the experiment.

Results

We conducted two ANCOVAs with type of overview (navigational and paper) as independent variable, scores on attentional abilities, visuo-spatial reasoning, lexical access and reading comprehension ability tests as covariates, and scores from factual and inferential questions as dependent variables. Students' scores did not differ for factual questions: navigational overview group: (M = .62 percentage of questions answered correctly; SD = .29), paper overview group: (M = .62; SD = .27), F (1, 60) = 0.00, p=.99. By contrast, results for scores on inferential questions revealed significant differences by group, F(1, 60) = 5.10; p=.03. After controlling for the effect of the covariates, results showed that students in the navigational overview group (M = .59; SD =.26) outperformed those in the paper overview group (M = .47; SD = .22).

Conclusions

Our results indicate that the use of navigational overviews improves comprehension of sixth graders to a further degree than a paper overview. This benefit is limited to inferential comprehension, which concurs with previous studies showing that overviews might help students to integrate ideas into a coherent representation (Puntambekar & Goldstein, 2007). In addition, this pattern of results allows clarifying how navigation overviews affect comprehension. Their effect can't only be due to

the fact that they provide an accessible visualization of the text macrostructure, because this is also the case for paper overviews. Nevertheless, navigational overviews also provide students with further navigational control, which could have helped them to focus on relevant nodes for their reading purpose (Scheiter & Gerjets, 2007).

Even though the present study contributes to the literature on hypertext comprehension by stressing the relevance of navigational overviews, it should be acknowledged that our investigation comes with certain limitations. Our findings are restricted to a sample of regular students reading a rather difficult hypertext (to which they mostly did not have background knowledge). Future research should study the potentials of such overviews to improve struggling readers' comprehension, and might clarify to what extent overviews are useful for a population of varying background knowledge. In addition, in our study we used hierarchical overviews, as opposed to networked or hybrid structures. That was done because hierarchical overviews have been the focus of most prior research, and because they are the most currently used by designers for Internet sitemaps (Pilgrim, 2007). However, further research should explore the potential of other overviews structures to foster children's comprehension.

References

Mayer, R. E. (1979). Twenty years of research on advance organizers: Assimilation theory is still the best predictor of results. *Instructional Science, 8,* 133-167.

Pilgrim, C. J. (2007). Trends in sitemap designs – A taxonomy and survey. W. Piekarski & B. Plimmer (Eds.). *Proceedings of the Eight Australasian conference on User interface, 64*, 95-102.

Puntambekar; J. & Goldstein (2007). Effect of visual representation of the conceptual structure of the domain on science learning and navigation in a hypertext environment. *Journal of Educational Multimedia and Hypermedia, 16,* 4.

Salmerón, L., Cañas, J.J., Kintsch, W. & Fajardo, I. (2005). Reading strategies and hypertext comprehension. *Discourse Processes, 40*, 171-191.

Scheiter, K. & Gerjets, P. (2007) Learner control in hypermedia environments. *Educational Psychology Review, 19.* 285 – 307.

Computer-based support of graph interpretation

Markus Vogel
University of Education Heidelberg, Germany
vogel@ph-heidelberg.de

Tina Seufert
University of Ulm, Germany
tina.seufert@uni-ulm.de

Abstract: The difficulties students have when working with graphs are well known by teachers and researchers. For example, treating the graph as a literal picture is an error that often occurs. An idea to find a remedy is to illustrate essential mental operations externally. This is called supplantation. An approach applying supplantation in the field of graph interpretation is developed based on theories of multimedia learning. Working with dynamic linked representations is a crucial element of this approach. In a first empirical study practical and theoretical impacts have been investigated. The results indicated that such a computer-based support of reading graphs can be a useful tool to enhance adequate understanding of graphs. Adjusting this kind of support to individual abilities in more detail was the objective of a second study. In this paper the most important results of this subsequent study are reported.

Keywords: Multiple representations, graph interpretation, supplantation

Motivation

There are mental transformations required to read logical pictures like graphs with a high level of abstraction. If a student does not recognize the abstract character he may interpret the abstract visualization in a non-abstract manner and thus fail interpreting the diagram. Intervention is necessary in such cases of misinterpretation. Focusing on interactive presentations, our main research question is: "How can interactive learning material support the understanding of graphs? How should it be designed?"

Theoretical background

If students are not able to perform adequate mental operations on graphs internally, they can be supported by external representations showing the necessary operations. This is called supplantation (Salomon 1994). In our context supplantation can support mental operations on graphs in two ways: supplantation of the imagination how to relate a certain point of the graph and the underlying concrete object or situation to each other (aspect of relation) and supplantation of the imagination how the concrete object or situation changes when a point of the graph is moved to the left or the right or the other way round (aspect of covariation). Working with multiple representations is the crucial factor for implementing the kind of supplantation described above: the abstract representation of a graph and an appropriate concrete representation of the underlying situation can be dynamically linked in a computer-based learning environment. This means that if something is changed in one representation, the corresponding changes will appear in the other representation simultaneously. In order to construct a coherent mental representation of the domain, learners have to understand each of the single representations as well as to integrate them. The integration process can be seen as a process of mapping of corresponding elements between the different representations (Seufert, 2003). In this way a familiar representation can be used to support the interpretation of a less familiar or more abstract one (Ainsworth, 1999).

Study

Research questions, subjects, procedure and material:

Based on a previous study (Vogel et al., 2007) the main objective of this subsequent study was to compare different types of reduced supplantation (supplantation only of the relation aspect and supplantation only of the covariation aspect). In addition, the visuospatial abilities on the students'

performance have been considered. In this study 49 middle-school students (9th grade) from three different classes with different mathematics teachers participated. Being a subsequent study using the same material and following the same procedure as the previous study in which the effects regarding to a control group were tested, this study followed a pretest-posttest-design with two groups: a relation group (24 students) and a covariation group (25 students). The students were randomly assigned to one of both groups. In each group the students had to work on five multipart tasks given in form of a multiple-choice questionnaire. The first and fifth tasks had to be solved without support and served as pre-test and post-test. Tasks 2, 3 and 4 were training units and were given in a java-programmed environment using notebooks. All tasks were about functional dependencies of geometric objects (e.g. how depends the height of a variable triangle with a constant area from the baseline) represented in a geometric figure and a graph (for details see Vogel et al., 2007). Due to organizational reasons of the school the participating students got a test to diagnose their visuospatial abilities (Ekstrom et al. 1976) after the post-test but not before as originally planned.

Hypotheses and Data:

The first hypothesis compares the effects of the two different treatments on learning outcome. The covariation aspect can be seen as a dynamic relationship between graph and geometric figure. So, there are elements of the static relation aspect enclosed in the dynamic covariation aspect but not vice versa (cf. Ainsworth & van Labeke, 2004). Because of this, we assumed that covariation supplantation provides more support and we state as our first hypothesis: Students of the covariation group have higher differences (variable diff) between pre-test and post-test than their colleagues of the relation group. The second hypothesis concerns the variable visuospatial abilities with regard to the different kinds of reduced supplantation. As mentioned above covariation is of dynamic nature whereas relation is of a static one. The dynamic characteristics of covariation might be too demanding to be internalized for those with lower visuospatial abilities. Thus, they might have more difficulties to work with this kind of reduced supplantation than interacting intensively with static representations of relation supplantation. We state: Students with low visuospatial abilities are expected to benefit especially from support of relation supplantation, students with high abilities from covariation supplantation.

The difference (variable diff) between correct answers in the pre- and post-test for all 49 students was of main interest. Treatment (variable treat) and visuospatial abilities (variable vispa) were recorded as covariables. To increase the data base the interaction time was recorded as well as time of viewing the work space and time of dragging the computer mouse.

Results:

First hypothesis: In the pre-test, there were no statistically significant differences between the treatment groups. Thus, we could compare the variable diff for these groups to test the first hypothesis. Because diff is a difference of raw scores of a non-standardized questionnaire, we applied the non-parametric two-sided Kruskal-Wallis Rank Sum test with treat as the grouping variable to look for differences. The result shows the treatment to be a nearly significant factor (Kruskal-Wallis chi-square = 3.04, df = 1, p-value = 0.08). Regarding to the direction of the first hypothesis our expectations could be met when interpreting the result of the applied two-sided test statistically as one-sided. The Wilcoxon Rank Sum Test approved it: The diff scores of the covariation supplantation group (M = 1.32, SD = 1.82) are significantly in excess of those of the relation group (M = 0.58, SD = 1.02, Z = 1.734, p-value = 0.04), and not vice versa. Second hypothesis: To look for the relationship between the variables treat and vispa we split up the two treatment groups along the variable vispa. We divided the groups by the 40% and 60% percentiles with respect to their scores in the test for visuospatial abilities and built subgroups (variable vispa.gr). The following mixed linear model was fitted to the data: “diff = treat + vispa.gr + treat x vispa.gr” Computations resulted in:

Table 1: Mixed linear model: regression coefficients, standard errors and p-values

	Intercept	Treat	vispa.gr	treat x vispa.gr
value (std. error)	2.760 (1.645)	-1.320 (1.024)	-1.475 (0.768)	1.037 (0.474)
P	0.10	0.20	0.06	0.03

Unlike the coefficients treat and vispa.gr the interaction coefficient treat x vispa.gr was significant. This agreed with our considerations underlying the second hypothesis. In addition to the significant interaction effect, within the vispa-high achievers the difference between covariation group (M = 1.6, SD = 1.96) and the relation group (M = 0.25, SD = 1.04) proved to be significant (Wilcoxon: Z = 1.735, p-value = 0.04). Because of the high variances this was not the case in the group of the vispa-low achievers (covariation group: M = 1.11, SD = 1.05, relation group: M = 0.40, SD = 1.58, Wilcoxon: Z = 1.073, p-value = 0.14). With respect to interaction behaviour we found within the group of the vispa-high achievers that time of viewing the workspace correlated with variable diff when working with covariation supplantation (Spearman's rank correlation: r = 0.60, p = 0.04), but not with relation supplantation (r = 0.07, p = 0.43). Within the group of the vispa-low achievers there was no comparable effect. These findings we read in reference to success in using the offered support efficiently.

Discussion and Conclusion

This subsequent study shows that different kinds of reduced supplantation provide help for different types of learners. Visuospatial abilities proved to be an important factor which influences interaction behaviour and success when working with different kinds of reduced supplantation. As a next step it would be interesting to investigate all variables of the first study (Vogel et al., 2007) and the subsequent study described above in a study with a larger number of participants. Thus, interaction effects can be specified in more detail and more detailed information with regard to the concept of aptitude treatment interaction (Cronbach & Snow, 1977) will be available.

References

Ainsworth, S. (1999). The Functions of Multiple Representations. *Computers & Education 33,* pp. 131–152.

Ainsworth, S., & Van Labeke, N. (2004). Multiple forms of dynamic representation. *Learning and Instruction, 14(3),* 241-255.

Cronbach, L. & Snow, R. (1977). *Aptitudes and Instructional Methods: A Handbook for Research on Interactions.* New York: Irvington.

Ekstrom, R. et. al. (1976). *Manual for Kit of Factor-Referenced Cognitive Tests.* Princeton: Educational Testing Service

Salomon, G. (1994). *Interaction of Media, Cognition, and Learning.* Hillsdale, New Jersey: Erlbaum.

Seufert, T. (2003). Supporting coherence formation in learning from multiple representations. *Learning and Instruction, 13,* 227-237.

Vogel, M., Girwidz, R. & Engel, J. (2007). Supplantation of Mental Operations on Graphs. *Computers & Education, 49(4),* pp. 1287-1298

Learner generated representations as a strategy for learning with text and pictures

Felix Wagner
Tina Seufert
Ulm University, Institute of Psychology and Education
Albert-Einstein-Allee 47, 89081 Ulm, Germany
felix.wagner@uni-ulm.de; tina.seufert@uni-ulm.de

Abstract. To understand learning material comprising multiple representations (i.e. text and pictures) it is crucial to build a coherent mental model of the given information. This process includes active selecting, organizing and integrating important parts of every given representation. Several studies have shown that the externalization (in forms of learner generated drawings) of the mental model can be effective when learning from text only material. In an experimental study we analyzed whether learner generated representations are also helpful when learning from text and pictures. Two randomly assigned groups were given different instructions. The experimental group was instructed to take graphical notes while working on the material, the control group was instructed to take notes in any form. Results have shown that the experimental group has generated more and better pictures but no differences were found for learning outcomes. A closer look at learner aptitudes indicated that drawing is a demanding process that may distract the learner´s attention from active learning.

Keywords: learner generated representation; learning; multiple representations.

Introduction and Theoretical Background

Learning a certain subject in school or university mostly means dealing with multiple given representations. In order to comprehend multiple representations adequately it is crucial to build a coherent mental model. This process includes active selecting, organizing and integrating important parts of any given representation (Mayer, 2005). Recent studies on text based learning material revealed that the externalization of the mental model in forms of learner generated pictorial representations (logical, realistic drawings) can be an effective strategy to foster better understanding of a to-be-learned concept: for generating an external pictorial representation of a to-be-learned concept, learners will have to mentally represent its global structure, which does not mean that the generated representation is an exact copy of the internally built mental model (Seufert, Zander, & Brünken, 2007; Van Meter, Aleksic, Schwartz, & Garner, 2006). Results of these studies also indicate that spatial abilities are an important factor for understanding the given subject using the strategy of generating representations (Seufert, et al., 2007). Also generating one's own representations may have a metacognitive learning effect as the learners are able to identify missing parts of the overall concept in their generated picture.

In the present study we analyzed whether the strategy of learner generated representations is also effective when learning from text and pictures. Substantial interest is whether learners generate more and especially more comprehensive representations when an instruction is given to take graphical notes while learning. Moreover, we assume an Aptitude-treatment-interaction effect, i.e. learners with high and low spatial abilities will respond to the instruction in a different way: especially learners with low spatial abilities will react to the instruction, i.e. they will create more, but not necessarily better graphics whereas learners with high spatial abilities should not need a special instruction to apply their abilities during learning. According to the findings of the text based studies we also expect a higher score in learning outcomes (especially for higher order cognitive processes like comprehension and transfer) for the instructed group. The instruction to externalize their knowledge graphically activates the learners to build one coherent analogue representation, including all information of text and pictures, i.e. a mental model – hence, they should acquire deeper and more comprehensive knowledge.

Method

In the study 33 psychology-students took part and were randomly assigned to the experimental or the control group. All participants were given the same learning material about a biological process within our cells which included text and pictures. The experimental group was instructed to take graphical notes while learning, the control group was instructed to take notes in any form. There has been no time limit for working with the material. In addition to learners´ prior knowledge specific characteristics have been assessed as control variables, such as age, sex, learning organization, current task motivation and capacity of working memory. Moreover we assessed learners' spatial abilities as an aptitude factor. For analyzing the ATI-effects two groups with low respective high spatial abilities have been built by a median split, hence all analyses have been conducted as a 2x2 factor ATI-design.

The dependent variables have been assessed after being finished working through the material and taking notes: learning outcomes including three subscales: recall, comprehension and transfer (all with sufficient internal consistency) and the amount and quality of the constructed pictures. The quality of the pictures has been assessed by scale rating the amount of information included within the picture, the enrichment compared to the original given representations and the accuracy of the generated representation. Moreover cognitive load had to be rated subjectively after learning and additionally after the learning outcome test on a 5-point likert scale from 1= very low mental effort to 5 = very high mental effort (based on Paas, 1992).

Results

Concerning the control variables, the two groups did only differ with respect to their current motivation, hence it has been included as covariate in all ANOVAS. For *learning outcomes* we found - contrary to our expectation - no treatment effect and no main effect for spatial abilities or ATI-effects on the learning outcomes for neither of the subscales.

For the *amount and quality of pictures* a main effect for the instruction was found: the amount of pictures that have been constructed ($F(1,28)=8.73$ $p<.01$, $\eta^2=.24$) as well as their quality ($F(1,28)=8.11$, $p<.01$, $\eta^2=.23$) were significantly higher in the experimental group. No main effect for spatial abilities or ATI-effect could be revealed. Especially learners with low spatial abilities have responded to the instruction. For *cognitive load* during the learning process no treatment effect or main effect for spatial abilities was found.

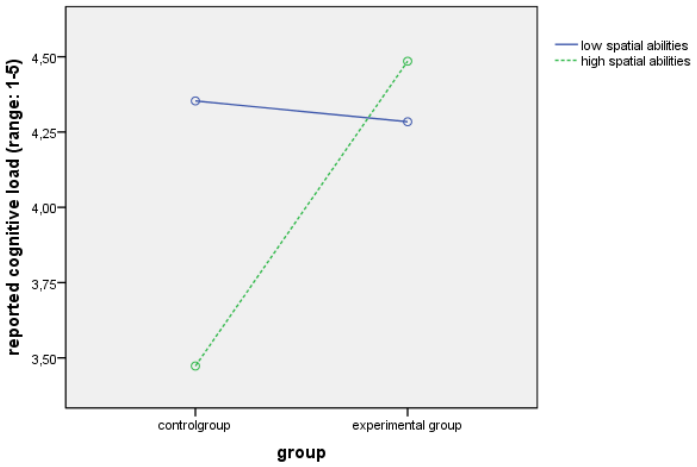


Figure 1: Cognitive load during learning for learners with high and low spatial ability in training and control group.

By trend we found an ATI effect ($F(1,28)=3.88$, $p=.059$, $\eta^2=.22$) (see Figure 1): Contrasts revealed that learners with high spatial abilities reported a higher cognitive load in the experimental group ($MD=-1.01$, $SE = 0.37$, $p=.011$) whereas learners with low spatial abilities did not differ significantly between the groups.

Summary and Discussion

We analyzed the effects of an instruction to take graphical notes while learning from text and pictures. Results showed that the instruction led to a higher amount of pictures produced as well as a higher quality. Especially learners with low spatial abilities responded to the instruction. But drawing pictures as a learning strategy for learning with text and pictures had no impact on either of the learning outcome subscales.

Analyzing learners´ characteristics revealed that those learners with higher spatial abilities reported a higher load score in the experimental group during learning and drawing process. Learners with high spatial abilities seem to invest more effort in taking graphical notes but without any positive effects on the assessed learning outcome. Hence, the highly reported load could be extraneous load that constrains the active learning process. Contrary to the results of studies analyzing learner generated representations when learning from text based material this strategy may become redundant when additional pictorial representation are being presented in the material. It seems that learners do not go beyond the given external representations and do not construct more comprehensive pictures that also comprise relevant text information. Concerning the crucial process of building a coherent mental model for learning with multiple representations, externalizing the mental model does not function as an additional enhancer for the cognitive process of coherence formation. Moreover it has to be concerned, that the material used in this study was of a much more complex subject than those used in the text based studies. It also has to be mentioned, that the sample was rather small for a two 2x2 factor designed study.

Hence, future experimental studies will have to analyze the redundancy effect of learner generated pictures when learning from text and pictures and also the effect of the material´s complexity will have to be analyzed. Moreover it would be interesting to also analyze metacognitive processes while learning and generating self-constructed representations.

References

Mayer, R. E. (2005). *The Cambridge handbook of multimedia learning*. Cambridge: Cambridge Univ. Press.

Paas, F. (1992). Training strategies for attaining transfer of problem-solving skill in statistics: A cognitive-load approach. J*ournal of Educational Psychology, 84*, 429-434.

Seufert, T., Zander, S., & Brünken, R. (2007). Das Generieren von Bildern als Verstehenshilfe beim Lernen aus Texten. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie, 39 (1)*, 33-42.

Van Meter, P., Aleksic, M., Schwartz, A., & Garner, J. (2006). Learner-generated drawing as a strategy for learning from content area text. *Contemporary Educational Psychology, 31*(2), 142-166.

How to Measure Cognitive Load while Learning from Multimedia Instructions? – An Experimental Dual-Task Study

Babette Park
Saarland University
Department of Education, Campus A 4.2, 66 123 Saarbrücken, Germany
b.park@mx.uni-saarland.de

Roland Brünken
Saarland University
Department of Education, Campus A 4.2, 66 123 Saarbrücken, Germany
r.bruenken@mx.uni-saarland.de

Abstract. The present study joins a series of studies about direct methods for measuring cognitive load while learning with multimedia instruction by using the dual-task paradigm. The goal of the present work was to develop a dual-task method, which measures cognitive load in a direct and continuous way. In addition and in contrast to the until now used secondary tasks, this new method is characterized by its independence from the presentation mode of the learning instructions (primary task), as the secondary task is realized by internalized cues: A previously practiced easy rhythm is executed continuously by foot-tapping of the learner while learning. The suitability of this method was examined in the frame of two studies (n = 30 each). Results show that rhythm precision and errors allow a precise and continuous measurement of cognitive load during the learning process.

Keywords: Cognitive load; working memory; executive control; measurement; dual-task; foot-tapping; rhythm

Theoretical Framework and Objectives

The present work was initialized due to recent publications in cognitive load research, which discuss the widespread and most frequently used subjective rating scale of Paas (1992) and recommend using objective and direct methods for measuring cognitive load (Brünken, Plass & Leutner, 2003; DeLeeuw & Mayer, 2008; Plass, Moreno & Brünken, 2010). Direct measurement can be realized for example by brain activity measures and dual-task performance (Brünken et al., 2003). Brain activity measures were so far not used in the frame of learning studies for economic and practical reasons. In contrast, a series of studies could already show that dual-task performance is a reliable and valid method to measure cognitive load (e.g. Brünken, Plass, & Leutner, 2004; DeLeeuw & Mayer, 2008), which is measured by the performance in a secondary task that has to be executed in parallel during the whole learning session. Differences in resource consumption caused by e.g. different presentation forms of the learning material (extraneous load) can be obtained by differences in secondary task performance. The established secondary tasks are realized by auditory or visual cues in the learning instruction (Brünken, et al., 2004). For example, in a study of Brünken et al. (2004), participants had to monitor a letter in the upper part of the computer screen and had to react by pressing the space bar, when a color change was observable. However, auditory or visual secondary tasks do not measure total cognitive load, but a modality-specific aspect, which is the cognitive load in the visual or acoustic subsystem of working memory. Moreover, these mentioned secondary tasks are dependent from learning instruction (primary task), as they require a conscious disruption of the learning process to respond to an auditory or visual cue. This is also the case in the original experimental task-switching design, which has been established as a cognitive psychology method to measure executive control processes in the frame of the working memory model of Baddeley (1992). For instance, participants have to alternate between adding and subtracting 3 to/from numbers on a list (Emerson & Miyake, 2003). In order to show that executive control is organized by inner speech that regulates switching between two tasks, Emerson and Miyake (2003) introduced over that an articulatory suppression task (saying "a-b-c" while switching) and could prove their hypothesis. Furthermore, the authors showed that an additional motor

task like frequent tapping even seems to stimulate cognitive processing of and the performance in motor or visual primary tasks (Brown & Marsden, 1991; Emerson & Miyake, 2003). The objective of the present work is to solve the problem that the secondary task should be independent from the primary task in educational research in the way that learners do not have to interrupt the primary task (learning) consciously and are not stimulated by the secondary task itself. A motor task could be the solution. However, this task should not be characterized by frequent tapping, but require inhibition processes. Inhibition processes are a good indicator for executive control processes (Cohen et al., 1997), which can be interpreted as a modality-unspecific total cognitive load indicator. For instance, an easy rhythm with pauses already requires inhibition, when learners have to consciously inhibit to tap. Moreover, the motor task should be independent from the primary task, which can be realized by internalized cues. The new invented secondary task should allow a precise and continuous measurement of cognitive load in the learning process.

Methods and Data Sources

The suitability of a new invented secondary task for continuously measuring cognitive load while learning was examined in the frame of two studies (n = 30 each). To examine this method, it was necessary to use learning material that could already show an instructional design effect on learning, which is the prerequisite of a cognitive load effect. We used seductive details material, which was already confirmed to induce a negative learning effect in the first study, $F(1, 29) = 2.92$, $p < .05$, $eta_p^2 = .10$ (Park, Moreno, Seufert & Brünken, in press). The second study now should show the hypothesized cognitive load effect and examine the new invented method. 30 high-school students (53.33 % female) with an average age of 16.93 years (SD = 1.36) took part. They were randomly assigned to one of the two experimental groups (with vs. without seductive details). The learning instruction consisted of a self-paced multimedia environment about the structure and function of a cellular molecule. Learners had to execute a foot-tapping rhythm task simultaneously to learning and continuously all over the learning session in both conditions. The rhythm was written in four-four time that is the easiest meter for playing music and was very easy: tap – tap – pause – pause / tap – tap – pause – pause /…. and so forth. Learners were introduced to this rhythm task before the session started. Working memory capacity, spatial ability, prior knowledge, and time-on-task served as control measures. Learning success was assessed with a learning performance test. Total cognitive load was measured by subjective ratings of mental effort (Paas, 1992) and by the rhythm task, which allowed analyzing the precision (standard deviation from individual rhythm baseline in milliseconds) as well as errors or rate changes (sum of rhythm rate changes in milliseconds).

Results and Conclusions

No statistical significant between-group differences were detected in any of the control variables working memory capacity, spatial ability, and prior knowledge. In line with the previous study, time-on-task differed significantly over the two conditions, $t(27) = 9.96$, $p < .05$, $d = 1.02$. Learners in the seductive details condition took more time to learn (M = 10.98 min, SD = 3.97 min) than learners who learned without seductive details (M = 7.96 min, SD = 1.39 min). Thus, we used time-on-task as a covariate in the following analyses. We conducted separate ANCOVAs using learning performance score and cognitive load ratings, respectively, as dependent variables. According to the previous study, the seductive details effect could be shown in the learning performance, as the learning success was significantly higher for learners, who learned without seductive details, $F(1, 27) = 3.54$, $p < .05$. Also in line with the first study, the seductive details effect could not be found in the subjectively rated cognitive load ($F < 1$). However, the new method for measuring cognitive load confirmed that learners of the seductive detail condition executed the rhythm not as precise (M = 196.92, SD = 71.20) as learners, who learned without seductive details (M = 151.87, SD = 59.59), $t(27) = 1.82$, $p < .05$, d =

.69. Furthermore, learners of the seductive details condition produced more rhythm changes (M = 220.69, SD = 129.39) than learners, who learned without seductive details (M = 138.87, SD = 81.61), $t(27) = 1.97$, $p < .05$, $d = .76$. These results confirm that seductive details are extraneously loading material. The significantly lower learning success of learners under the seductive details-condition is accompanied by significantly lower rhythm precision. Thus, learners undergo higher cognitive load under this condition. This difference in cognitive load could not be measured by subjective ratings. This argues for the suitability and a high sensitivity of the new instrument for measuring cognitive load in working memory. The operationalization of the secondary task allows measuring cognitive load, as this is a continuous task that is independent from the primary task. Moreover, the rhythm task includes inhibition processes, as learners have to stop tapping in the rhythm pauses, which can be used as an indicator for executive control and modality-unspecific total cognitive load. Rhythm precision and errors or rate changes allow a precise measurement of cognitive load in the learning process.

Discussion and Future Directions

The present work offers a new method to measure cognitive load in an objective and direct way. This rhythm task is in contrast to previously used dual-task methods independent of the learning material by using internalized cues. Moreover, this method is not modality-specific as visual or auditory secondary tasks, which were introduced in cognitive load research so far. However, this new method should be examined in other studies, which induce different cognitive load factors, such as modality, redundancy, or learning-conducive tools like mental animation tasks. One more future direction is to compare the present method with other methods for measuring cognitive load in an empirical study to gain insight into differential effects of the few methods, which are operationalized until now.

References

Baddeley, A. D. (1992). Working memory. New York: Oxford University Press.

Brünken, R., Plass, J. L., & Leutner, D. (2003). Direct measurement of cognitive load in multimedia learning. *Educational Psychologist, 38*, 53-61.

Brünken, R., Plass, J., & Leutner, D. (2004). Assessment of cognitive load in multimedia learning with dual-task methodology: Auditory load and modality effects. *Instructional Science, 32*, 115-132.

Cohen, J.D., Perlstein, W.M., Braver, T.S., Nystrom, L., Noll, D.C., Jonides, J., & Smith, E.E. (1997). Temporal dynamics of brain activation during a working memory task. *Nature, 386*, 604-608.

DeLeeuw, K., & Mayer, R. (2008). A comparison of three measures of cognitive load: Evidence for separable measures of intrinsic, extraneous, and germane load. *Journal of Educational Psychology, 100*, 223-234.

Paas, F. (1992). Training strategies for attaining transfer of problem-solving skill in statistics: A cognitive-load approach. *Journal of Educational Psychology, 84*, 429-434.

Park, B., Moreno, R., Seufert, T., & Brünken, R. (in press). Does cognitive load moderate the seductive details effect? A multimedia study. Computers in Human Behavior.

Plass, J. L., Moreno, R., & Brünken, R. (2010). *Cognitive Load Theory*. New York: Cambridge University Press.

Seductive Illustrations: Double-Edged Effects?

Ulrike Magner
Rolf Schwonke
Alexander Renkl
University of Freiburg, Department of Psychology, Educational and Developmental Psychology
Engelbergerstr. 41, D-79085 Freiburg, Germany
ulrike.magner@psychologie.uni-freiburg.de
rolf.schwonke@psychologie.uni-freiburg.de
renkl@psychologie.uni-freiburg.de

Vincent A. W. M. M. Aleven
Octav Popescu
Human-Computer Interaction Institute, School of Computer Science, Carnegie Mellon University
5000 Forbes Ave, Pittsburgh, PA 15213, USA
aleven@cs.cmu.edu
octav@cmu.edu

Abstract. Do decorative pictorial illustrations distract from learning and, thus, decrease learning outcomes, as suggested by Cognitive Theory of Multimedia Learning? Or can pictorial illustrations trigger interest and thereby enhance learning as suggested by interest theories? Although these approaches seem to contradict each other, we assume that both are justified. Interesting pictorial illustrations elicit simultaneously unfavorable and favorable processes. We hypothesize that for uninteresting pictorial illustrations in a computer-based learning environment, the unfavorable distraction effect dominates. Hence, uninteresting pictorial illustrations should lead to lower learning outcomes as compared to interesting pictorial illustrations or no pictorial illustrations. In our first study we determined the potential of different pictorial illustrations to trigger interest in geometry learning and to identify interesting and uninteresting pictorial illustrations. The findings of our second study supported our hypothesis for meaningful (conceptual) learning outcomes. A learning environment with uninteresting pictorial illustrations was in particular detrimental for learning.

Keywords: Cognitive Theory of Multimedia Learning; Interest research; Computer-based learning.

Most (German) textbooks contain pictorial illustrations that are interesting but often do not contain essential information about the learning contents. Are such pictorial illustrations "*seductive details*" that impede learning, as suggested by the Cognitive Theory of Multimedia Learning (e.g., Harp & Mayer, 1997)? Or do they enhance interest and, thereby, the efforts for meaningful learning, as suggested by interest theories (Hidi, 2001)? Although both approaches seem to contradict each other we assume that both are justified. Actually, pictorial illustrations can elicit both unfavorable and favorable processes at the same time. The net effect of pictorial illustrations on learning outcomes should depend on how strong the effects are of distraction on the one hand and of eliciting interest on the other hand. Against this background, we assume that uninteresting pictorial illustrations primarily distract and therefore hinder learning, as compared to learning without interesting or no pictorial illustrations. Interesting pictorial illustrations may in part distract the learners but at the same time enhance interest and, thereby, effort for meaningful learning. Thus, it may depend on the amount of interest and effort for meaningful learning whether interesting pictorial illustrations are even more favorable than learning without pictorial illustrations.

We tested our assumptions in the context of learning in an intelligent tutoring system. More specifically, we used a geometry lesson from the Cognitive Tutor. The Cognitive Tutor is successfully applied in diverse learning domains (for an overview, see Anderson, Corbett, Koedinger & Pelletier, 1995) We conducted a first study to analyze how much interest different types of pictorial illustrations elicit. In a second study, we analyzed the learning outcomes of a Cognitive Tutor lesson with interesting pictorial illustrations, uninteresting pictorial illustrations, or no pictorial illustrations. Our expectation was that the learning environment with uninteresting pictorial illustrations would result in lower learning outcomes than the other two conditions (i.e., interesting pictorial illustrations and no pictorial illustrations). In addition, we compared the latter conditions with no specific expectation.

Study I

In a mixed between- and within-subjects design 87 eighth grade students (35 male; 52 female; age: *M* = 13.9 years; *SD* = 0.6) from three classrooms of a German secondary school (Gymnasium) rated the interestingness of each geometry problem (e.g., vertical angle) with and without pictorial illustrations (44 different pictorial illustration combinations, 16 combinations without pictorial illustrations) on nine-point Likert scales (interest-items were adapted from Schiefele, 1990). The pictorial illustrations showed real-life situations.

The primary goal of the study was to differentiate between the most interesting and the least interesting pictorial illustrations. For this purpose we ranked the pictorial illustrations with respect to how much interest they elicited. A comparison of the most interesting pictorial illustrations (upper quarter) with the least interesting pictorial illustrations (lower quarter) yielded a mean difference with an effect size of $d = .56$.

Pictorial illustrations rated as "interesting" could be characterized as *dynamic* (e.g., showing activities such as sailing or volleyball). Pictorial illustrations rated as "uninteresting" could be characterized as *static* (e.g., showing artifacts such as compasses or traffic signs).

Study II

The main goal of our second study was to test the hypothesis that students learning geometry from a computer-based learning environment with uninteresting pictorial illustrations will learn less than students with either no pictorial illustrations or with interesting pictorial illustrations. For the comparison of interesting and no pictorial illustrations we had no explicit expectations. Participants were 80 sixth grade students (46 male; 33 female; 1 missing; age: *M* = 11.5 years; *SD* = 0.5) of a German secondary school (Gymnasium). In a between-subjects design students from three classrooms were randomly assigned to one of the three experimental conditions. Learning outcomes were assessed in terms of conceptual and procedural knowledge.

The experimental sessions lasted about 90 minutes. First, all students were tested about their prior conceptual and prior procedural knowledge of intersecting lines (e.g., vertical and complementary angles). After a short introduction into the topic of intersecting lines and into operating the Cognitive Tutor, all participants had 35 minutes to solve problems in the Cognitive Tutor. Afterwards all participants worked on a posttest (about 25 minutes). Finally, all students answered a set of demographic questions.

To answer the research question, we conducted an ANCOVA with planned contrasts. Prior conceptual knowledge was significantly related to conceptual learning outcomes $F(1,74) = 14.90$, $p < .05$, $r = .15$. Therefore, we included it as covariate. In a first contrast we compared the condition with uninteresting pictorial illustrations with the other two conditions (no pictorial illustrations and interesting pictorial illustrations). Results showed that students learning with uninteresting pictorial illustrations , as expected, performed lower in terms of conceptual learning outcomes than students in learning with interesting pictorial illustrations and without pictorial illustrations $F(1,74) = 8.51$, $p < .05$, *partial* $\eta^2 = .10$. A second planned contrast compared the condition with interesting pictorial illustrations with the condition without pictorial illustrations. We found no significant differences, $F(1,74) = 1.59$, $p > .05$, *partial* $\eta^2 = .02$. Procedural learning outcomes did not differ significantly between conditions. The analyses of the log-file data is still in progress.

General Discussion

We found in Study I that dynamic pictorial illustrations were mostly rated as interesting whereas static pictorial illustrations were mostly rated as uninteresting. We used the most interesting pictorial illustrations and the less interesting ones in a computer-based learning environment for Study II.

Learning success with either interesting pictorial illustrations or no pictorial illustrations did not differ. Learning with uninteresting pictorial illustrations, however, reduced learning success. We assume that these illustrations did not trigger interest, but rather only distracted the learners. These results show the double-edge effect of pictorial illustrations (see also Park, Moreno, Seufert, and Brünken, in press). Pictorial illustrations can enhance learning if they are interesting but they also can reduce learning if they are uninteresting. Therefore, pictorial illustrations should be used with care when no knowledge is available how interesting the illustrations might be for learners (see also Lenzner, and Schnotz, 2009).

A restriction of Study II is that we found effects only for conceptual learning but not for procedural learning. One possible explanation for this is that interest primarily supports efforts for meaningful learning (Hidi, 2001) as measured in particular by our conceptual knowledge posttest problems. More "mechanical" knowledge on calculation procedures was not fostered by the "interest-enhanced" efforts for meaningful learning. Generally, the results should be interpreted with some caution as more detailed process analyses (especially interest ratings assessed online during the learning phase) are still in progress. In further studies, we want to investigate specific learning processes as elicited by different types of pictorial illustrations and specific conditions (e.g., differences in prior knowledge) where positive or negative effects of pictorial illustrations dominate.

References

Anderson, J. R., Corbett, A. T., Koedinger, K. R., & Pelletier, R. (1995). Cognitive tutors: Lessons learned. *The Journal of the Learning Sciences, 4,* 167-207.

Harp, S. F., & Mayer, R. E. (1997). The role of interest in learning from scientific text and illustrations. On the distinction between emotional interest and cognitive interest. *Journal of Educational Psychology, 89*(1), 92-102.

Hidi, S. (2001). Interest, reading, and learning: Theoretical and practical considerations. *Educational Psychology Review, 13*(3), 191-209.

Lenzner, A. & Schnotz, W. (2009). *Aktivierung von Lernstrategien durch Bilder*. *[Activation of learning strategies through pictures]* In R. Plötzner, T. Leuders, A. Wichert (Hrsg.). Lernchance Computer – Strategien für das Lernen mit digitalen Medienverbünden. [Learning opportunity computer – strategies to learn with digital media networks] Münster: Waxmann-Verlag.

Park, B., Moreno, R., Seufert, T., & Brünken, R. (in press). *Does cognitive load moderate the seductive details effect?* A multimedia study. Computers in Human Behavior.

Schiefele, U. (1990). Thematisches Interesse, Variablen des Leseprozesses und Textverstehen. [topic interest, variables of reading processes and text comprehension*]. Zeitschrift für experimentelle und angewandte Psychologie, XXXVII*(2) [Journal of experimental and applied psychology], 304-332.

Reducing Intrinsic Cognitive Load: Different Strategies with a Common Explanation

Paul Ayres
University of New South Wales
Sydney, Australia
p.ayres@unsw.edu.au

Abstract. Learners often struggle with task complexity (intrinsic cognitive load) and therefore there is a need to reduce it. A successful strategy in CLT research has been to isolate elements. Whole tasks are deconstructed into partial tasks, thus reducing the number of interacting elements that need to be processed by the learner. Partial schemas developed from part-tasks enable learners to deal with more complex full tasks at a later stage. However, other research within CLT and within other paradigms, have also identified strategies to reduce task complexity. This paper reviews these methods such as pre-training, focusing on subgoals, and presenting declarative and procedural information separately. It is concluded that in most cases a part-whole approach is advocated, but all essentially rely on methods to reduce element interactivity.

Keywords: Cognitive load theory; intrinsic cognitive load; element interactivity

The concept of element interactivity can provide a theoretical construct underpinning task complexity and learning. Some material low in element interactivity and consequently low in intrinsic cognitive load requires few working memory resources because the constituent elements do not interact and can be learned in isolation. Other materials high in element interactivity have elements that interact and must be processed simultaneously as they cannot be understood as single elements. Such information requires more working memory resources. Some information is so high in element interactivity that the demands placed on working memory exceed its capacity to process the information. How can students learn new, high element interactivity information if their WM capacity is overloaded? The aim of this paper is to demonstrate that cognitive load theory (CLT) and other theoretical approaches have provided some answers to this question, all of which depend on the underlying strategy to reduce element interactivity in some form or the other.

Within CLT, some studies have used a direct approach to reducing the number of interacting elements by dissembling whole-tasks into partial-tasks. The strategy has been called *isolating elements*. Pollock, Chandler and Sweller (2002) combined a sequential approach with a strategy to directly reduce intrinsic cognitive load. Apprentices were taught how to conduct electrical safety tests. To isolate elements Pollock et al. initially focused instruction on explaining only basic procedural steps, such as how to conduct a resistance test. This was followed by a second phase, where the learning materials were repeated with full interacting elements, including other relevant explanatory information to fully understand all aspects of the task. Consequently, the isolated elements group experienced a progression from low to high element interactivity, which was found to be superior to a strategy that repeated the high element interactivity conditions twice. Ayres (2006) also used an isolated elements approach to learn basic algebraic concepts. To create an isolated- elements environment, Ayres designed a set of worked examples that demonstrated only one calculation at a time. This isolated-elements strategy was compared with an integrated (interacting elements group) strategy where a group of students were given full worked examples showing all calculations together. A significant expertise reversal effect was found (see Kalyuga, Ayres, Chandler & Sweller, 2003). Students with the least mathematical ability benefited from the isolated elements approach, whereas students with the higher mathematical ability benefited from the fully integrated worked examples approach.

A number of other methods have also been successful in reducing intrinsic. One such method is to develop specific prior knowledge before the final materials are presented. This method is often referred to as *pre-training*. Mayer, Mathias and Wetzell (2002) asked students to learn from a narrated animation on how brakes work. By pre-training on the component models as opposed to learning the

component and causal models simultaneously, more attention could be paid later to causal effects. Basic pre-training, led to significant improvements on problem solving in this multimedia environment, by reducing element interactivity. The component and causal models are closely related and so their elements interact. A causal model is probably unintelligible without the component model. Presenting both simultaneously best exemplifies the interactivity between the elements but at the cost of a very heavy, intrinsic cognitive load that may prevent learning. By learning the component model first, many of the interacting elements can be embedded in schemas that can be treated as a single element when later considering the causal model. In this way, element interactivity remains relatively low throughout learning and so within working memory limits. Clarke, Ayres and Sweller (2005) also conducted a study that focused on pre-training a secondary skill (spreadsheet knowledge) that was required for learning specific primary concepts (mathematical graphs). Clarke et al. found that students with initially low knowledge of spreadsheets benefited from pre-training on spreadsheets before using them to learn mathematical concepts compared with a concurrent strategy of simultaneously dealing with the spreadsheets and mathematical concepts. Simultaneously dealing with elements associated with both spreadsheets and mathematics overwhelmed working memory resources for these students. In contrast, students who had more knowledge of spreadsheets benefited from the concurrent approach. These more knowledgeable learners already had many of the elements associated with spreadsheets incorporated into schemas and so it was wasteful teaching them about spreadsheets independently of the mathematics.

Catrambone (1998) observed that learners have difficulty transferring knowledge gained through a set of examples to tasks that are conceptually similar but procedurally quite different. To overcome this problem, Catrambone showed that if learners structured their solutions in terms of subgoals, transfer of knowledge was achieved. An important part of this process was a cueing strategy, where labels were used to cue students into noticing that certain steps could be grouped. The underlying theoretical argument proposed that if the learners were cued that certain solution steps belong together then they will try to self-explain the purpose of the steps and why they belong together. From the present perspective, it can be noted that Catrambone also commented that a learner is more likely to integrate new knowledge with old if tasks are completed in small sections, which is consistent with a reduction in intrinsic cognitive load. By creating an instructional environment that focuses on subgoals, element interactivity is lowered because only the elements within a subgoal need to be considered at a given time rather than all of the elements in the task

Kester, Kirschner and van Merriënboer (2006) distinguished between two types of information that must be managed during problem solving: declarative and procedural. Kester et al. argued that processing both at the same time could lead to cognitive overload. In particular it was theorized that declarative knowledge has a higher degree of element interactivity than procedural information and therefore should not be presented during practice. By avoiding procedures initially, more working memory can be devoted to elaboration of the new information, leading to schema acquisition. On tasks that required trouble-shooting in electrical circuits, it was found that a strategy that sequenced information in the order of declarative (pre-practice) followed by procedural (during practice) or vice versa, was superior than a strategy that presented both declarative and procedural knowledge together.

Gerjets, Scheiter and Catrambone (2004) distinguished between *molar* and *modular* presentation of solutions, arguing that traditional approaches emphasize the categorization of problems, as an important step in problem solving. Students learn categories of problems and their associated solutions in a molar approach. This strategy creates a high cognitive load, as it requires learners to consider multiple structural task features at the same time. To prevent this situation, they advocated a decrease in intrinsic load through a modular approach that emphasized partly independent modules that could be used for required calculations. Because each module could be considered meaningfully in isolation, element interactivity and intrinsic cognitive load was reduced. In a series of experiments Gerjets et al. directly compared a modular strategy with a molar strategy. From a CLT perspective, by considering a

generalised formula (molar approach) there are a number of interacting elements present that must be considered simultaneously. By breaking down the formula into constituent parts (modular approach), elements are isolated. In the Gerjets, Scheiter and Catrambone studies, the complexity of the tasks themselves were not reduced, only the presented solutions were reduced in complexity.

Intrinsic cognitive load is often considered fixed and dependent upon expertise, but it can be manipulated by changing the nature of the tasks. Although approached from different theoretical considerations, the studies described in this paper all changed intrinsic cognitive load by reducing element interactivity in the early stages of learning. Hence, considerations of element interactivity may be a useful theoretical framework for researchers who are focused on investigating problem complexity. Furthermore, in a recent commentary, Sweller (2010) argues that element interactivity should be central to cognitive load theory, not only because it explains the concept of intrinsic load, but also because it can be applied to understanding both extrinsic and germane cognitive load.

References

Ayres, P. (2006). Impact of reducing intrinsic cognitive load on learning in a mathematical domain, *Applied Cognitive Psychology, 20*, 287-298.

Catrambone, R. (1998). The subgoal learning model: Creating better examples so that students can solve novel problems. *Journal of Experimental Psychology: General, 127*, 355-376.

Clarke, T., Ayres, P., & Sweller J. (2005). The impact of sequencing and prior knowledge on learning mathematics through spreadsheet applications, *Educational Technology, Research and Development, 53(3)*, 15-24.

Gerjets, P., Scheiter, K, & Catrambone, R. (2004). Designing instructional examples to reduce cognitive load: Molar versus modular presentation of solution procedures, *Instructional Science, 32*, 33-58.

Kalyuga, S., Ayres, P., Chandler, P., & Sweller, J. (2003). The expertise reversal effect. *Educational Psychologist, 38*, 23-31.

Kester, L., Kirschner, P.A. & van Merriënboer, J. (2006). Just-in-time information presentation: Improving learning a troubleshooting skill. *Contemporary Educational Psychology, 31*, 167–185.

Mayer, R. E., Mathias, A., & Wetzell, K. (2002). Fostering understanding of multimedia messages through pre-training: Evidence for a two-stage theory of mental model construction. *Journal of Experimental Psychology: Applied 8(3)*, 147-154.

Pollock, E., Chandler, P., & Sweller, J. (2002). Assimilating complex information. *Learning and Instruction*, 12, 61-86.

Sweller, J. (2010). Element interactivity and intrinsic, extraneous and germane cognitive load. Educational Psychology Review, 22, 123-138.

When Non-Linearity Contributes to Germane Cognitive Load: Effects of Content and Task Complexity

Joerg Zumbach and Andrea Hellmayr
University of Salzburg
Hellbrunnerstraße 34, 5020 Salzburg, Austria
joerg.zumbach@sbg.ac.at

Abstract. In an experiment, the influence of content and task complexity on Hypermedia learning is examined. It is assumed that non-linear information retrieval does not, in general, lead to Extraneous Cognitive Load and, thus, might be disadvantageous compared to linear navigation. Results reveal that if complex relationships within a domain have to be acquired, non-linearity might foster schema acquisition rather than linear access. Results can be explained by the need of elaboration processes and schema activation due to non-linear navigation demands.

Keywords: Hypermedia; Cognitive Load; Task Complexity

Introduction: Non-Linearity in Hypermedia Learning

Hypermedia learning is mainly characterized as learning with non-linear organized, linked text-based nodes. Although there is a huge body of research on this kind of learning with non-linear information media, basic theoretical considerations about advantages and disadvantages are rare. From an applied cognitive science perspective, Hypermedia learning should actually be an inadequate format of instruction. The basic reason therefore is that, non-linearity increases cognitive load. Navigation planning, which is necessary for hypermedia learning, can be regarded as an additional cognitive task. In terms of Cognitive Load Theory (e.g. Sweller, 1994), additional cognitive resources that occupy working memory resources and that are not directly relevant for learning, increase Extraneous Cognitive Load. This phenomenon, rather known as 'Cognitive Overhead', should per se lead to worse performance of hypermedia learning when compared with linear learning material. Indeed, empirical research indicates that in such comparisons of Hypermedia learning environments with linear media, non-linear information retrieval leads to increased cognitive load and to worse learning performance (e.g. Macedo-Rouet, Rouet, Epstein & Fayard, 2003; Niederhauser, Reynolds, Salmen & Skolmoski, 2000). Possible advantages like ease of information retrieval are strongly limited by the additional cognitive load resulting from navigation planning. As a consequence, Niederhauser et al (2000, p. 251) state that "…proponents of using hypertext for instruction must consider cognitive load issues when developing hypertext-based materials and training students in their use".

However, there is also a huge body of empirical research that shows no differences between linear and non-linear information retrieval, and sometimes even advantages of Hypermedia learning (e.g. Chen & Rada, 1996). Following Zumbach and Mohraz (2008), one cannot assume general disadvantages from non-linear learning environments, especially in ill-structured and complex domains. Sometimes, Hypermedia learning could even contribute to increased learning performance rather than linear learning material. One assumption could be that an increase in cognitive load (also Extraneous Cognitive Load) might trigger deeper elaboration processes by increasing effort. Thus, if a learner faces the need to solve a problem (experienced by higher cognitive load), schemata activation and active problem-solving become likely. This might for instance explain why learners with prior knowledge seem to benefit from Hypermedia learning rather than novices. Their prior knowledge enables them to activate schemata and to active process new information and integrate them into their existing knowledge structure while novices are simply overcharged.

Prior knowledge seems to be not the only predictor for success or failure of non-linear information media but one of the empirically most validated (cf. Balcytiene & Aukse, 1999; Scheiter, Gerjets, Vollmann & Catrambone, 2009). Another influential factor seems to be the content/domain and the

subsequent test design itself. Foltz (1996, p. 11) concludes: „Many existing texts are likewise not designed for linear reading, such as encyclopedias and technical manuals. " Vice versa, Zumbach and Mohraz (2008) resume that some texts, especially with a linear narrative structure, are not suitable for non-linear reading.

Taking together these findings and considerations, the following hypotheses can be derived: First, if a domain is ill-structured and in our daily experience rather accessed in a non-linear than in a linear manner, a non-linear learning environment should support an adequate mental representation better than a linear learning environment. Second, prior knowledge should contribute to schema activation and acquisition and might be able, especially in Hypermedia learning, to compensate cognitive load caused by navigation planning. Third, well-structured information with low problem complexity might be better processed by means of linear access to learning material. As active problem solving is not necessary here, corresponding problem-solving schemata do not have to be activated. Thus, non-linear learning environments do not contribute to activate resources for Germane Cognitive Load and Extraneous Cognitive Load might inhibit learning. These assumptions were tested in the following experiment.

Method

Learning material and sample

In order to examine the influence of linear vs. non-linear information design within an ill-structured domain that has rather a non-linear than linear access, we developed a virtual city guide for the Austrian city Linz and its geographical as well as cultural sights. In a linear version, learners were only able to follow a linear path with forward and backward navigation possibilities. In a non-linear version, navigation was only possible via hyperlinks from either sites that bordered to each other or that had shared information which was linked associatively. Overall, the learning environments consisted of fifteen sights (with one site per node) with 1401 words.

Sample

57 participants, all pupils in eighth grade (age between 13 and 14), took part in this experiment (31 male and 26 female). They were randomly assigned to one of the two conditions. Participation was on a voluntary basis, no reward was given.

Dependant variables and course of the study

For assessment of knowledge acquisition, two instruments have been developed: a multiple choice test that was designed to test mere facts about the sights ("factual knowledge") and a test with three open questions that tested knowledge about structure and interrelationships of the sights and their facts in the learning environment ("complex knowledge"). Both were used in pre- and post test. In post test, the Mental Effort Rating Scale (MERS; e.g. Paas, 1992) for assessing cognitive load has been administered. Treatment time was constant with 20 minutes, with pre- and post test, overall participation time was 45 minutes.

Results

A Multiple Analysis of Covariance with both knowledge pre tests as covariates, treatment conditions as fixed factor and both knowledge post test as well as MERS as dependant variables revealed a significant overall main effect ($p<0.05$) and, subsequent to ANOVA results, a significant influence of the covariate "complex knowledge" ($p<0.001$). Pairwise comparisons showed that the treatment only had a significant effect on acquisition of complex knowledge ($p<0.05$) but not on cognitive load as measured with MERS and factual knowledge. Here, the non-linear condition resulted in the best

performance. The covariate "complex knowledge" as assessed in the pre test had significant influence on the results in the knowledge post test ($p<0.05$) and cognitive load ($p<0.05$). The more knowledge participants had prior to the treatment, the lower was the experienced cognitive load ($r = -.33$; $p<.01$).

Discussion

In this experiment, the influence of content and task complexity on Hypermedia learning has been examined. The hypothesized assumption was that non-linear information retrieval does not in general lead to increased cognitive load (here presumably Extraneous Cognitive Load) and, thus, might be disadvantageous compared with linear navigation. The results confirm the assumption that if complex relationships within a domain have to be acquired, non-linearity might foster schema acquisition rather than linear access. Here the need of elaboration processes and schema activation due to non-linear navigation demands might contribute to use free working memory resources for Germane Cognitive Load activation. Nevertheless, this is only possible if prior knowledge enables schema activation and if the domain/task complexity has characteristics of non-linearity.

References

Balcytiene, A. (1999): Exploring individual processes in knowledge construction with hypertext. *Instructional Science, 27*, 303-328.

Chen, C., & Rada, R. (1996). Interacting with hypertext: A meta-analysis of experimental studies. *Human-Computer Interaction, 11*, 125–156.

Foltz, P.W. (1996). Comprehension, coherence and Strategies in Hypertext and Linear Text. In J.-F. Rouet, J. Levonen, A. Dillon, & R. Spiro (Eds.) *Hypertext and Cognition* (pp. 109-136). Hillsdale, NJ: Lawrence Erlbaum.

Macedo-Rouet, M., Rouet, J.-F., Epstein, I., & Fayard, P. (2003). Effects of Online Reading on Popular Science Comprehension. *Science Communication, 25*(2), 99-128.

Niederhauser,D., Reynolds, R.E., Salmen, D.J., & Skolmoski, P. (2000). The influence of cognitive load on learning from hypertext. *Journal of Educational Computing Research, 23*(3), 237–255.

Paas, F. G. (1992). Training Strategies for Attaining Transfer of Problem-Solving in Statistics: A Cognitive-Load Approach. *Journal of Educational Psychology, 84*, 429-434.

Scheiter, K., Gerjets, P., Vollmann, B., & Catrambone, R. (2009). The impact of learner characteristics on information utilization strategies, cognitive load experienced, and performance in hypermedia learning. *Learning and Instruction,19*(5), 387-401.

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and Instruction, 4*, 293-312.

Zumbach, J., & Mohraz, M. (2008). Cognitive load in hypermedia reading comprehension: Influence of text type and linearity. *Computers in Human Behavior, 24*, 875–887.

Effects of Worked Examples, Example-Problem Pairs, and Problem-Example Pairs Compared to Problem Solving

Tamara van Gog
Institute of Psychology, Erasmus University Rotterdam
P.O.Box 1738, 3000DR Rotterdam, The Netherlands
vangog@fsw.eur.nl

Liesbeth Kester
Centre for Learning Sciences and Technologies, Open University of The Netherlands
P.O.Box 2960, 6417 PC Heerlen, The Netherlands
Liesbeth.kester@ou.nl

Fred Paas
Institute of Psychology, Erasmus University Rotterdam
P.O.Box 1738, 3000DR Rotterdam, The Netherlands
paas@fsw.eur.nl

Abstract. Research has demonstrated that instruction that relies more heavily on example study is more effective for learning than instruction consisting of problem solving. However, 'a heavier reliance on example study' has been implemented in different ways, using worked examples only, example-problem pairs, or problem-example pairs. Despite a large amount of research on example-based learning, these three strategies have not been compared to each other and to problem solving in a single study. Moreover, effects on cognitive load of these different strategies have not yet been systematically compared. Therefore, this study investigated the effects on cognitive load and learning of example study only, example-problem pairs, problem-example pairs, and problem solving only. Results show that it is not strictly necessary to alternate example study and problem solving: example study only and example-problem pairs were more effective and efficient than problem solving only and problem-example pairs.

Keywords: worked examples; problem solving; cognitive load

Introduction

Whereas conventional problems contain only a description of "givens" (e.g., how fast a car accelerates and its average velocity) along with a goal statement (e.g., 'calculate how far the car has travelled'), worked examples additionally show learners the worked-out solution steps required to reach the goal. Research has shown that for novices, instruction that relies more heavily on worked example study is more effective for learning and transfer than instruction consisting of problem solving, and is also often more efficient, in that this higher learning is reached with less investment of time or mental effort (for reviews, see Atkinson, Derry, Renkl, & Wortham, 2000; Sweller, Van Merriënboer, & Paas, 1998). This is known as the 'worked example effect' (Sweller et al.).

Placing more emphasis on example study during instruction can be done in different ways. A few studies have compared the effects of example study only to problem solving only, and found example study to be more effective for learning and transfer as well as more efficient in terms of mental effort investment (Nievelstein, Van Gog, Van Dijck, & Boshuizen, 2010; Van Gerven, Paas, Van Merriënboer, & Schmidt, 2002; Van Gog, Paas, & Van Merriënboer, 2006). Most studies, however, have alternated example study with problem solving. Several studies have shown that example-problem pairs were more effective for learning and transfer than problem solving only (e.g., Cooper & Sweller, 1987; Sweller & Cooper, 1985). Sweller and Cooper (1985) mention that engaging in solving a similar problem immediately after example study may be more motivating for students, because it is more active than studying another example would be. A few studies have investigated the use of problem-example pairs (e.g., Reisslein, Atkinson, Seeling, and Reisslein, 2006; Stark, Gruber, Renkl,

& Mandel, 2000), arguing that when learners first experience deficiencies in their performance during problem solving, they may be more motivated to study the example and may focus on the steps that they could not solve. Even though many of the above mentioned studies were inspired by cognitive load theory (Sweller et al., 1998) not all of them addressed the effects of cognitive load imposed by the by the different example-based learning strategies.

Despite the substantial amount of research that has been conducted on the effectiveness of each of those different strategies, no comparison has been made between all those strategies in a single study, so it is an open question which strategies are most and which are least effective for novices' learning. Therefore, this study compared the effects of examples only, example-problem pairs, problem-example pairs, and to problem solving only on novices' cognitive load and learning.

Method

Participants

Participants were 103 secondary education students from two Dutch schools (48 male; age $M = 16.22$, $SD = 0.84$). Participants were randomly assigned to one of the four conditions: (1) problem solving only ($n = 26$), (2) problem-example pairs ($n = 26$), (3) example-problem pairs ($n = 25$), and (4) example study only ($n = 26$).

Materials and procedure

Participants first completed a prior knowledge test on electrical circuits troubleshooting (cf. Van Gog, Paas, & Van Merriënboer, 2008). Then, they engaged in two pairs of training tasks (i.e., four tasks in total) consisting of a malfunctioning parallel electrical circuit (cf. Van Gog et al., 2006, 2008) presented on paper that participants had to 'troubleshoot' (i.e., diagnose the fault), or the solution to which they had to study (i.e., when it was presented as a worked example). After the training tasks, participants solved a retention test problem and a transfer test problem. Immediately after each example or problem in the learning or test phase, participants rated the amount of mental effort they invested on the 9-point rating scale developed by Paas (1992).

Results

Mental effort invested in the training tasks was significantly lower in the examples only and example-problem pairs conditions than in the problems only and problem-example pairs conditions. Performance on both the retention and transfer test was significantly higher in the examples only and example-problem pairs conditions than in the problems only and problem-example pairs conditions. Mental effort invested in the retention test was significantly higher in the problem-example pairs condition than in the example-problem pairs and examples only conditions, and mental effort invested in the transfer test was significantly higher in the problem-example pairs than in the example-problem pairs condition.

Discussion

Results showed that the problem solving only and problem-example pairs conditions were less effective than the examples only and example-problem pairs conditions. Not only did the examples only and the example-problem pairs conditions significantly outperform the problem solving only and problem-example pairs conditions on the retention and transfer test, this higher performance was also reached with significantly lower investment of mental effort during the training. This is indicative of higher efficiency in terms of the learning process, that is, in terms of the cognitive 'costs' and benefits

of training (see Hoffman, & Schraw, 2010; Van Gog & Paas, 2008). These results show that it is not so much the amount of examples provided to students (i.e., example only and example-problem pairs were both more effective than the other conditions and did not differ from each other), but also the way in which these are sequenced that determines the effects on learning (i.e., example-problem pairs were more effective than problem-example pairs). Future research should investigate why solving a problem first and then receiving an example is not as effective as the opposite sequence; this might for example be the result of processes such as hindsight bias.

References

Atkinson, R. K., Derry, S. J., Renkl, A., & Wortham, D. (2000). Learning from examples: Instructional principles from the worked examples research. *Review of Educational Research, 70*, 181-214.

Cooper, G., & Sweller, J. (1987). The effects of schema acquisition and rule automation on mathematical problem-solving transfer. *Journal of Educational Psychology, 79*, 347-362.

Hoffman, B., & Schraw, G. (2010). Conceptions of efficiency: Applications in learning and problem solving. *Educational Psychologist, 45*, 1-14.

Nievelstein, F., Van Gog, T., Van Dijck, G., & Boshuizen, H. P. A. (2010). *The worked example and expertise reversal effect in less structured tasks: Learning to reason about legal cases*. Manuscript submitted for publication.

Paas, F. (1992). Training strategies for attaining transfer of problem-solving skill in statistics: A cognitive load approach. *Journal of Educational Psychology, 84*, 429-434.

Reisslein, J., Atkinson, R. K., Seeling, P., & Reisslein, M. (2006). Encountering the expertise reversal effect with a computer-based environment on electrical circuit analysis. *Learning and Instruction, 16*, 92-103.

Stark, R., Gruber, H., Renkl, A. & Mandl, H. (2000). Instruktionale Effekte einer kombinierten Lernmethode: Zahlt sich die Kombination von Lösungsbeispielen und Problemlöseaufgaben aus? [Instructional effects of a combined learning method: Does the combination of worked-out examples and problem-solving tasks pay off?] *Zeitschrift für Pädagogische Psychologie, 14*, 205-217.

Sweller, J., & Cooper, G. A. (1985). The use of worked examples as a substitute for problem solving in learning algebra. *Cognition and Instruction, 2*, 59-89.

Sweller, J., Van Merriënboer, J. J. G., & Paas, F. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10*, 251-295.

Van Gerven, P. W. M., Paas, F., Van Merriënboer, J. J. G., & Schmidt, H. G. (2002). Cognitive load theory and aging: Effects of worked examples on training efficiency. *Learning and Instruction, 12*, 87-105.

Van Gog, T., & Paas, F. (2008). Instructional efficiency: Revisiting the original construct in educational research. *Educational Psychologist, 43*, 16-26.

Van Gog, T., Paas, F., & Van Merriënboer, J. J. G. (2006). Effects of process-oriented worked examples on troubleshooting transfer performance. *Learning and Instruction, 16*, 154-164.

Van Gog, T., Paas, F., & Van Merriënboer, J. J. G. (2008). Effects of studying sequences of process-oriented and product-oriented worked examples on troubleshooting transfer efficiency. *Learning and Instruction, 18*, 211-222.

Effects of Segmented and Actively Segmenting Worked Examples on Learning

Ingrid A. E. Spanjers
Department of Educational Development and Research & School of Health Professions Education, Maastricht University
P.O. Box 616, 6200 MD Maastricht, The Netherlands
i.spanjers@educ.unimaas.nl

Tamara van Gog
Institute of Psychology, Erasmus University Rotterdam
P. O. Box 1738, 3000 DR Rotterdam, The Netherlands
vangog@fsw.eur.nl

Jeroen J. G. van Merriënboer
Department of Educational Development and Research & School of Health Professions Education, Maastricht University
P.O. Box 616, 6200 MD Maastricht, The Netherlands
j.vanmerrienboer@educ.unimaas.nl

Abstract. Novices learn more effectively and efficiently from worked examples than from problem solving. Presenting worked examples in a segmented format or instructing students to segment worked examples actively may support learning, since it encourages learners to chunk information elements belonging together and self-explain why they belong together. On the other hand, actively segmenting may form an additional task imposing cognitive load on the learner that could either benefit or hamper learning. In this experiment, 34 secondary school students studied segmented worked examples or were instructed to actively segment worked examples during study. The results showed that studying segmented worked examples required less mental effort than being instructed to actively segment examples with equal learning outcomes. It can be concluded that studying segmented worked examples was more efficient than being instructed to actively segment examples during study.

Keywords: Worked examples; Segmentation; Cognitive Load; Learning

A large body of research has shown that for novices, instruction consisting of studying worked examples is more effective (i.e., higher learning outcomes) and efficient (i.e., higher learning outcomes reached with less investment of time and/or effort) than instruction consisting of problem solving (for reviews, see Atkinson, Derry, Renkl, & Wortham, 2000; Sweller, Van Merriënboer, & Paas, 1998). In addition to studying the benefits of worked examples compared to problem solving, research has also investigated means to further improve learning from worked examples, by manipulating the example design (see Atkinson et al., 2000; Paas & Van Gog, 2006).

People mentally divide events or procedures described in text or shown in dynamic visualisations into pieces (e.g., Kurby & Zacks, 2008; Zacks, Speer & Reynolds, 2009), and this influences the way in which they remember the information (e.g., Kurby & Zacks, 2008). Providing learners with segmented examples that are already divided into pieces may reduce cognitive load, since the segments provide a cue, so learners do not have to search for the boundaries between pieces themselves (cf., Schwan, Garsoffky, & Hesse, 2000; see also Wouters, Paas, & Van Merriënboer, 2008). According to the subgoal learning model, such cueing can also foster learning by stimulating learners to chunk information elements together and to self-explain why they belong together (e.g., Catrambone, 1998). Studies with different types of learning material provide evidence for positive effects of cueing what information elements belong together. Catrambone (1995) studied effects of examples on probability calculation that did or did not include a label for a particular calculation sub-step and that did or did not place that calculation sub-step on a separate line. Learning outcomes were higher and students mentioned a sub-step more often in their description of the calculation procedure

in the conditions in which a label was provided, the step was visually isolated, or both, compared to the control condition in which no cues whatsoever were provided. Florax and Ploetner (2010) found that learners who studied segmented explanatory text accompanied by pictures on the human nervous system retained more from the text than learners who studied the text in a non-segmented format. Finally, positive effects of segmentation on learning (i.e., higher) and cognitive load (i.e., lower) have also been found with animations (e.g., Hasler, Kersten, & Sweller, 2007; Spanjers, Wouters, Van Gog, & Van Merriënboer, in press).

On the other hand, instructing learners to actively segment instructional material themselves may encourage them to focus on which information elements belong together, which may increase cognitive load, but might also stimulate learners to process the information more deeply, for example, by self-explaining why parts belong together. Therefore, actively segmenting worked examples may be a form of interactivity that could support learning. However, positive effects of interactivity are only found when the interactivity evokes the right kind of cognitive activities, that is, activities which contribute to understanding (Moreno & Mayer, 2007). The instruction to actively segment might also be an additional task that distracts from learning. This study investigated the effects on cognitive load and learning for novice students studying segmented worked examples and novice students instructed to segment examples during study.

Method

Thirty-four Dutch secondary education students were randomly assigned to the segmented or actively segmenting condition. They first completed a pretest on probability calculation. Then, they studied four worked examples on probability calculation. Students in the segmented condition studied worked examples that were segmented by blank lines between the pieces. Students in the actively segmenting condition were instructed to actively segment worked examples by placing marks at the boundaries of what they considered a new step in the procedure. Finally, students completed a posttest. They rated the mental effort invested in studying the examples and solving the posttest problems as an indication of cognitive load (Paas, 1992).

Results

There were no significant differences between conditions on the pretest (segmented M = 5.06, sd = 1.64; actively segmenting: M = 4.18, sd = 1.51: $t(32)$ = -1.63, p = .11). The students who studied segmented worked examples invested less mental effort in studying the examples (M = 3.22, sd = 1.59; $t(32)$ = -4.35, p = .00) and in solving the posttest problems (M = 3.62, sd = 1.81; $t(32)$ = -2.34, p = .03) than the students who were instructed to actively segment the examples during studying (example study: M = 5.67, sd = 1.69; test problems: M = 4.93, sd = 1.42). There were no differences in performance on the posttest (segmented: M = 6.18, sd = 2.88; actively segmenting: M = 5,29, sd = 2.66; $t(32)$ = 0.93, p = .36).

Conclusion

Studying segmented examples and being instructed to actively segmenting examples led to equal learning outcomes; however, studying segmented examples required less mental effort during example study and during the test. As such, the segmented examples were more efficient in terms of the learning process as well as in terms of learning outcomes (Van Gog & Paas, 2008). This result is relevant for (research on) the design of worked examples and other instructional material. It shows that actively manipulating the instructional material during study requires additional effort for novices, but does not always support learning more than studying material that was already manipulated by

someone else. This may be different for advanced learners, though, so future studies should examine under which conditions interactivity is effective.

References

Atkinson, R. K., Derry, S. J., Renkl, A., & Wortham, D. (2000). Learning from examples: Instructional principles from the worked examples research. R*eview of Educational Research, 70,* 181–214.

Catrambone, R. (1995). Aiding subgoal learning: Effects on transfer. *Journal of Educational Psychology, 87,* 5-17.

Catrambone, R. (1998). The subgoal learning model: Creating better examples so that students can solve novel problems. *Journal of Experimental Psychology: General, 127,* 335-376.

Florax, M., & Ploetner, R. (2010). What contributes to the split-attention effect? The role of text segmentation, picture labeling, and spatial proximity. *Learning and Instruction, 20,* 216-224.

Hasler, B. S., Kersten, B., & Sweller, J. (2007). Learner control, cognitive load and instructional animations. *Applied Cognitive Psychology, 21,* 713-729.

Kurby, C. A., & Zacks, J. M. (2008). Segmentation in the perception and memory of events. *Trends in Cognitive Sciences, 12,* 72-79.

Moreno, R., & Mayer, R. (2007). Interactive multimodal learning environments. *Educational Psychology Review, 19,* 309-326.

Paas, F. (1992). Training strategies for attaining transfer of problem-solving skills in staticstics: A cognitive load approach. *Journal of Educational Psychology, 84,* 429-434.

Paas, F., & Van Gog, T. (2006). Optimising worked example instruction: Different ways to increase germane cognitive load. *Learning and Instruction, 16,* 87-91.

Schwan, S., Garsoffky, B., & Hesse, F. W. (2000). Do film cuts facilitate the perceptual and cognitive organization of activity sequences? *Memory & Cognition, 28,* 214-223.

Spanjers, I. A. E., Wouters, P., Van Gog, T., & Van Merrienboer, J. J. G. (in press). An expertise reversal effect of segmentation in learning from animations. *Computers in Human Behavior.*

Sweller, J., Van Merriënboer, J. J. G., & Paas, F. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10,* 251-296.

Van Gog, T., & Paas, F. (2008). Instructional efficiency: Revisiting the original construct in educational research. *Educational Psychologist, 43,* 16-26.

Wouters, P., Paas, F., & Van Merriënboer, J. J. G. (2008). How to optimize learning from animated models: A review of guidelines based on cognitive load. *Review of Educational Research, 78,* 645-675.

Zacks, J. M., Speer, N. K., & Reynolds, J. R. (2009). Segmentation in reading and film comprehension. *Journal of Experimental Psychology: General, 138,* 307-327.

How Different Ratios of Giving and Withholding Guidance in Computer-Supported Learning Affect Cognitive Load and Learning Outcomes

Rolf Schwonke
Alexander Renkl
University of Freiburg, Department of Psychology, Educational and Developmental Psychology
Engelbergerstr. 41, D-79085 Freiburg, Germany
rolf.schwonke@psychologie.uni-freiburg.de
renkl@psychologie.uni-freiburg.de
Ron Salden
Vincent Aleven
Human-Computer Interaction Institute, School of Computer Science, Carnegie Mellon University
5000 Forbes Ave, Pittsburgh, PA 15213, USA
rons@cs.cmu.edu
aleven@cs.cmu.edu

Abstract. This experiment investigated effects of different ratios of worked solution steps (high guidance) and to-be-solved problem steps (low guidance) on cognitive load and learning outcomes in the domain of geometry. High-school students (N = 125) worked on a geometry lesson in a Cognitive Tutor under five different ratios of worked steps and problem steps (0/5, 1/4, 2/3, 3/2, or 4/1) that were presented for an easy and a difficult geometry principle. The amount of subjectively perceived cognitive load of a given ratio moderated the effectiveness of guidance. Strength and shape of the interaction effects differed depending on the difficulty of the to-be-learned concepts (easy vs. difficult) and the type of learning outcomes (procedural vs. conceptual knowledge). Thus, in determining optimal amounts of assistance the type of learning outcomes, the difficulty of single to-be-learned knowledge chunks, and perceived cognitive load (as a potential moderating variable) should be considered.

Keywords: Intelligent Tutoring Systems; worked examples; learning by problem solving; cognitive load.

In a recent discussion initiated by Kirschner, Sweller, and Clark (2006) Kirschner et al. claimed "guided instruction" to be generally superior over less guided forms of instruction when learning is the primary goal of the instruction. The Expertise-Reversal Effect within Cognitive Load Theory (e.g., Kalyuga, Ayres, Chandler, & Sweller, 2003), however, suggests that most appropriate student guidance is provided when a procedure offers much support in the beginning of a learning phase and increasingly less support when the learners proceed in skill acquisition. According to the Assistance Dilemma as postulated by Koedinger and Aleven (2007) it is crucial to hold the right balance between offering guidance to the students (e.g., worked solution steps) and deliberately withholding it (e.g., problem solving demands). This study addresses the question of how quickly guidance (here, worked solution steps) should be faded. Based on assumptions of the Assistance Dilemma, we assumed an inverted u-shaped type of relation between the number of worked steps and learning outcomes (see Koedinger & Aleven, 2007). Moreover, as suggested by the Expertise-Reversal Effect (Kalyuga et al., 2003) the speed of fading of worked steps should differ for different skill components depending on their difficulty (against the background of prior knowledge). Related to this, conceptual understanding should profit more from the possibility to study and understand worked steps, whereas the formation of procedural rules should profit more from active problem solving. Against this background, we investigated the effects of different ratios of worked steps and to-be-solved problem steps on cognitive load and learning outcomes.

Method

One-hundred-twenty-five German high-school students (84 female = 67 %; 41 male = 33 %; mean age: M = 14.87 years; SD = 0.60; grade 9) participated in this study. The students received 20 € as compensation. In a Cognitive Tutor lesson on circles geometry, for each of three geometry principles (i.e., major-minor arc, interior angle, and exterior angle) the students had five learning opportunities (either a to-be-solved step or a worked step). We systematically varied the number of worked steps (0 to 5) that were presented for each principle before the to-be-solved steps (1 to 4). The total number of worked steps that each student received was, however, held constant. Prior knowledge in terms of problem solving performance and conceptual understanding was assessed with a total of six items (three items for each type of knowledge with one item related to each of three geometry principles). Raw scores were transformed to percentages of correct responses (by dividing the raw scores by the maximum score of the scales). For the research questions, we selected major-minor arc as an *easy principle* (procedural pre-test score: M = .61; SD = .45; conceptual pre-test score: M = .72; SD = .41) and exterior angle as a *difficult principle* (procedural pre-test score: M = .07; SD = .20; conceptual pre-test score: M = .10; SD = .24). The posttest contained 27 items (procedural and conceptual knowledge). Procedural knowledge was measured with four items for each of three principles (1 point per item = max. 4 points) and conceptual knowledge with five items per principle (1 point per item = max. 5 points). Raw scores were transformed to percentages of correct responses. Internal consistency (Cronbach's α) was as follows: procedural knowledge of exterior angle: α = .76, major-minor arc: α = .64; conceptual knowledge of exterior angle: α = .73, major-minor arc: α = .62. Cognitive load was measured immediately after the learning phase by a questionnaire with six items (Likert-type scales; 1 = *very low*; 6 = *very high*). Three items addressed cognitive load as perceived when studying worked steps – separately for each principle (Cronbach's α = .68) and three items addressed cognitive load as perceived when working on to-be-solved steps – separately for each principle (Cronbach's α = .73). The experiment was conducted in group sessions; the participants worked individually on computers. After filling out a questionnaire on demographic data all participants worked on a pretest, read a written introduction into the geometry principles, and worked on two introductory problems to get acquainted with the Cognitive Tutor. After the learning phase, the participants filled in a cognitive load questionnaire and completed a posttest.

Results

Procedural posttest scores related to the easy principle differed significantly for different ratios of worked steps and to-be-solved steps, $F(4, 119) = 3.00$, $p < .05$, $\eta^2 = .09$. Participants who received five to-be-solved steps and no worked step acquired more procedural knowledge than participants who received three worked steps and two to-be-solved steps (ΔM = .28, SE = .09, $p < .05$) or four worked steps and only one to-be-solved step (ΔM = .25, SE = .09, p = .08). Other posttest scores (i.e., conceptual knowledge related to the easy rule, procedural and conceptual knowledge related to the difficult rule) did not differ significantly across different ratios of worked steps and to-be-solved steps (all Fs < 1). Ratings of cognitive load (assessed separately for worked steps and to-be-solved steps and separately for the easy and the difficult rule) were generally negatively related to learning outcomes. Correlation coefficients ranged from r = -.25 ($p < .05$) to r = -.47 ($p < .001$). Moreover, learners, rated cognitive load as induced by to-be-solved steps generally to be higher than cognitive load as induced by worked steps. This was true for both the easy principle (to-be-solved steps: M = 2.73, SD = 1.28; worked steps: M = 2.16, SD = 1.06), $F(1, 98) = 36.82$, $p < .001$, $\eta^2 = .27$, and for the difficult principle (to-be-solved steps: M = 3.47, SD = 1.08; worked steps: M = 2.81, SD = 1.07), $F(1, 98) = 38.97$, $p < .001$, $\eta^2 = .29$. Cognitive load ratings did not differ across different ratios of worked steps (all Fs < 1). A moderation analysis (using multiple regression), however, revealed aptitude-treatment interaction

effects (easy rule: $\Delta R^2 = .05$, $\Delta F(1, 118) = 9.51$, $p = .003$; difficult rule: $\Delta R^2 = .02$, $\Delta F(1, 119) = 3.15$, $p = .079$) on learning outcomes between the amount of guidance (i.e., the ratio of worked steps and to-be-solved steps) and the amount of perceived cognitive load (with prior knowledge included as a covariate). Strength and shape of these interaction effects differed depending on the difficulty of the to-be-learned rule. The most important finding of this analysis was that the negative effect of guidance on the acquisition of the easy principle (as reported above) was only found for learners who perceived cognitive load of a given ratio of worked steps and to-be-solved steps as high, $ß = -.44$, $t(118) = -4.47$, $p < .001$ (test of the simple slope of the ratio of worked steps at +1 *SD* of perceived cognitive load). Learners who perceived cognitive load as low, on the other hand, acquired the easy principle equally well across different ratios, $ß = .005$, $t(118) = 0.04$, $p = .97$ (test of the simple slope at -1 *SD* of cognitive load). A reverse (but less pronounced) pattern was found for the difficult principle.

Summary and Discussion

The present findings contribute to Cognitive Load research on the worked example effect in that they provide evidence for the assumed reduction of cognitive load by worked-examples. Irrespective of the ratio of problem solving and example-based learning, problem solving was found to induce more cognitive load than example-based learning. In addition, the findings extend research on the Expertise-Reversal Effect in two ways. First, the findings suggest that the effect is moderated by the amount of cognitive load that is attributed by learners to a given learning situation. Second, the findings further suggest that the effect varies with the type of learning outcomes (here, procedural vs. conceptual knowledge). Problem solving had an advantage over different proportions of example-based learning only for the acquisition of procedural knowledge, not for conceptual knowledge. Thus, guided forms of instruction might lose their effectiveness for the development of conceptual understanding later than for procedural skills – or potentially not at all. In these respects, our findings also contrast with suggestions of Kirschner, Sweller, and Clark (2006) who argued for a general superiority of guided forms of instruction over less guided forms. Our findings rather suggest that further research should consider variables such as the type of (desired) learning outcomes, the relative difficulty of single knowledge components, and potential interactions of guidance and cognitive load as perceived by the learners.

References

Kalyuga, S., Ayres, P., Chandler, P. & Sweller, J. (2003). The expertise reversal effect. *Educational Psychologist, 38,* 23-31.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*, 75–86.

Koedinger, K. R., & Aleven V. (2007). Exploring the assistance dilemma in experiments with Cognitive Tutors. *Educational Psychology Review*, *19*, 239-264.

Leaflets About Climate Change and Invasive Species: The Effects of How Information is Presented on Emotions and Learning

Christine Otieno
University of Freiburg, Department of Psychology
D-79085 Freiburg, Germany
otieno@psychologie.uni-freiburg.de

Alexander Renkl
Katharina Liebler
University of Freiburg, Department of Psychology
D-79085 Freiburg, Germany
renkl|liebler@psychologie.uni-freiburg.de

Ulrich Deil
Thomas Ludemann
University of Freiburg, Department of Biology
D-79104 Freiburg, Germany
deil|ludemann@biologie.uni-freiburg.de

Hans Spada
University of Freiburg, Department of Psychology
D-79085 Freiburg, Germany
spada@psychologie.uni-freiburg.de

Abstract. Leaflets are a common way to spread information in every-day life, for example, about invasive species and their dangers. Some available leaflets about invasive species present facts in an "expository" way, whereas others use a more sensational style. We investigated the effects of "sensational" and "neutral" versions of five leaflets about climate change and about invasive species on emotions and learning. Seventy students read the leaflets, rated their emotions, and completed a posttest with multiple-choice items and open questions. The sensational condition showed stronger negative emotions and better learning outcomes compared to the neutral condition. Additionally, conditions differed in the quality of what they learned. Students in the sensational condition recalled significantly more negative and significantly less positive and neutral aspects of climate change and invasive species than students in the neutral condition.

Keywords: Emotion, Informal Learning, Instructional Design

Introduction

Lifelong learning is a popular catchphrase in today's news and politics. However, it is important to note that it does not only refer to institutionalized learning in the courses of further education but to all forms of learning in everyday life and at the workplace. To differentiate institutionalized and instructed learning from interest-guided, self-directed learning Livingstone (2006) introduced the term *informal learning*. Informal learning refers to all forms of "intentional or tacit learning in which we engage […] without direct reliance on a teacher or an externally organized curriculum" (Livingstone, 2006, p.204). While many studies investigated the amount and kind of informal learning people engage in (for an overview see Livingstone, 2006), little is known about influences of the design of informal sources like the internet or information leaflets on informal learning. As representational style is an important stylistic device in public information through the media, more insight is needed on its influences in order to understand (informal) learning processes. For example, some available leaflets about such topics as climate change and invasive species primarily present facts in an

"expository" way, whereas others use a more "sensational" style. What are the effects of these different styles on the readers of such leaflets?

Van Zomeren, Spears, and Leach (in press) compared a group of participants reading only basic information about the climate crises and a group who read additional information concerning possible negative future consequences. The group with the additional information showed more fear than the group reading the basic information only. Another study on the effects of watching the rather sensational movie about the causes of global warming "An Inconvenient Truth" by former US Vice-President Al Gore, indicated that watching the movie increased not only concern but also knowledge about global warming (Nolen, in press). Taken together these findings lead to the following research questions: Does a sensational design of information leaflets elicit negative emotions? And: does a sensational design at the same time lead to improved learning?

We tested our research questions on the effects of the type of information presented on emotions and learning in a pre-post-test design using five leaflets informing about climate change and about local invasive species. The leaflets were either formulated in a rather sensational way (sensational condition) or an expository way (neutral condition). The length of texts and basic information as well as the pictures used were held constant across conditions.

Method

Seventy students of psychology (age: M = 22.82; SD = 5.06) were randomly assigned to the sensational condition (information formulated in a sensational, rather negative way, using expressions like "extreme dangers"; 36 participants) or the neutral condition (information formulated in an expository, rather positive, way, using expressions like "possibly problems"; 34 participants). They all completed a pretest on knowledge about and perception of climate change and local invasive species. They then read their respective versions of five short information leaflets: one about climate change , two about invasive plants and two about invasive animals. After reading each leaflet students were asked to rate their emotions on four 5-scale items (1= not at all angry/sad/guilty/affected to 5= very angry/sad/guilty/affected) as well as their risk perception on seven 5-scale items. Finally students completed a posttest. It consisted of five open questions ("Which do you consider the three most important aspects you would tell a friend about…?") and six multiple choice items on the information presented in the leaflets. Answers to open-ended questions were segmented and coded differentiating between positive, negative and neutral statements about topics covered. Risk perception is not included in this report.

Results

Negative emotions (anger, guilt and sadness) were significantly stronger in the sensational condition than in the neutral condition, $F(1, 67) = 6.44$; $p < .05$; $\eta^2 = .09$ (ANCOVA controlling for prior knowledge). Students in the sensational condition performed significantly better on the multiple choice posttest (quantitative measure, recognition), $F(1, 67) = 4.29$; $p < .05$; $\eta^2 = .06$ (ANCOVA controlling for prior knowledge). No difference in the overall number of statements between conditions was found as can be expected due to the phrasing of open questions (quantitative measure, recall). Additionally, there was a qualitative difference in what students recalled in response to the open questions in the posttest. The students in the sensational condition made significantly more statements about negative aspects, $F(1, 67) = 52.90$; $p < .001$; $\eta^2 = .44$, whereas students in the neutral condition made significantly more statements about positive, $F(1, 67) = 57.21$; $p < .001$; $\eta^2 = .46$, and neutral aspects, $F(1, 67) = 11.23$; $p < .01$; $\eta^2 = .14$ (ANCOVAs controlling for prior knowledge).

Discussion

Up to now, research on instructional design has rarely focused on emotions and their influence on learning. Given the results of Nolen (in press) and van Zomeren (in press) it seems likely however, that representational style of information not only influences emotions but also learning. Therefore, effects of representational style on emotions and learning could comprise important implications for instructional design. To gain a deeper insight in the interdependencies of emotions and learning we conducted a study varying the representational style of design and measuring elicited emotions as well as learning outcome. Our results indicate, as expected, that a more sensational representational style does not only affect emotions but also learning. Specifically we found that elicited negative emotions seem to be associated with improved learning. This is contrary to many claims in neuroscience (e.g. Ashby, Isen, & Turken, 1999) that in particular a positive affective state is associated with improved learning, as well as findings on the effects of achievement emotions on learning (e.g., Pekrun, 2006). Pekrun (2006) claims that positive emotions (e.g. joy, pride) usually have positive or no effects on learning, whereas negative emotions (e.g. fear, anger) usually have negative or no effects on learning. Our findings show that negative emotions can even have positive effects under some circumstances.

In addition to the quantitative learning effects we found differences in the quality of information recalled. Students in the sensational condition recalled significantly more negative information than students in the neutral condition, whereas students in the neutral condition recalled significantly more positive and neutral information. These findings indicate that the representational style of information influences what kind of information is remembered. Similar to social cues in the personalization principle of Mayer (e.g., 2003) sensational style seems to increase memory for the rather sensational aspects taught. At the same time sensational style seems to hinder memory for positive and neutral aspects. In analogy to the effect of seductive details (e.g. Harp & Mayer, 1998) this effect could be termed as seductive emphasis. However, before we can establish a seductive emphasis effect, findings have to be replicated.

References

Ashby, F.G., Isen, A.M., Turken, A.U. (1999). A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review, 106*, 529–550.

Harp, S. F., & Mayer, R. E. (1998). How seductive details do their damage: A theory of cognitive interest in science learning. *Journal of Educational Psychology*, *90*(3), 414-434.

Livingstone, D. W. (2006). Informal Learning: Conceptual Distinctions and Preliminary Findings. In Z. Bekerman, N. C. Burbules & D. Silberman-Keller (Eds.), *Learning in Places: The Informal Education Reader*. New York: Peter Lang.

Mayer, R. E. (2003). The promise of multimedia learning: using the same instructional design methods across different media. *Learning and Instruction,13*(2), 125-139.

Nolan, J. M. (in press). "An Inconvenient Truth" Increases Knowledge, Concern, and Willingness to Reduce Greenhouse Gases. *Environment and Behavior.*

Pekrun, R. (2006). The Control-Value Theory of Achievement Emotions: Assumptions, Corollaries, and Implications for Educational Research and Practice. *Educational Psychology Review, 18*(4), 315-341.

Van Zomeren, M., Spears, R., & Leach, C.W. (in press). Experimental evidence for a dual pathway model analysis of coping with the climate crisis. *Journal of Environmental Psychology.*

Computer-based Practice in School: Students' State- and Trait Emotions and the Impact of Solving Word Problems on Mathematics Performance

Maria Tulis
University Bayreuth, Germany
Universitätsstr. 30, 95444 Bayreuth
maria.tulis@uni-bayreuth.de

Abstract. The current study examined effects of computer-based practice (CBT) on math performance by increasing student's activity in mathematical problem solving. Furthermore, effects on state and generalized trait emotions in high/low achieving as well as male/female students were examined. Results indicate differences between academic trait emotions (measured with questionnaires) and the more transient on-task state emotions: Gender differences in domain specific trait emotions were replicated, but not for students' state emotions during CBT. Likewise, no differences between high- and low achieving students were found in the CBT condition, but in traditional math instruction. Results confirmed effects of CBT on students' math performance. Performance gains correlated with the increased number of word problems solved by students. Effects of CBT on students' generalized enjoyment, reduced boredom and anger were found.

Keywords: computer-based learning; mathematics; academic emotions; problem solving

Introduction and Theoretical Background

Solving word problems is important for improving mathematical understanding – several studies conclude that students' mathematical problem-solving skills should be enhanced besides computational skills (e.g. Fuchs et al., 2008). However, word problems are seldom given in regular math classes (e.g. Stern, 2003). Therefore, students' performance on word problems is often poor. High self-efficacy and continuous engagement are important, because making mistakes and overcoming impasses play a fundamental role in solving word problems. Positive task-related emotions, such as interest and enjoyment are associated with persistence and engagement (e.g. Hidi & Ainley, 2002), whereas many students report negative emotions in connection with word problems (CTGV, 1992). A lot of studies report boys experiencing more (trait-) enjoyment or pride and less anxiety in math than girls (e.g. Frenzel et al., 2007). Other studies report differences between high- and low achieving students: Gläser-Zikuda and Mayring (2003) found high-achieving students reporting more enjoyment in questionnaires, but no differences in reports of specific emotional states in diary logs. However, only few studies investigated students' state-emotions during learning processes and many researchers complain about a lack of empirical insight into the impact of emotional states on learning and achievement in computer-based learning environments (e.g. Pekrun, 2005). Individualized CBT, as being "emotionally safe" (Goldin et al., 2007) and providing individual feedback, may be beneficial especially to struggling learners, low-achieving students or children with negative motivational patterns in mathematics (e.g. girls). Furthermore, CBT programs provide appropriate exercises and allow *every* student *actively* solving problems. Therefore, our aim was to (1) examine students' state emotions during CBT as well as effects on students' trait emotions and (2) the impact of solving word problems on performance gains through CBT. Particularly, we wanted to examine possibilities to foster low-achieving students' positive emotions in addition to effects on performance. Several studies show the effectiveness of CBT with respect to achievement measures (e.g. Kulik, 2003; Koedinger et al., 1997) with an average effect size of $d = 0.35$. In a recent review, Slavin and Lake (2008) reported moderate effects ($d = 0.19$) in 38 studies of CBT (involving control groups using traditional textbooks), especially for computation. Our previous studies (Schoppek & Tulis, 2010) have shown that low- and high-achieving students gained equally from CBT with our training software compared to control conditions ($d = 0.65$).

Method and Research Questions

To test the effectiveness of CBT, our program was implemented for five months in 12 regular math classes (grade 5, n = 344 students). Additionally, students of 13 control classes (n = 341 students) followed traditional practice lessons. In each CBT class, students were randomly assigned to control- and experimental group. In the experimental condition, one regular math lesson per week was replaced by CBT while students of the control group followed the traditional practice lesson with their math teacher. After the first half of the intervention period, performance measures were collected and groups in each class were switched. Habitualized math-emotions (Academic Emotion Questionnaire, Pekrun et al., 2002) as well as a pre- and posttest to measure performance were assessed before and after the intervention in all 25 classes. In addition, CBT-students' on-task performance was analyzed and task-related emotional responses of interest, enjoyment, pride, boredom, anger, anxiety and shame were recorded several times during CBT using emoticons (cf. face icons, Ainley et al., 2005). Besides computation problems, the program administers a high proportion of word problems tailored to students' individual performance level. Every student's time on task is increased compared with whole class practice. Therefore, we hypothesized CBT to enhance students' math performance (*Hypothesis 1):* Students of the CBT-condition should outperform students of the traditional-practice-condition in the posttest (control- versus CBT-classes) as well as midterm test (control- versus experimental group in each CBT class). Furthermore, we expected that performance gains of the experimental group in the CBT-classes are due to increased solving of word problems (*Hypothesis 2).* Besides these effects on performance, all students, but especially low-achievers were expected to report less habitualized boredom, anger, anxiety and shame as well as more positive trait emotions relating to mathematics (enjoyment, pride) after CBT than before *(Hypothesis 3).* In line with previous findings, we expected differences between high- and low achieving students as well as gender differences with respect to students' habitualized math emotions before the intervention. Because of individualization in CBT, smaller or no such differences in students' emotions experienced *during* CBT were expected (*Hypothesis 4).*

Results and Discussion

Neither pretest performance differences between control- and CBT-classes, nor between experimental- and control groups were found. Experimental results within CBT-classes (d = .43) as well as comparison with control classes showed the expected effects on performance. With respect to the impact of solving word problems, groups of students with many versus few problems (controlling for achievement level) were analyzed. Posttest performance was used as dependent variable. Results indicated significant differences: Students with more word problems outperformed students with less word problems during CBT. Regarding students' state emotions *during* CBT, no gender differences in enjoyment, pride, anxiety, shame or sadness were found (girls even reported interest more frequently than boys). It turned out that high- and low-achieving students did not differ in their experiences of enjoyment during CBT, but well in their emotional states during traditional practice. However, significant gender differences in trait emotions were replicated, girls reporting less enjoyment and more shame and anxiety than boys in mathematics. The expected positive effects of CBT (compared to control classes) on students' habitualized emotions in mathematics were found for enjoyment and reduced boredom. There was a significant interaction between students' perceived excessive demands in traditional lessons and reduced anger after CBT. Educational implications based on the results that highlight the role of students' state emotions and problem solving in CBT will be discussed. Findings on students' state- and trait emotions indicate differences between the general or habitualized domain

specific emotions and situational emotional processes – differences that should be emphasized in future research.

References

Ainley, M.; Corrigan, M.; Richardson, N. (2005). Students, tasks and emotions: Identifying the contribution of emotions to students' reading op popular culture and popular science texts. *Learning and Instruction*, 15, 433-447.

Cognition and Technology Group at Vanderbilt. (1992). The Jasper series as an example of anchored instruction: Theory, program description, assessment data. *Educational Psychologist, 27*(3), 291-315.

Frenzel, A.C., Pekrun, R., & Goetz, T. (2007). Girls and mathematics – A hopeless issue? A control value approach to gender differences in emotions towards mathematics. *European Journal of Psychology of Education*, 22(4), 497-514.

Fuchs, L.S., Fuchs, D., Stuebing, K., Fletcher, J.M., Hamlett, C.L., & Lambert, W. (2008). Problem Solving and Computational Skill: Are They Shared or Distinct Aspects of Mathematical Cognition? *Journal of Educational Psychology*, 100(1), 30-47.

Gläser-Zikuda, M., & Mayring, P. (2003). A qualitative oriented approach to learning emotions at school. In: P. Mayring & C. von Rhoeneck (Eds.), *Learning emotions: The influence of affective factors on classroom learning*, 103-126. Berlin: Peter Lang.

Goldin, G.A., Epstein, Y.M., & Schorr, R.Y. (2007). Affective pathways and structures in urban student's mathematical learning. In: D.K. Pugalee, A. Rogerson & A. Schinck (Eds.), *Mathematics education in a global community*, 260-264. Charlotte, NC: Center for Mathematics, Science and Technology Education.

Hidi, S., & Ainley, M. (2002). Interest and adolescence. In: F. Pajares & T. Urdan. (Eds.). *Academic motivation of adolescents*, 247-275.Greenwich, CT: IAP.

Koedinger, K.R., Anderson, J.R., Hadley, W.H., & Mark, M. (1997). Intelligent tutoring goes to school in the big city. *International Journal of Artificial Intelligence in Education*, 8, 30-43.

Kulik, J.A. (2003). Effects of using instructional technology in elementary and secondary schools: What controlled evaluation studies say. Arlington, VA: SRI International.

Pekrun, R. (2005). Progress and open problems in educational emotion research. *Learning and Instruction*, 15(5), 497-506.

Pekrun, R.; Goetz, T.; Titz, W. & Perry, R.P. (2002). Academic Emotions in students' Self-Regulated Learning and Achievement: A Program of Qualitative and Quantitative Research. *Educational Psychologist*, 37(2), 91-105.

Schoppek, W., & Tulis, M. (2010). Enhancing arithmetic and word problem solving skills efficiently by individualized computer-assisted practice. *The Journal of Educational Research*, 103(4), 239-252.

Slavin, R.E., & Lake, C. (2008). Effective programs in elementary mathematics: A best-evidence synthesis. *Review of Educational Research*, 78(3), 427-515.

Stern, E. (2003). Früh übt sich - Neuere Ergebnisse aus der LOGIK-Studie zum Lösen mathematischer Textaufgaben. In: A. Fritz, G. Ricken; S. Schmidt (Hrsg.), *Handbuch Rechenschwäche*, 116-130. Weinheim: Beltz.

Are Pictures More Motivating Than Text? Effects of Presentation Codality on Interest

Cornelia Schoor
TU Dresden
Institut für Pädagogische Psychologie und Entwicklungspsychologie, 01062 Dresden, Germany
cornelia.schoor@tu-dresden.de

Maria Bannert
TU Chemnitz
Professur Pädagogik des E-Learning und der Neuen Medien, Reichenhainer Str. 41, 09126 Chemnitz, Germany
maria.bannert@phil.tu-chemnitz.de

Abstract. The role of codality for knowledge acquisition is well researched. Pictures can have a positive influence on knowledge acquisition, but only under certain circumstances. Nevertheless, it is commonly assumed that pictures are more motivating than text. However, this assumption is not empirically validated. The present study addressed this lack by asking whether the codality of presentation (text only, picture only, text plus picture) influences the interest in the topic as well as the perceived interestingness of the material. Results show that text alone is less interesting than the picture or text plus picture, while there was no impact on the interest in the topic. This result confirms the common assumption that pictures are perceived as more motivating. However, as topic interest was not influenced it is questionable whether the interestingness of the materials results in better information processing and knowledge acquisition.

Keywords: codality; text; picture; motivation; interest; interestingness.

Theoretical and Empirical Background

Pictures play an important role for learning both with classic textbooks and with digital media. Comparably numerous studies on learning processes and learning outcomes show that pictures can have a beneficial effect but are not bound to do so: According to the multimedia effect for example, learning from text and pictures results in better learning outcome than learning from text alone (e.g. Mayer, 2001). Task-appropriate pictures may help constructing mental models (Schnotz & Bannert, 2003). However, pictures might also act as seductive details and hinder learning (e.g. Garner, Gillingham, & White, 1989).

Another function of pictures is motivational (Niegemann et al., 2008). In this area, there is comparably little research. For example, Salomon (1984) showed that students see themselves as more self-efficacious with TV material than with print material. Meanwhile, Harp and Mayer (1997) found that adding entertaining text and illustrations led to higher ratings of interestingness whereas explanative illustrations had no effect on this measure.

Interest and interestingness can be seen as a form of (intrinsic) motivation (e.g. Krapp, 1999). Following for example Renninger, Hidi and Krapp (1992) we differentiate between (individual or topic) interest, which refers to enduring personal value ascribed to a topic (Schraw & Lehman, 2001), and interestingness (or situational interest), which is a characteristic of a (learning) situation and therefore context-specific. We assume that pictures influence the interestingness of learning material. As interest might develop from interestingness (Hidi & Renninger, 2006), pictures might influence interest as well but probably not within a short time frame.

Method

Participants and Design

72 students of Chemnitz University of Technology participated in the study. Participants were recruited by advertisement on several student mailing lists. They studied mainly educational science in

the bachelor (59 students) or master (6 students) programme. 72.2% of them were female, 27.8% were male. Their mean age was 23.0 years (*SD* = 2.89). Participants were randomly assigned to one of three experimental conditions: text-only, picture-only, or text plus picture. This resulted in *N* = 24 participants per group.

Procedure

The whole study took place in the internet. After a welcome page, participants were assigned to one of the three experimental groups by a random generator. First, all participants got a page containing a (control) text about winemaking. On the next screen, participants' interest in the topic and interestingness of the material were measured as control variables, and after that we checked for proper learning by asking three multiple choice questions on the content. The following screen covered sparkling winemaking (the target content) and was different for the three experimental groups: One group again received only text explaining sparkling winemaking, whereas the picture-only group got a picture with short annotations in it and the text-plus-picture group studied the same picture without annotations but with a short explaining text. After that, participants had to report their interest in the topic of sparkling winemaking and the interestingness of the material. Again, we then checked for proper learning by means of three multiple choice questions on sparkling winemaking. On the last screen, participants were thanked, informed and dismissed. Participants finished the study after about 20-30 minutes.

Material and Instruments

Learning Material. Participants first learned about winemaking in text-only codality. Thereby, we were able to control for interest in the topic independently of the presentation codality. The text consisted of 361 words presented on one screen.

The actual target content was the next learning topic covering sparkling winemaking. Despite the topic similar to winemaking, this content was completely independent of the first. The participants received the information either as written text (316 words on one screen) or as a picture with necessary annotations or as a short text (122 words) and the same picture with only the key words in it.

Interest and Interestingness. Interest and interestingness were assessed by means of 5 items each which the participants had to rate on a 7-point Likert scale. A sample item for interest was "I take a great interest in sparkling winemaking." Interestingness was assessed by items like "The kind of presentation motivated me to look at the topic in great detail."

Knowledge Test. In order to check whether participants really worked on the task, they were asked three multiple choice questions after each of the learning topics. Each multiple choice question comprised three answer alternatives one of which was correct. The correct answers were summed up and corrected for guessing.

Results

An ANOVA showed a significant effect for presentation codality on interestingness ($F(2, 69) = 14.41$, $p < .001$, $\eta_p^2 = .30$). A post-hoc Scheffé test revealed that participants with text-only presentation codality reported significantly less interestingness ($M = 2.55$, $SD = 1.29$) than participants with picture-only ($M = 4.58$, $SD = 1.45$) or text and picture presentation codality ($M = 4.49$, $SD = 1.68$). Neither the ANOVA for interest ($F(2, 69) = 0.54$, $p = .59$, $\eta_p^2 = .02$) nor the ANOVA for knowledge ($F(2, 69) = 1.19$, $p = .31$, $\eta_p^2 = .03$) showed any significant group differences.

Discussion

In this study, codality of information presentation (with or without picture) seems indeed to influence the interestingness of the learning material and therefore motivation of the learners. However, it did not influence topic interest. Both findings are similar to those of Harp and Mayer (1997). Yet, as interest is dependent on an object, our findings should be replicated by means of another learning topic. Meanwhile, we found no effect of presentation codality on knowledge acquisition. As this aspect was not the focus of our study, knowledge acquisition was operationalized quite simply and we therefore cannot draw a general conclusion. It might be possible that interestingness of learning material influences the learning process positively while it also might be the case that this turns out to be – like seductive details – a negative aspect of learning material. The possible consequences on cognitive variables of the learning process and the learning outcome have to be assessed in further studies. For this purpose, it is important not only to find and use material which is meaningful in different codalities but also to consider the codality of knowledge assessment (c.f. Brünken, Steinbacher, Schnotz & Leutner, 2001).

Acknowledgement

We want to thank Ingmar Bechstein for bringing up this research question and for data collection.

References

Brünken, R., Steinbacher, S., Schnotz, W., & Leutner, D. (2001). Mentale Modelle und Effekte der Präsentations- und Abrufkodalität beim Lernen mit Multimedia [Mental models and effects of presentation and retrieval cue codality in multimedia learning]. *Zeitschrift für Pädagogische Psychologie, 15*(1), 16-27.

Garner, R., Gillingham, M. , & White, C. (1989). Effects of "seductive details" on macroprocessing and microprocessing in adults and children. *Cognition & Instruction, 6*, 41–57.

Harp, S., & Mayer, R. (1997). The role of interest in learning from scientific text and illustrations: On the distinction between emotional interest and cognitive interest. *Journal of Educational Psychology, 89*(1), 92-102.

Hidi, S., & Renninger, A. (2006). The Four-Phase Model of interest development. *Educational Psychologist, 41*(2), 111-127.

Krapp, A. (1999). Intrinsische Lernmotivation und Interesse. Forschungsansätze und konzeptuelle Überlegungen [Intrinsic learning motivation and interest - Research approaches and conceptual considerations]. *Zeitschrift für Pädagogik, 45*(3), 387-406.

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

Niegemann, H., Domagk, S., Hessel, S., Hein, A., Hupfer, M., & Zobel, A. (2008). *Kompendium multimediales Lernen* [Compendium Multimedia Learning]. Heidelberg: Springer.

Renninger, A., Hidi, S., & Krapp, A. (1992). *The role of interest in learning and development*. Hillsdale, NJ: Lawrence Erlbaum.

Salomon, G. (1984). Television is "easy" and print is "tough": The differential investment of mental effort in learning as a function of perceptions and attributions. *Journal of Educational Psychology, 76*(4), 647-658.

Schnotz, W., & Bannert, M. (2003). Construction and interference in learning from multiple representation. *Learning and Instruction, 13*(1), 141-156.

Schraw, G., & Lehman, S. (2001). Situational interest: A review of the literature and directions for future research. *Educational Psychology Review, 13*(1), 23-52.

Implementation Intentions to Support Strategy Use in Multimedia Learning

Kim Stalbovs,
Katharina Scheiter, &
Peter Gerjets
Knowledge Media Research Center
Konrad-Adenauer-Str. 40, 72072 Tübingen, Germany
{k.stalbovs, k.scheiter, p.gerjets}@iwm-kmrc.de

Abstract. Successful learning with text and picture requires learners to actively process both information sources. This can be achieved by applying appropriate learning strategies. However, it is not guaranteed that learners will use such strategies. Therefore, a promising means to facilitate the use of learning strategies are implementation intentions. Implementation intentions are specific "if-then" plans that strongly link opportunities for applying learning strategies with the actual act of applying such strategies. In order to investigate the effects of implementation intentions on learning outcomes, a study was conducted comparing two groups who learned either with or without implementation intentions. Current interest in the learning task was included as a predictor. The positive effect of implementation intentions was moderated by the learners' interest in the task. Especially less interested learners benefited from implementation intentions, indicating that implementation intentions facilitate learning of learners with less suitable learner characteristics in particular.

Keywords: Multimedia learning, implementation intentions, learning strategies, motivation.

Research on multimedia learning (i.e., learning with text and picture) has shown that a presentation of text and picture yields better comprehension than a presentation of text alone (Mayer, 2009). This advantage is ascribed to the availability of two representational formats, which allows for the construction of a more sophisticated mental representation. In order to profit fully from multimedia, however, an active processing of both representations is necessary. Learners can achieve this by applying cognitive strategies (Weinstein & Mayer, 1986). Cognitive strategies are defined as strategies that facilitate the encoding and processing of information.

Cognitive strategies specific to multimedia learning can be derived from the Cognitive Theory of Multimedia Learning (Mayer, 2009). They pertain to the selection of relevant information in text and picture, to the organization of selected information into verbal and pictorial mental representations by connecting relevant elements within each respective representation, and to the integration of both mental representations (Kombartzky, Plötzner, Schlag, & Metz, in press).

Students have to learn, however, when and how to use these strategies. If the initiation of behavior is not automated yet, the active and deliberate use of strategies demands central-executive resources (Ferndandez-Duque, Baird, & Posner, 2000). Therefore, measures for improving the use of cognitive strategies should aim at facilitating the automation of strategy initiation. To achieve this, we suggest the use of implementation intentions.

Implementation intentions are a well-researched concept in motivational psychology. They represent specific "if-then" plans that link situational cues with the actions necessary for attaining a goal (Gollwitzer & Sheeran, 2006). That is, if a goal is to acquire knowledge from a multimedia presentation, then a corresponding implementation intention could be: "*If* I have read a sentence, *then* I will look for corresponding elements in the picture." A meta-analysis incorporating 63 studies indicates that implementation intentions are highly efficient for goal attainment across a variety of samples, settings, domains, and dependent variables (Gollwitzer & Sheeran, 2006).

After a person has formed an implementation intention, the situational cues defined therein become highly activated and will facilitate the recognition of a situation that requires a corresponding action. Recognizing this situation will then automatically trigger this action. Hence, actions that are evoked by implementation intentions, share similarities with automated behavior (Gollwitzer & Sheeran, 2006). The formation of implementation intentions delegates behavioral control from the self to specific

situational circumstances, thus creating "instant habits". Therefore, they should be advantageous compared to an active and cognitively demanding control of action.

Hypotheses

We assumed that implementation intentions are effective in supporting the use of cognitive strategies in multimedia learning. Learners who have internalized implementation intentions about the use of strategies should show more frequent strategy use and consequently better comprehension than learners who have not. Since the effect of implementation intentions is sensitive to motivational factors, we further hypothesized that current learning motivation plays an important moderating role when learning with implementation intentions. Based on previous research, there might be two possible moderation effects. On the one hand, Koestner, Lekes, Powers, and Chicoine (2002) found that implementation intentions are more effective if aiming at advancing intrinsic goals than if they are aimed at advancing extrinsic goals. Thus, implementation intentions might show a stronger effect for learners who are highly motivated with regard to the learning task. On the other hand, implementation intentions have shown a compensatory effect to overcome initial reluctance when the activities involved are unpleasant (e.g., Orbell & Sheeran, 2000). Hence, implementation intentions might help especially those learners who are less motivated with regard to the task at hand.

Method

Sixty students from the University of Tübingen participated in this study (44 female, 16 male; mean age = 23.72 years, *SD* = 3.79 years). The study used a two-group experimental design with current learning motivation acting as a covariate.

The experiment used paper-based materials and was split into three parts: First, participants' current learning motivation and other control variables (prior knowledge, reading skills) were assessed. Their current learning motivation was measured as a covariate by means of the *Questionnaire of Current Motivation* (Rheinberg, Vollmeyer, & Burns, 2001). The scale "task interest" was deemed the most important aspect of motivation for this study's task. Then, in the following learning phase, participants had to learn about the biological processes of mitosis and meiosis by means of an illustrated explanatory text (2,119 words, 19 schematic illustrations).

Before studying the materials, participants in the experimental condition were instructed to internalize two pre-phrased implementation intentions about the use of strategies of text-picture integration ("If I have turned a page, then I will thoroughly look at the picture first." and "If I have read a sentence, then I will search the picture for the contents described therein."). In the control condition, participants were not instructed to internalize implementation intentions. They were, however, informed of the usefulness of the two learning strategies contained in the pre-phrased implementation intentions. After learning, participants' learning outcomes were assessed by a multiple-choice post-test, both recall and transfer.

Results

Multiple regression analyses were conducted for recall and transfer performance with implementation intentions, task interest, and the interaction of implementation intentions and task interest as predictors. Concerning recall performance, the regression model was significant (adj. R^2 = .13, $F(3,56)$ = 3.83, p = .01). There was neither a main effect for implementation intentions (b = 2.65, SE = 1.78; β = .19, p = .14), nor for task interest (b = -1.63, SE = 1.82, β = -.11, p = .38). However, as expected, an interaction between both predictors emerged (b = -5.65, SE = 1.82, β = -.39, p = .003), R^2 change = .17, F change (3,56) = 3.83, p = .01. Simple slopes analyses for low and high task interest were conducted (cf. Aiken & West, 1991). For learners with low task interest, a significant positive slope

indicated that implementation intentions positively influenced recall performance (b = 8.31, SE = 2.6, β = .59, p = .002), while no effect was found for learners with high task interest (b = -3.00, SE = 2.49, β = -.21, p = .23; see Figure 1). For transfer performance, the regression model was only marginally significant (adj. R^2 = .08, F(3,56) = 2.64, p = .06). We found no main effect for implementation intentions (b = .66, SE = 1.5; β = .06, p = .66), but a main effect for task interest (b = -3.42, SE = 1.53, β = -.29, p = .03). Surprisingly, transfer performance decreased with increased task interest. Furthermore, there was a significant interaction between both predictors (b = -3.22, SE = 1.53, β = -.27, p = .04), R^2 change = .12, F change (3,56) = 2.64, p = .06. Simple slopes analyses showed that implementation intentions had a marginally positive effect for learners with low task interest (b = 3.88, SE = 2.19, β = .33, p = .08), but no effect was found for learners with high task interest (b = -2.56, SE = 2.1, β = -.22, p = .23). Summing up, the results suggest that implementation intentions support learners with little task interest, but do not affect the performance of learners with higher task interest.

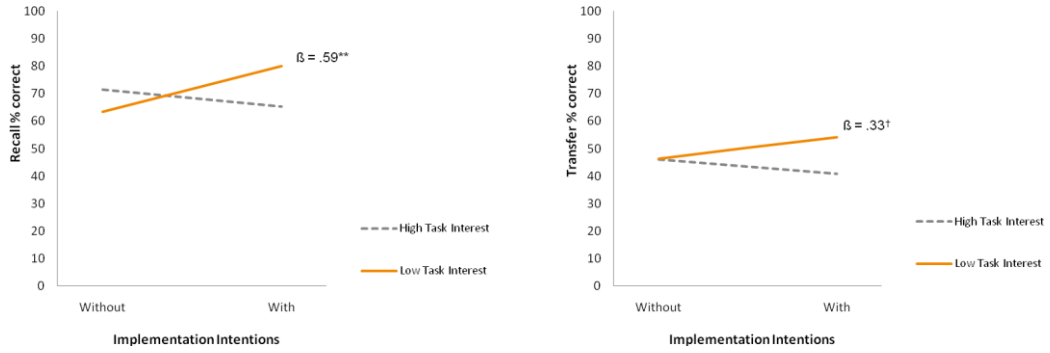


Figure 1. Simple slopes analyses for recall and transfer performance. † p < .10, ** p < .01.

Discussion

While the use of implementation intentions did not show an overall positive effect on learning outcomes, it was shown that implementation intentions significantly help uninterested learners to improve their learning performance, while seemingly not harming highly interested learners. This result corresponds well with previous findings that implementation intentions have a strong compensatory effect, especially when the involved activities are unpleasant (e.g., Orbell & Sheeran, 2000). Thus, implementation intentions seem to be a promising means in order to improve learning especially for those who are in need of help the most.

References

Aiken, L. S., & West, S. G. (1991). Multiple Regression: Testing and interpreting interactions. Thousand Oaks: Sage.

Ferndandez-Duque, D., Baird, J. A., & Posner, M. I. (2000). Attention and awareness in self-regulation. Consciousness & Cognition, 9, 324-326.

Gollwitzer, P. M., & Sheeran, P. (2006). Implementation intentions and goal achievement: A meta-analysis of effects and processes. In M. P. Zanna (Ed.), Advances in Experimental Social Psychology (Vol. 38, pp. 69-119). San Diego: Academic Press.

Koestner, R., Lekes, N., Powers, T. A., & Chicoine, E. (2002). Attaining personal goals: Self-concordance plus implementation intentions equals success. Journal of Personality and Social Psychology, 83, 231-244.

Kombartzky, U., Plötzner, R., Schlag, S., & Metz, B. (in press). Developing and evaluating a strategy for learning from animations. Learning and Instruction. doi:10.1016/j.learninstruc.2009.05.002

Mayer, R. E. (2009). Multimedia learning (2nd ed.). Cambridge: Cambridge University Press.

Orbell, S., & Sheeran, P. (2000). Motivational and volitional processes in action initiation: A field study of implementation intentions. Journal of Applied Social Psychology, 30, 780-797.

Weinstein, C. E., & Mayer, R. E. (1986). The teaching of learning strategies. In Wittrock, M. C. (Ed.), Handbook of research on teaching (pp. 315-327). New York: Macmillan.

The impact of motivation-related variables on scaffold use

Lai Jiang and Jan Elen
Katholieke Universiteit Leuven, Department of Educational Sciences, Centre for Instructional Psychology and Technology
Andreas Vesaliusstraat 2, Belgium
jiang.lai@student.kuleuven.be

Abstract. The use of scaffolds lies at the core of the effectiveness of learning environments. In view of establishing a solid research agenda on the optimization of the use of scaffolds, this study aims at investigating the effects of motivational variables on scaffold use. More specifically, the effect of (a) achievement goal orientation and (b) self-efficacy on students' use of learning goals and postquestions were studied. One hundred and ten students in three conditions studied a science text in 50 minutes. Participants had to respond to learning goals and/or to postquestions. Their usage of these scaffolds was recorded in log files. The results revealed that quantity of scaffold use was influenced by achievement goal orientation and self-efficacy. Avoidance goal orientation and self-efficacy influenced quality of scaffold use which in turn was found to predict students' posttest score. The results confirm the importance of motivational variables in scaffold use.

Keywords: scaffold use**;** goal orientation; self-efficacy; perceived usefulness; perceived ease of use

Introduction

Scaffolds are often added to/inserted in the learning environment because of anticipated or typical learner difficulties associated with a task. They are beneficial for learning only when they are adequately and optimally used (Elen & Clarebout, 2006). Therefore, the use of scaffolds lies at the core of the effectiveness of learning environments and the study of that use is of paramount importance to instructional research.

It has been claimed that to make best use of scaffolds, students must be knowledgeable and motivated enough to (1) recognize scaffolds' functionalities, (2) be able to carry out the cognitive operations these scaffolds suggest (knowledgeable: cognitive / metacognitive ability required), and (3) be willing to pursue the learning path proposed by the scaffolds (motivation required) (e.g., Elen & Clarebout, 2006; Winne, 1983). In order to ensure students are knowledgeable and motivated to adequately and optimally use scaffolds, the factors that contribute to students' knowledgeability and motivation need to be identified.

While cognitive and metacognitive (regulative factors), such as prior knowledge and self-regulation skills, have already been widely empirically studied (e.g., prior knowledge: Martens, Valcke, & Portier, 1997; metacognitive skills: Azevedo & Witherspoon, 2009), much less is known about what makes learners motivated to use scaffolds. To date self-efficacy and achievement goal orientation have been claimed to influence quantity of scaffolds use through its impact on task engagement (Aleven, Stahl, Schworm, Fischer, & Wallace, 2003; Elen & Clarebout, 2006). In addition, self-efficacy and goal orientation were assumed to exert influence on quality of scaffold use through their impact on strategy use. However, the arguments are mainly theoretical rather than empirically supported. Thus, there is a need for research that identifies the variables influencing students' motivation on adequate and optimal use of scaffolds. Of special interest in the current study is the investigation on how students' achievement goal orientation and self-efficacy influence their actual use of two scaffolds (i.e., learning goals and postquestions).

Method

Materials

A program, called OBESITAS, provides a computer-based prose environment in which participants were asked to study a scientific text[11] on the relation between overweight and impulsivity. The text comprises 2,178 words (17 paragraphs). Each paragraph was displayed on a separate screen. Learning goals were provided at beginning of the text and/or postquestions were inserted at the end of the text.

Participants and procedure

One hundred and ten university students were pre-tested one week before the experiment. The results of the pretest were used to equally assign higher/lower prior knowledge students into three conditions. In the experiment, before completing the self-efficacy and goal orientation questionnaires[12], participants got the opportunity to have a glance at the to-be-learnt text and to read a short description of the post-test. This would allow them to have a clear idea about the task demand. Afterwards they were invited to indicate their self-efficacy and goal orientation with respect to the upcoming task. Then, they got the text on their computer screen. Students studied the text in one of three conditions: with learning goals (n = 37); with postquestions (n = 37), and with both (n = 35). During the learning session, all learning behaviours of each participant were recorded in individual logfiles. Finally, a post-test was conducted to measure participants' factual knowledge (i.e., terms and abbreviations) (recorded as knowledge score), understanding of the relations between causal factors for obesity (recorded as insight score) and the ability to solve problems (recorded as application score).

Measure quality of scaffold use

Students in the learning goal condition and combined condition were asked to interpret the assigned learning goals and specify their learning objectives based on the assigned goals. A note space was provided which allowed students to write down notes. These were recorded and used to find out whether students carried out the intended cognitive processes (e.g., searching the text for relevant information and making inference of the text). The following variables were recorded in logfiles and used to assess quality of scaffold use: students' responses to learning goals, answers to the postquestions, notes and study sequence. The quality assessment intended to find out whether students used learning goals/postquestions to monitor their cognitive actions and to adjust their studying processes when necessary.

Results

The relations between quantity and quality of scaffold use and performance

The current results are in line with the argument that scaffold use is a highly relevant factor for students' performance in instructional environments. Time spent on postquestions was found to be positively related to the knowledge score. Quality of scaffold use was found to be highly correlated to knowledge score, insight score and application score.

The relations between learner variables and quantity of scaffold use

A negative correlation between performance-avoidance goal orientation and time spent on the postquestions, r = -.21, p < .05 (one-tailed) was found. The relation between mastery-avoidance and time spent on learning goals was not linear. Students who were medium mastery-avoidance goal

[11] The text in this study was the first part of a text used in Clarebout and Elen study (2009)

[12] Goal orientation was measured through a Dutch version of Elliot's instrument (Elliot & McGregor, 2001). Self-efficacy was measured by the questionnaire based on MSLQ (Pintrich et al., 1991) & STPQ (Lodewyk & Winne, 2005).

oriented were willing to spend the most time on learning goals. Self-efficacy was negatively related to the sum of the access times of postquestions, $r = -.17$, $p < .05$ (one-tailed).

The relations between learner variables and quality of scaffold use

Avoidance goal orientation (i.e., performance-avoidance goal and mastery-avoidance goal) had negative impacts on quality use of scaffolds. A quadratic relation is found, suggesting that a medium self-efficacy is most beneficial for scaffold use.

Conclusions

This study provides insights into the impact of scaffold use on performance and of motivational variables on scaffold use. Results suggested that goal orientation and learning efficacy are the potential variables influencing quantity of scaffold use. Hence, instructors may create situations in which students' motivation for using scaffolds are promoted. Examples could, for instance, manipulate students' learning efficacy as a means to promote optimal scaffold use. Specifically, in this study, avoidance goal orientation and learning efficacy were found to be important variables for quality of scaffold use. This implies that instructors should pay attention to students' task specific goal orientations in environments as well as their learning efficacy level. Research has shown that altering the general goal structure of learning environments as well as the feedback students receive during their learning can affect students' goal orientation and self-efficacy (e.g., Linnenbrink, 2005).

References

Aleven, V., Stahl, E., Schworm, S., Fischer, F., & Wallace, R. (2003). Help seeking and help design in interactive learning environments. *Review of Educational Research*, *73*, 277-320.

Azevedo, R., & Witherspoon, A. M. (2009). Self-regulated use of hypermedia. In A. Graesser, J. Dunlosky, D. Hacker (Eds.), *Handbook of metacognition in education*. Mahwah, NJ: Erlbaum.

Clarebout, G., & Elen, J. (2009). The complexity of tool use in computer-based learning environments. *Instructional Science: An International Journal of Learning and Cognition*, *37*, 475-486.

Elen, J., & Clarebout, G. (2006). The use of instructional interventions: Lean learning environments as a solution for a design problem. In J. Elen & R. E. Clark (Eds.), *Handling complexity in learning environments: Research and theory* (pp. 185-200). Amsterdam: Elsevier.

Linnenbrink, E. A. (2005). The dilemma of performance-approach goals: The use of multiple goal contexts to promote students' motivation and learning. *Journal of Educational Psychology*, *97*(2), 197-213.

Martens, R. L., Valcke, M. M., & Portier, S. J. (1997). Interactive learning environments to support independent learning: the impact of discernability of embedded support devices. *Computers in Education*, *28*, 185-197.

Winne, P. H. (1983). Training students to process text with adjunct aids. *Instructional Science*, *12*, 243-266.

Motivated (e)-learning : results of a European project as starting point to explore social-psychological dimensions of effective social interaction.

Maria Cristina Matteucci
University of Bologna, Department of Education, Faculty of Psychology, p.za A.Moro,90, Cesena, Italy, mariacristina.matteucci@unibo.it

Birgitta Kopp
Ludwig-Maximilians-University, Leopoldstraße 13, 80802 Munich, Germany, birgitta.kopp@psy.lmu.de

Carlo Tomasetto
University of Bologna, Department of Education, Faculty of Psychology, p.za A.Moro,90, Cesena Italy, carlo.tomasetto@unibo.it

Abstract. In the framework of a European Socrates-Minerva project, the learner-tutor interaction has been investigated as key aspect in order to foster collaborative knowledge construction. Aiming at identifying effective supporting strategies, seventy-eight e-tutors from 17 different European countries completed a questionnaire on their actual experience asking for main support methods. Results showed that e-tutors support collaborative learning in providing specific technical and didactical support and in fostering the collaborative learning process, especially content-specific activities like online discussion.

Keywords: knowledge construction; social interaction; European project; collaborative learning.

Theoretical Background

In the last two decades, the epistemic-engagement view, in which learning is assumed to emerge from learners-tutor-content exchanges, has become the main approach of many scholars in the field of e-learning (Larreamendy-Joerns & Leinhardt, 2006). There is ample empirical evidence that cognitive processes necessary for deep learning and information retention occur in social interaction and that "collaborative learning" is the "royal road" to knowledge acquisition (e.g. Kreijins et al. 2003). But co-construction of knowledge is not an inevitable consequence of allowing students to interact with each other: learning does not happen just because technological tools and pedagogical devices make it possible. Literature offers abundant indications of possible interventions to enhance the quality of CSCL activities, but little is known about the e-tutors' beliefs and practices, i.e., which of the input, process, and output aspects are considered the most important by e-tutors, and upon which of them they mainly exert their interventions. In the framework of a European project[13] (*"Social networks and knowledge construction promotion in e-learning contexts")* we conducted an exploratory study with the purpose to identify which pedagogical and technological tools, activities or strategies are useful to enhance the effectiveness of social interaction in e-learning contexts (Matteucci et al., in press).

Method

Participants

To investigate how and when e-tutors intervene in respect to support online collaboration, each partner of the EU project (from Italy, Germany, Finland, Switzerland, and France) contacted colleagues involved in e-learning experiences and invited them to complete a questionnaire on their e-learning experiences. Inclusion criteria were as follow: (a) the respondent is a teacher, an instructor, or a tutor

[13] This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein. Authors acknowledge project partners and the EACEA.

of an e-learning course (or, otherwise, he/she knows the experience sufficiently to give details about it); (b) the course is ongoing or it has been delivered in recent past; (c) the course is/has been delivered in blended or full-distance modality; (d) the course include online social interaction activities/collaborative learning activities (such as discussions, cooperation, collaboration, etc.). The final group of participants includes seventy-eight e-tutors from 17 different European countries.

Instrument

Data were collected using a structured web-based questionnaire developed according to the input-process-output model (Hackman, 1983) and, therefore, divided into three main sections: input (characteristics of participants, technical aspects, didactical organization), process (cognitive and social aspects of group work), and output features (evaluation of products and processes). As for the process section, the focus of our paper, the questionnaire comprised the following structure: In a first step, the importance of each of these dimensions was asked for on a six-point Likert scale (from 1, *not important*, to 6, *very important*). In a second step, e-tutors were asked whether they intervened to foster the specific collaborative activity and, if yes, in a third step they were asked how they intervened, if no, why they did not intervene.

Results

Results regarding the importance of *cognitive activities* show that, overall, e-tutors evaluate cognitive activities as very important for collaborative online learning (see table 1), whereas results regarding *social activities* show that e-tutors seldom intervene to avoid dysfunctional phenomena (see table 2).

Table 1: Evaluation of the importance of cognitive activities and intervention percentage

Cognitive activity	Mean (SD)*	Intervention rate in %**
Exchange of knowledge	5.19 (1.23)	73.1
Considering different perspectives	4.92 (1.49)	62.8
Online discussion	5.10 (1.34)	80.8
Argumentation	4.87 (1.52)	78.2
Collaborative problem solving	4.54 (1.81)	67.9

*(Min.1, Max. 6, N=77) ** no answer: 1.3%

Most interventions deal with the promotion of the cognitive functioning of individuals, rather than with the support of effective social interactions. Online discussion and exchange of knowledge seem to be the most important processes and the former, probably because of its more general character, is also the aspect in which e-tutors intervened most (80.8%). Collaborative problem or case solving is, on the contrary, the least important aspect, although the high variance of the score indicates that a number of e-tutors rate this aspect as much above (or much below) this average score. A possible explanation is that e-tutors who adopted problem-based learning are likely to consider this aspect as very important, while the other respondents consider it less important.

As for the social aspects of the collaboration process, the majority of e-tutors did not intervene, and the main motivation is that intervention was not necessary (mentioned 62 times by respondents). The only aspect, which saw the majority of interventions by e-tutors, was actually the learners' tendency to turn to the e-tutor, in order to ask for content-related information, and to wait for answers, instead of posing questions to their peers (53.8% of respondents intervened for this reason). The most interesting and recurrent methods of intervention used by e-tutors to promote various cognitive and social processes of collaboration are similar and consist in the creation of groups, roles/responsibilities

assignation, use of rules/scripts, different forms of feedback and various types of activities for learners (e.g. collaborative construction documents, discussions on peers' problem solution, ePortfolio, etc.).

Table 2: Intervention of e-tutors regarding social activities in per cent

Social activity		Intervention rate in %
Motivational aspects	Different group goals (2 items)	29.5 / 28.2*
	Competition	23.1*
Interpersonal interaction	Interpersonal conflicts	37.2 **
	Balanced participation	47.4*
	Diffusion/lack of responsibility	38.5*
Social influencing factors	Ignoring minorities	33.3*
	Imposing group members	28.2*
Information processing	Superficial discussion	33.3*
	Addressing the tutor rather than group members (2)	53.8 / 48.7*

* no answer: 3.8% ** no answer: 2.6%

Discussion

The importance of some cognitive and social processes (e.g., social dynamics, collaboration feedback, etc.) appears to be in part neglected by e-tutors involved in this study. Instructional designer and e-tutors must not ignore the social-psychological dimensions of the desired social interaction (Kreijins, Kirschner, & Jochems, 2003). As for the results concerning social processes, two principal interpretations can be formulated: 1) dysfunctional phenomena in collaboration were either not present or not noticed in several experiences; 2) these social phenomena- if present -were not considered as a significant problem for e-tutors. E-tutors intervened when directly involved by learners' request.

Further research on social-psychological dimensions of effective social interaction and motivated e-learning are needed and could be of strategic interest to European Union. ICT is a key theme for EU and a research plan considering social ingredients of motivation in e-learning contexts could fill the gap. In this framework, social psychological principles of motivation (like self-beliefs, causal attributions, stereotype influence, implicit theories of intelligence) need to be considered together with criteria for supporting effective social interactions.

References

Deci, E.L., & Ryan, R.M. (2002).The paradox of achievement: The harder you push, the worse it gets. In J. Aronson (Ed.*), Improving Academic Achievement* (pp. 62-87). San Diego: Academic Press.

Hackman, J.R. (1983). The design of work teams. In J.W. Lorsch (Ed.), *Handbook of organizational behavior* (pp. 315-342). Englewood Cliffs, NJ: Prentice-Hall.

Kreijins, K., Kirschner, P.A., Jochems, W. (2003). Identifying the pitfalls for social interaction in comupter-supported collaborative learning environments: a review of the research. *Computers in Human behavior, 19*, 335-353.

Larreamendy, Joerns J. & Leinhardt G. (2006). Going the distance with online education. *Review of Educational Research, 76*(4), pp. 567–605.

Matteucci, M.C., Tomasetto, C., Mazzoni, E., Gaffuri, P., Selleri, P., & Carugati, F. (in press). Knowledge Construction in E-Learning Context. In R.V. Nata (Ed.), *Progress in Education, 19*, New York: Nova Science Publishers.

Supporting Online Design-Based Learning with Collaboration Scripts and Incomplete Concept Maps

Walid El-Refai
Department Psychology, Ludwig-Maximilians-University (LMU) Munich
Leopoldstr. 15, 80802 Munich, Germany
Email: walid.el-refai@ psy.lmu.de

Ingo Kollar
Department Psychology, Ludwig-Maximilians-University (LMU) Munich
Leopoldstr. 13, 80802 Munich, Germany
Email: ingo.kollar@ psy.lmu.de

Frank Fischer
Department Psychology, Ludwig-Maximilians-University (LMU) Munich
Leopoldstr. 13, 80802 Munich, Germany
Email: frank.fischer@ psy.lmu.de

Abstract. This study examined the effects of two types of scaffolding (collaboration scripts and incomplete concept maps) and their combination to support students in a design-based online learning environment in their effort to design, build, and publish web sites. The students followed two cycles of activities, which were derived from the Learning by Design (LBD) approach. The results showed positive effects of both treatments on the acquisition of factual knowledge on web site design as well as on the acquisition of Web-design skills. Yet, combining the two treatments did not lead to higher levels of knowledge and skill acquisition than any of the two treatments alone. Thus, to be effective, online DBL should be augmented by either incomplete concept maps or collaboration scripts.

Keywords: Design-based online learning; Learning by Design, collaboration scripts; concept maps; social scaffolding; task scaffolding; computer-supported collaborative learning.

Introduction

Design-based Learning (DBL) has gained wide-spread attention in the Learning Sciences (e.g. Kolodner, 2002). In DBL, students engage both in complex design processes and in challenging investigation processes. Moreover, as at least central steps of DBL are typically completed by small groups of learners, they also need to engage in high-level collaboration processes, which as research shows rarely happen spontaneously (e.g., Cohen, 1994). Clearly, for DBL to be effective, students need to be properly scaffolded.

In this study, we established an online DBL environment, which was enriched by two types of scaffolding: (1) social scaffolding, which was implemented using a computer-supported collaboration script (Kollar, Fischer & Hesse, 2006) that prompted collaboration and interaction between learning partners, and (2) content scaffolding, which was realized by using incomplete concept maps supporting students by externally representing domain-specific knowledge that was necessary for the design task (Tergan & Keller, 2005). The main research question was whether collaboration scripts and incomplete concept maps as well as their interaction have a positive effect on the acquisition of domain-specific knowledge and of skills related to the design and building of web sites in an online DBL environment. We expected that a combination of the two treatments would yield the most positive results, because incomplete concept maps should increase students' discussions about web site design concepts and a collaboration script should help learners engage in higher-level discourse processes on these web site design concepts, which in turn should lead to a deeper elaboration of the learning material and thus, learning.

Method

Participants and design

100 students from the Educational Technology Department of Tanta University (Egypt) from grade 3 and 4 from the Faculty of Specific Education participated in the study in the winter term of 2009. 15 participants were male, and 85 participants were female. We established an experimental 2x2-factorial design with the collaboration script (without vs. with) and incomplete concept maps (without vs. with) as independent variables (see table 1). The students were randomly assigned to dyads which were then randomly assigned to one of the four experimental conditions.

Table 1: Design of the empirical study.

		Collaboration Script	
		Without	With
Incomplete Concept Map	Without	N= 20 (10 dyads)	N= 24 (12 dyads)
	With	N= 24 (12 dyads)	N= 32 (16 dyads)

Procedure and learning environment

The students participated in an online DBL environment, which was inspired by the Learning by Design (LBD) approach (Kolodner, 2002). The students' task was to build tourist web sites about Egypt by aid of the software "FrontPage". The learning phase consisted of five phases (task presentation and exploration of already existing web sites, online tutorials on web design knowledge and skills, planning and discussing the set up of the web sites, building and publishing web sites, and redesigning/rebuilding/republishing web sites), which in total took seven weeks. In each phase, the students worked individually, in small groups (dyads), and in plenary sessions (all groups together). The treatment was realized in the small-group (dyadic) phases. Each dyad had a private chat room for conducting small-group discussions which were scaffolded by either an incomplete concept map, a collaboration script, both or none of the two. In addition, each dyad had a private wiki page to receive comments, questions, and answers from other groups during the sessions. Each dyad was allowed to evaluate only one other group, which was assigned to them before the session by the teacher.

Independent, dependent and control variables

Independent variables were the computer-supported collaboration script and the incomplete concept map, which were used to support the dyads' discussion in all learning phases except the fifth phase. The *collaboration script* involved specific prompts to engage the dyads in inquiry-based discussions by showing specific activities and roles, such as asking questions, accepting answers with comment(s), and refusing answers with justifications. One *incomplete concept map* was included in every learning phase except for the second phase, which included nine concept maps to stimulate the dyads to think more about the concepts and the relationships. The dyads had to complete missing concepts and relations in each concept map and to discuss its contents. Dependent measures were the individual students' performance in two post tests. A *factual knowledge test* assessed students' domain-specific content knowledge about FrontPage software and standards for designing web sites. The test consisted of 66 multiple choice questions. The other test assessed the students' *Web-design skills* by asking them to demonstrate all 292 web design features of FrontPage. Both tests were also used as pretests which were used as control variables in the subsequent analyses. All reliabilities were sufficient and ranged between α = .72 and α = .96 (Cronbach's Alpha).

Results and Discussion

With respect to the acquisition of *factual knowledge*, an ANCOVA with the collaboration script and the incomplete concept maps as fixed factors and the post test scores in the factual knowledge test as dependent variable and the pre test scores as a covariate was conducted. It showed significant and positive main effects for both treatments ($F(1,95) = 21.87$, $p < .001$, $Eta^2 = .19$ for incomplete concept maps, and $F(1,95) = 7.05$, $p < .001$, $Eta^2 = .07$ for the collaboration script). However, the interaction effect did not reach statistical significance ($F(1,95) = 2.30$; *n.s.*). A similar pattern was found with respect to the acquisition of *Web-design skills.* There, an ANCOVA with the collaboration script and the incomplete concept map as fixed factors, the post test scores in the Web-design skills test as dependent variable and the pre test scores as a covariate was conducted. It also showed significant and positive main effects for both treatments ($F(1,95) = 17.52$, $p < .001$, $Eta^2 = .16$ for incomplete concept maps, and $F(1,95) = 21.53$, $p < .001$, $Eta^2 = .19$ for the collaboration script), but no significant interaction effect ($F(1,95) < 1$; *n.s.*). Altogether, the results support our expectation that online DBL can drastically be improved by adequate scaffolding. As our study indicates, implementing social and content scaffolds in an online DBL environment are powerful means to improve individual knowledge and skill acquisition. However, implementing social scaffolds (a collaboration script) may have stronger effects on skill than on factual knowledge acquisition, and implementing content scaffolds (incomplete concept maps) may have stronger effects on factual knowledge rather than skill acquisition. It is likely that the collaboration script facilitated the communicative-coordinative processes within the dyads (Dillenbourg, 2002; Kollar, et al., 2006) and positively affected the interaction between the students so that knowledge and especially skill acquisition were finally alleviated. The incomplete concept map, in turn, provided the students with conceptual support concerning the domain-specific content of the task. This may have successfully circumvented memory limitation (Cox & Brna, 1995) during work in the online environment (Tergan & Keller, 2005), which enabled the students to acquire especially factual knowledge on Web-design concepts which at least partially could be transformed into skills as well. Yet, it seems that the effects of the two treatments do not add up. Obviously, providing learners with incomplete concepts is enough to help them engage in high level learning processes, and the same is true for collaboration scripts. Further process analyses are needed to shed more light on the underlying processes which contributed to these results.

References

Cohen, E. G. (1994). Restructuring the classroom: Conditions for productive small groups. *Review of Educational Research, 64*(1), 1-35.

Cox, R. & Brna, P. (1995). Supporting the use of external representations in problem solving: the need for flexible learning environments. *Journal for Artificial Intelligence in Education, 6*, 239-302.

Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In P. A. Kirschner (Ed.), *Three worlds of CSCL. Can we support CSCL* (pp. 61-91). Heerlen: Open Universiteit Nederland.

Kollar, I., Fischer, F., & Hesse, F. W. (2006). Collaboration scripts - a conceptual analysis. *Educational Psychology Review, 18*(2), 159-185.

Kolodner, J. L. (2002). Facilitating the Learning of Design Practices: Lessons Learned from an Inquiry into Science Education. *Journal of Industrial Teacher Education*, 39(3), 1-31.

Tergan, S.-O., & Keller, T. (Eds.). (2005). *Knowledge and Information Visualization - Searching for Synergies*. Heidelberg: Springer.

Students' Expectations and Perceptions on Instruction: The Role of Students' Behavior

Dr. Karen Könings
Maastricht University, Dept. of Educational Development and Research
P.O Bbox 616, 6200 MD Maastricht, The Netherlands
Kd.Konings@EDUC.unimaas.nl

Prof. dr. Paul A. Kirschner
Open University of the Netherlands, Centre for Learning Sciences and Technologies
P.O. Box2960, 6401 DL Heerlen, The Netherlands
Paul.Kirschner@OU.nl

Abstract. Student expectations influence perceptions of instruction, which eventually affect learning behavior. Expectations may bias perceptions related to information processing and behavioral bias (i.e., matching behavior to expectations). This study investigates how student expectations and their perceptions of interactivity relate to their behavior during training and to what extent communication behavior predicts perceptions of interaction. Participants ($N = 19$) filled in questionnaires about their expectations and perceptions on interactivity of a professionalization session. Their behaviors in the session were also videotaped and analyzed. Results show that students' expectations and perceptions are correlated with their verbosity. Expectations of trainer centeredness of the training correlate to less interactive behavior on the part of the student, while more interaction relates to higher perceptions of the participation. Especially with respect to participation, the verbosity correlates with higher perceptions, what provides evidence for a behavioral bias of expectations. Impact of the results will be discussed.

Keywords: Expectations; perceptions; interactive behavior

Introduction

How student expectations influence their perceptions of a learning environment is highly relevant because these perceptions determine their study behavior and, consequently, their performance in and effectiveness of the environment (Entwistle, 1991). Expectations can bias perceptions in three ways (Olson et al., 1996) by (1) biasing information-gathering because attention is directed towards information either consistent or inconsistent with expectations, (2) biasing information interpretation because information is likely to be interpreted in a way consistent with expectations, and (3) biasing subsequent behavior. People behave in ways consistent with their expectations (ibid). In addition to directly affecting behavior, expectations may shape the environment as people tend to behave such that way that their behavior optimally matches their expectations, and thus, they create what they expect, a phenomenon known as a self-fulfilling prophecy (Merton, 1948).

The first two forms of influence occur without directly observable activities from the student, as information processing processes are rarely visible. They could only be investigated indirectly by asking students about it. The third form of influence, however, is clearly observable in the educational setting: Students are likely to behave differently, depending on their expectations. Earlier research has shown that, students' expectations on characteristics of a learning environment relate to their later perceptions (Könings, Brand-Gruwel, van Merriënboer, & Broers, 2008). However, it is not known to what extent these relations are due to differences in information processing or to student behaviors. The current study investigates student expectations and perceptions of a training, along with their behaviors. Interactivity is chosen as main topic, since interactive behaviors are easily observed.

The first research question is: How do the participants' expectations and perceptions on interactivity relate to their interactive behaviors during the training? A second goal is to investigate whether interactive behavior predicts perceptions on interactivity, in addition to the role of expectations. Also, the role of work engagement is explored as an internal variable that may influence information processing processes.

Method

Participants were 19 secondary school teachers in a professionalization program (and are therefore called students in this study). The training session on the results of educational research that took place in their schools and its applicability in daily practice lasted two hours. The trainer presented a power-point presentation on the results of studies about student and teacher perspectives on secondary education. The trainer frequently asked questions to the students and provided ample room for discussion.

At the beginning of the session, all participants filled out a questionnaire on their expectations for the session and at the end they reported on their perceptions. The questionnaire consisted of four small inventories: (1) Student Participation Inventory ($\alpha = .96$), with items on proactivity versus passivity during the session; (2) Student Motivation Inventory ($\alpha_{T1} = .88$), on interest and motivation for the training; (3) Student Centeredness Scale ($\alpha = .82$), with items on the degree to which the training focuses on discussing their own questions and practical problems, and (4) Trainer Centeredness Scale ($\alpha = .73$), on the degree to which the trainer determines the content. Additionally, participants filled in the Utrecht Work Engagement Scale (Schaufeli & Bakker, 2003), consisting of three scales: vitality, devotion, and absorption.

During the meeting, participant-interactions were recorded by two cameras. Recordings were analyzed using Observer XT (Noldus, 2009), by coding all moments that one of the participants was talking. The coding scheme used three labels: spontaneous statement, answering a trainer question, and asking the trainer a question. Speaking time is the main measure used in the analyses. All reported results are significant at the level of $\alpha < .05$.

Results

Based on earlier research (Könings et al, 2008), we assumed that expectations and perceptions were correlated. This assumption proved true as most scales they were significantly correlated ($r_{SPI} = .47$, $r_{EMI} = .46$, $r_{TCS} = .63$), though for student centeredness the correlation was not significant.

To answer the first research question, Pearson's correlations were computed. Relating expectations and perceptions to interactive behaviors showed that expectations of trainer-centeredness correlated negatively with asking questions ($r = -.72$). Perceptions of student participation correlated positively to spontaneous contribution ($r = .53$) and total speaking time ($r = .49$). Further, using the Utrecht Work Engagement Scale, expectations of trainer centeredness correlated with higher absorption ($r = .46$); while perceptions of student centeredness correlated negatively to devotion ($r = -.56$) and absorption ($r = -.54$). Finally, perceptions on the Motivation Inventory correlated positively to both variables ($r = .60$; $r = .54$, respectively).

For the second research question, multiple regressions were conducted. In the first model, the expectation measures on the four scales were included, using a backward procedure. In the second model, the measures of communication behaviors were added (i.e., speaking time: statements, questioning, answering, total time). Finally, the subscales of the Utrecht Work Engagement Scale were added. Since there was no significant relation between expectations and perceptions on the Student Centeredness Scale this scale was excluded from the analyses. Results showed that perception scores on all scales were predicted by the expectation scores on the same scales. Especially for the Student Participation Inventory, speaking time had a substantial impact on perceptions. Accounting for speaking time on statements almost doubled the explained variance of the model. Furthermore, absorption showed to contribute to lower perceptions on participation, but higher motivation scores.

Table 1: Significant Regression Weights ($p < .05$) of Variables Predicting Perceptions.

Dependent variable	Model	R^2	*Independent variable(s)*	*B*	*SE B*	*β*
Student Participation Inventory	1	.23	Expectations on participation	.58	.27	.47
	2	.45	Speaking time: Spontaneous statements	.01	.004	.48
			Expectations on participation	.50	.24	.41
	3	.57	Speaking time: Spontaneous statements	.01	.004	.48
			Expectations on participation	.48	.21	.40
			Absorption	-.39	.19	-.36
Student Motivation Inventory	1	.22	Expectations on motivation	.72	.35	.46
	3	.43	Absorption	.75	.32	.47
Trainer Centeredness	1	.39	Expectations on trainer centeredness	.57	.18	.63

Conclusions and Discussion

This study investigates the role of students' expectations on determining behaviors and perceptions of a training. With respect to the relationship between expectations/perceptions on interactivity and interactive behaviors, expecting a trainer centered session correlates with less questioning behavior and higher absorption in work. More speaking time relates to higher perceptions on participation. Those with higher student centeredness perceptions were less devoted and less absorbed. Also, interactive behavior appears to have an added-value with respect to expectations in predicting perceptions on student participation. On the other scales this influence was less clear. This may be due to the fact that these scales were conceptually less clearly linked to concrete behavior.

This study contributes to our theoretical understanding of how students' instructional expectations influence their learning perceptions. Interactive behaviors play a clear role in predicting perceptions on participation during training. This has practical implications, since it stresses the importance of acknowledging the influence of student expectations on the way lessons take place. Additionally, it showed those with highest motivation and devotion to absorption in their work resist interaction during a professionalization session.

References

Entwistle, N. J. (1991). Approaches to learning and perceptions of the learning environment. *Higher Education, 22*, 201–204.

Könings, K. D., Brand-Gruwel, S., van Merriënboer, J. J. G., & Broers, N. (2008). Does a new learning environment come up to students' expectations? A longitudinal study. *Journal of Educational Psychology, 100*, 535-548.

Merton, R. K. (1948). The self-fulfilling prophecy. *Antioch Review, 8,*193–210.

Olson, J. M., Roese, N. J., & Zanna, M. P. (1996). Expectancies. In E. T. Higgins & A. W. Kruglanski (Eds.), *Social psychology: Handbook of basic principles* (pp. 211–238). New York: Guilford Press.

Schaufeli & Bakker (2003). *Utrechtse bevlogenheidsschaal: Handleiding* [Utrecht Work Engagement Scale: Manual]. Retrieved April 22, 2010, from http://www.schaufeli.com

Integrating Web 2.0 and Immersive Technologies during Formative Assessment Fosters Knowledge Construction

Michael Filsecker
Universität Duisburg-Essen, Forsthausweg 2, LC 21, 47058 Duisburg, Germany.
michael.filsecker@uni-due-de

Daniel T. Hickey
Indiana University CRLT, 1900 E 10th St #524, Bloomington, IN 47404, USA
dthickey@indiana.edu.

Eun Ju Kwon,
Indiana University, CRLT, 1900 E 10th St #524, Bloomington, IN 47404, USA
ejkwon@indiana.edu.

Abstract. Taiga Park, an immersive virtual world within Quest Atlantis, was designed to contextualize elementary students' socio-scientific inquiry in ecological science. Through several iterations, innovative assessments have been refined for supporting in-game students' enlistment of core ecological concepts. The present study describes a further refinement of in-game *reflection questions* and the incorporation of a *wiki* to foster collaborative knowledge construction and supporting the challenge process of drafting scientific explanations about the causes of the ecological disaster in Taiga. Video and content analysis of students' activities and artifacts together with performance assessment and external achievement items are examined.

Keywords: Wiki, immersive technologies, formative assessment, knowledge building.

Introduction

Working life requires that people communicate across space, time and culture, using different tools, mostly in ill-defined projects (Lund, Rasmussen and Smordal, 2010). In this context, full participation requires opportunistic enlistment, and meaningful application, co-construction and creation of knowledge (Lund et al., 2010). For Gee (2008), neither rich immersive environments nor overt instruction can promote this kind of knowledge. We need *post-progressive pedagogies* that combine instruction with well-designed *feedback* and *scaffolding* activities more akin to the supports for learning in commercial video games. That is, formative assessment practices. These afford different roles for the protagonists, changing the communication flow, and giving students back more agency in their learning (Bereiter & Scardamalia, 1989). The purpose of this study is to explore the degree at which a collective-oriented tool such as a wiki can provide opportunities for students' self and peer assessment, collective knowledge construction and teacher expert feedback to support students' agency, understanding of Taiga narrative and drafting of intensive-writing quest embedded in each mission of the game.

Wikis – where anyone can contribute, revise, delete and change - allowed us to initially accomplish the goal of complementing the immersive experience and agency provided by the game. This ambitious goal differs from others attempts of wiki use that seem to be less theory-driven (cf. Parker & Chao, 2007). From Lund's work on wikis (2010), we considered the relationship the tool (wiki) and the task (collective gathering information), in order to design the collective-oriented wiki activities. Formative assessment (FA) practices, as described by Black and Wiliam (2009), represent a powerful way to foster agency and collective knowledge construction among students. Consequently, our design goal was for the wiki to provide opportunities for students and teachers to engage in FA practices foor supporting learning.

Methods

The 15-hour Taiga curriculum, was designed to engage students in complex socioscientific inquiry, and help them learn ecological science concepts (e.g. Erosion and Eutrophication) (Hickey, Ingram-Goble, & Jameson, 2009). This work is based on Design-based Research (DBR), because its characteristics make it for improving innovative educational practices and retrospectively understand how an outcome was produced, expanding the notion of transfer (e.g., Lobato, 2008).

The participants were 100 sixth graders from an urban middle class elementary school, distributed in 4 periods of approximately 25 students each. The sources of data are five hours of video tape, recordings of interviews (students & teacher), students' artifacts and tests.

Quantitative results

Results show a significant improvement in the scores of both the performance assessment (Lee River) and the external, standard based test (see Table 1).

Table 1: Mean, standard deviation, t test and effect size of pre and post tests.

Assessments	Pre Mean (SD)	Post Mean (SD)	t	ES
Lee River (PA)	6.2(3.4)	13.5(6.2)	10**	1.5
External test	17.5(6.4)	20.8(7.5)	4.4**	.47

Note: **p<.001

A multivariate interaction effect between Time (pre-post) and Year (200-2010) on the learning outcomes could be found [F(1,144)=3.86, p=.051], indicating that students involved in the present design outperformed students in 2009 design. We can, therefore, conclude that our refinements – the inclusion of the wiki and the reflection questions - represent promising ideas and design strategies to further support agency and collective knowledge construction.

References

Black, P. & William, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability*, *21*(1)5, 5-31.

Bereiter, C., & Scardamalia, M. (1989). Intentional learning as a goal of instruction. In L. B. Resnick (Ed.), Knowing, learning, and instruction: Essays in honor of Robert Glaser (pp. 361-392). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Gee, J.P. (2008). Game-Like learning: an example of situated learning and implications for opportunity to learn. In Moss et al. (eds.), *Assessment, Equity, and opportunity to learn*. Cambridge University Press. 200-221.

Hickey, D. T., Ingram-Goble, A., & Jameson, E. (2009). Designing assessments and assessing designs in virtual educational environments. *Journal of Science Education Technology*, *18*(2), 187-208. 9

Hmelo-Silver, C. E., Duncan, R. G., Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist, 42*, 99-107

Lobato, J. (2008). Research methods for alternative approaches to transfer: Implications for design experiments. In A. Kelly, R. Lesh, & J. Baek (Eds.), Handbook of design research methods in education: innovations in science, technology, engineering, and mathematics learning and teaching (pp. 167-194). New York: Routledge.

Lund, A., Rasmussen, I., and Smordal, O. (2010). Joint designs for working in wikis: a case of practicing across settings and modes of work. In H. Daniels, A. Edwards, Y. Engstrom, T. Gallagher, & S. Ludvigsen (Eds.), *Activity theory in practice: Promoting learning across boundaries and agencies* (pp. 207-230). New York: Routledge.

Parker, K. R., & Chao, J. T. (2007). Wiki as a teaching Tool. Interdisciplinary Journal of Knowledge and Learning Objects, 3, 57–72.

Training Focused Processing of Explanations: How can Transfer Across Domains be Fostered?

Kirsten Berthold
Educational Psychology, Department of Psychology, University of Bielefeld
33501 Bielefeld, Germany
kirsten.berthold@uni-bielefeld.de

Lucie Faulhaber
Talia Guevara
Alexander Renkl
Educational and Developmental Psychology, Department of Psychology, University of Freiburg
79085 Freiburg, Germany
faulhaber@psychologie.uni-freiburg.de
guevara@psychologie.uni-freiburg.de
renkl@psychologie.uni-freiburg.de

Abstract. Instructional explanations are used widely, however, studies show that they often have no effects on learning outcomes. When instructional explanations are delivered recipient learners may be mentally passive leading to shallow processing which could explain the ineffectiveness of the explanations. Against this background, we developed two training interventions on focused processing regarding the central principles and concepts of explanations. In Experiment 1, a training intervention addressing focused processing in the topic of percent calculation fostered the quality of focused processing and learning outcomes in a subsequent learning environment on probability (within-domain transfer: mathematics). In Experiment 2, a training intervention on the biological topic of heredity fostered the quality of focused processing of explanations and learning outcomes in a subsequent learning environment on the mathematical topic of probability theory (between-domain transfer). These findings suggest that training interventions support transfer of focused explanation processing not only across topics but also across domains.

Keywords: Focused processing; Instructional explanations; Training intervention; Transfer

Instructional explanations are used widely, however, empirical evidence of its effectiveness is sparse with studies often reporting that no positive effects on learning outcomes are seen (for an overview, see Wittwer & Renkl, 2008). When instructional explanations are delivered recipient learners may be mentally passive leading to shallow processing which could explain the ineffectiveness of the explanations. This learner passivity might be particularly detrimental in computer-based learning environments because the instructor cannot directly monitor the processing of the explanations, as might be possible in face-to-face contact. A consequence of shallowly processing explanations is that learners do not actively integrate the new information in their own knowledge base. Moreover, Renkl and Atkinson (2007) propose that active integration of the new information is not sufficient; rather, the learners should focus on the central concepts and principles to be learned (e.g., biological rules, mathematical theorems, etc.). Based on these premises we developed computer-based training interventions to foster focused processing of explanations in a subsequent computer-based learning environment. A restriction of many training concepts, tested in other contexts, was that they employed the same type of materials in the training phase as in a subsequent learning phase (e.g., Roll, Aleven, McLaren, & Koedinger, 2006). Therefore, it would be useful to design a training intervention for focused processing of instructional explanations that could be used in a subsequent learning environment for several topics or domains. On this basis, we carried out two experiments to test the effects of training interventions on focused processing of instructional explanations on learning processes (i.e., indicator of processing of instructional explanations) and learning outcomes when later working in a learning environment including explanations on another topic without any support.

Experiment 1

In Experiment 1, the topic of the training intervention was percent calculation. The subsequent computer-based learning environment included instructional explanations on the topic of probability theory. Specifically, we addressed the following research question: Does a training intervention on focused processing of explanations on percent calculation foster focused processing of explanations and learning outcomes in a subsequent learning environment on probability theory?

Method

We addressed this research question by using an experimental design with two conditions: a) Experimental condition with training intervention; b) Control condition without training intervention. Participants were 30 female and 47 male high-school students from grade 10 of Peruvian schools. The mean age of the participants was approximately 14 years. The training intervention of the experimental condition consisted of the following main elements: 1. Learning goals. 2. Theoretical information about focused processing of instructional explanations (e. g., how to understand why a principle or concept is as it is). 3. Corresponding examples from the topic of percent calculation. 4. Demonstration of a cognitive model of how to successfully process explanations. 5. Practice. In the control condition, the learners were placed in a similar computer-based learning environment in terms of contents (percent calculation), structure (theoretical information, examples, and practice), and length (approx. 54 minutes). The topic of focused processing of explanations, however, was not touched upon. In a subsequent learning phase, learners in both conditions worked in a computer-based learning environment on probability theory. With respect to this computer-based learning environment, we assessed the quality of the focused processing of explanations by analyzing annotations the participants had written in text boxes during the learning phase. The learning outcomes were analyzed with a post-test on both procedural and conceptual knowledge.

Results

T-tests revealed that the training intervention significantly fostered the quality of the focused processing of the explanations, $t(74) = 3.29$, $p = .001$, $d = .76$, while working in the subsequent learning environment on probability theory. In addition, participants in the training intervention group outperformed their counterparts in the control group with respect to learning outcomes, $t(62) = 2.49$, $p = .004$, $d = .61$. This effect on learning outcomes was significantly mediated by the quality of focused processing, Sobel-test $z = - 2.96$, $p = .003$. Thus, the training intervention fostered learning outcomes because it effectively trained the learners in focused processing of explanations.

Experiment 2

In Experiment 1, we showed a transfer effect of the training intervention from percent calculation to probability theory. However, this transfer is limited to the domain of mathematics. It would be even more helpful if the transfer effect fostered transfer from one domain (e.g., biology) to another (e.g., mathematics). Therefore, we developed a training intervention on a topic from the domain of biology, more specifically heredity, and tested its effect on learning processes and outcomes. More specifically, we addressed the following research question: Does a training intervention of focused processing of explanations on heredity (domain: biology) foster focused processing of explanations and learning outcomes in a subsequent learning environment on probability theory (domain: mathematics)?

Method

As in Experiment 1, we addressed this research question using an experimental design with two conditions: a) Experimental condition with training intervention; b) Control condition without training

intervention. Participants were 29 female and 11 male high-school students from grades 10 and 11 of German schools. The mean age of the participants was approximately 16 years old. The training intervention and the learning environment of the control condition (both approx. 23 min.) consisted of the same elements as in Experiment 1, but addressed the biological topic of heredity and not percentage calculation. In the subsequent learning phase, the learners of both conditions worked on the slightly modified computer-based learning environment on probability theory from Experiment 1. As in Experiment 1, we assessed the quality of focused processing of explanations and learning outcomes.

Results

A *t*-test yielded evidence that the learners in the training group showed a better quality of the focused processing of the explanations while working in the subsequent learning environment on probability theory, $t(35) = 2.96$, $p = .005$, $d = .95$. With respect to learning outcomes, participants in the training group outperformed their counterparts in the control group, $F(2, 37) = 4.87$, $p = .034$, $\eta^2 = .12$ (knowledge-related learning prerequisites were included as a co-variate in an ANCOVA because they significantly predicted learning outcomes). This effect on learning outcomes was significantly mediated by the quality of focused processing while working in the learning environment on probability theory, Sobel-test $z = 2.20$, $p = .028$. Thus, the training intervention fostered learning outcomes because it effectively trained the learners with respect to focused processing of explanations.

Discussion of Experiments 1 and 2

In sum, the findings of Experiment 1 and Experiment 2 show that training interventions on focused processing regarding the central principles and concepts of explanations in one topic or domain can effectively foster learning outcomes in another topic or even another domain. The effects of the training interventions on learning outcomes were mediated by the quality of the trained focused processing. We have therefore taken a first promising step toward a training intervention that fosters transfer, not only across different topics (from percent calculation to probability theory in Experiment 1), but also across different domains (from biology to mathematics in Experiment 2). Such transfer effects after such short training phases (54 minutes in Experiment 1 and 23 minutes in Experiment 2) are unusual. Given the transfer effect from biology to mathematics, can we now claim that we have developed a training intervention that can prepare learners for focused processing of explanations in *any* domain? Certainly not, as before we can make such claims, we have to show that our training intervention produces transfer effects in other domains as well.

References

Renkl, A., & Atkinson, R. K. (2007). Interactive learning environments: Contemporary issues and trends. An introduction to the special issue. *Educational Psychology Review, 19,* 235–238.

Roll, I., Aleven, V., McLaren, B., & Koedinger, K. (2006). Designing for metacognition–Applying cognitive tutor principles to the tutoring of help seeking. *Metacognition and Learning, 2,* 125–140.

Wittwer, J., & Renkl, A. (2008). Why instructional explanations often do not work: A framework for understanding the effectiveness of instructional explanations. *Educational Psychologist, 43,* 49–64.

Two Instructional Aids to Optimize Processing of Instructional Explanations

Julian Roelle
Department of Psychology, Educational Psychology, University of Bielefeld
POB 100131, 33501 Bielefeld, Germany
julian.roelle@uni-bielefeld.de

Kirsten Berthold
Department of Psychology, Educational Psychology, University of Bielefeld
POB 100131, 33501 Bielefeld, Germany
kirsten.berthold@uni-bielefeld.de

Alexander Renkl
Department of Psychology, Educational and Developmental Psychology, University of Freiburg
Engelbergerstr. 41, 79085 Freiburg, Germany
renkl@psychologie.uni-freiburg.de

Abstract. Instructional explanations are commonly used, however, previous studies have often shown that their effects on learning outcomes are minimal. This failure of explanations may be due to mental passivity of the learners or because learners' needs are not adequately adapted to. Against this background we developed two instructional aids to optimize processing of explanations: (a) Prompts to induce a focused processing of the explanations, (b) Adaptive explanations. We tested their effects in a 2x2-factorial experimental design with the following factors: (a) Prompts for focused processing (yes vs. no) and (b) Adaptive explanations (yes vs. no). Participants were 82 psychology students. We found that adaptive explanations did not foster knowledge acquisition. Focused processing prompts did, however, enhance the acquisition of conceptual knowledge and transfer. These effects were mediated by elaborations directed to domain principles. We conclude that the processing of explanations can be optimized by introducing prompts for focused processing.

Keywords: Adaptive instructional explanations; Focused processing; Written instructional explanations

Instructional explanations are a very common means of instruction. They are explicitly designed for the specific purpose of teaching (e.g., Leinhardt & Steele, 2005) and they communicate particular contents to the learners. Despite the widespread use of instructional explanations, empirical studies often show that their effects on learning outcomes are minimal (for an overview, see Wittwer & Renkl, 2008). This failure of instructional explanations might be due to two main problems. First, often instructors do not adapt the instructional explanations to the knowledge and needs of the learners or recipients, even though findings indicate that learner-tailored explanations can support learners in acquiring new knowledge (Nückles, Wittwer, & Renkl, 2005). This effect could be a result of a more active or focused processing of the adaptive explanations, due to their higher relevance for ongoing knowledge construction processes. Second, mental passivity and a resultant shallow processing on the part of the learner could go some way in explaining the ineffectiveness of instructional explanations. This shallow processing may mean that the learners do not actively integrate the new information into their own knowledge base. A viable approach to overcoming the recipient learners' mental passivity during learning from instructional explanations was introduced by Berthold and Renkl (2010). They carried out an experiment in the domain of probability theory where instructional explanations were provided together with prompts inducing focused processing of the central concepts and principles of the explanations. The authors found that focused processing prompts fostered far transfer and conceptual knowledge. The prompts inducing focused processing were based on the "focused processing stance" proposed by Renkl and Atkinson (2007), which assumes that actively processing the learning contents is not sufficient. Rather, the attention of the learners should be focused on the central domain principles and concepts to be learned. The empirical evidence supporting the approach

introduced by Berthold and Renkl (2010) exclusively stems from experiments conducted in well-structured domains (e.g., mathematics). Therefore, the question remains open as to whether this approach also fosters learning outcomes in ill-structured domains. In two recent reviews, adaptation of instructional explanations (Wittwer, Nückles, & Renkl, 2010) and prompts inducing focused processing (Berthold & Renkl, 2010) were discussed as instructional aids that can foster learning from instructional explanations. Possible additive effects or interactions of these two instructional aids to optimize processing of instructional explanations are still to be explored in a computer-based learning environment.

Against this background we implemented instructional explanations on the ill-structured domain of management theory. This was carried out in a computer based learning environment. The following research questions were addressed:

1. Does the provision of prompts relating to focused processing foster learning outcomes?
2. Does the provision of adaptive explanations foster learning outcomes?
3. Do the provision of prompts relating to focused processing and the provision of adaptive explanations have additive effects or do they interact with respect to learning outcomes?

In addition to these questions, we were interested in the effects of the two types of instructional assistance on learning processes (i.e., processing the explanations).

Method

We addressed these research questions in a 2x2-factorial experimental design with the following factors: (a) Prompts to induce focused processing (yes vs. no) and (b) Adaptive explanations (yes vs. no). Participants were 82 undergraduate psychology students. In a computer-based learning environment (domain: management theory; specific topics: scientific management and socio-technical systems) instructional explanations were presented in four instructional units. Focused processing was induced by presenting specific prompts which learners were required to answer in a written format. After each unit the learners' understanding of the particular contents was tested. Afterwards, in the conditions with adaptive explanations the learners were provided with explanations intended to remedy their specific comprehension difficulties. These comprehension difficulties were assessed whilst the learners worked on the instructional unit. The learners in the conditions without adaptive explanations were provided with explanations that were chosen at random. We assessed the quality of the processing of the explanations by analyzing the annotations the learners were required to type in text boxes during the learning phase. The learning outcomes were assessed with a post-test on both conceptual knowledge and transfer.

Results

To address the research questions, we employed 2x2-factorial ANOVAs. We found significant main effects of the focused processing prompts on transfer, $F(1, 78) = 16.93$, $p < .001$, $\eta^2 = .17$, and conceptual knowledge, $F(1, 78) = 8.44$, $p = .005$, $\eta^2 = .09$. We found, however, that the provision of adaptive explanations fostered neither transfer, $F < 1$, nor conceptual knowledge, $F(1, 78) = 1.31$, $p = .257$. We did not find significant interactions between prompts and adaptive explanations with respect to transfer and the acquisition of conceptual knowledge, both $Fs < 1$. Further analyses were carried out on the annotations the learners were required to type in text boxes during the learning phase. These showed that the focused processing prompts fostered elaborations that focused on domain principles and concepts, $F(1, 77) = 108.79$, $p < .001$, $\eta^2 = .58$. Additionally, mediation analyses revealed that whilst learners worked within the learning environment, elaborations that focused on domain principles and concepts significantly mediated the effects on transfer, Sobel-test $z = 2.83$, $p = .005$ and conceptual knowledge, Sobel-test $z = 2.29$, $p = .022$.

Discussion

We found that prompts to induce focused processing fostered transfer and conceptual knowledge in the domain of management theory. This effect was mediated by elaborations focussing on domain principles and concepts. No effects on learning outcomes were found for the provision of adaptive explanations. This could partially be explained by shortcomings of the adaptation mechanism and the design of the adaptive explanations. Further analysis suggested that these adaptive explanations did not only remedy comprehension difficulties of the learners who lacked the knowledge that should have been provided by the respective adaptive explanations but also enhanced the performance of learners when they were chosen at random. Thus, the learners in the groups without adaptive explanations who were provided with randomly chosen explanations also benefited from these explanations. These findings imply two conclusions with respect to instructional design:

1. Evidently, focused processing prompts do not only foster processing instructional explanations and learning outcomes in well-structured domains such as mathematics but also in ill-structured domains such as management theory.

2. Elaborations on domain principles and concepts appear to be an important mediator of the effects of focused processing prompts on learning outcomes across different domains (see also Berthold & Renkl, 2010). Thus, instructional features of learning environments should elicit these processes in computer-based learning environments.

References

Berthold, K., & Renkl, A. (2010). How to foster active processing of explanations in instructional communication. *Educational Psychology Review, 22,* 25-40. doi: 10.1007/s10648-010-9124-9.

Leinhardt, G., & Steele, M. D. (2005). Seeing the complexity of standing to the side: Instructional dialogues. *Cognition and Instruction, 23*(1), 87-163.

Nückles, M., Wittwer, J., & Renkl, A. (2005). Information about a layperson's knowledge supports experts in giving effective and efficient online advice to laypersons. *Journal of Experimental Psychology: Applied, 11*(4), 219-236.

Renkl, A., & Atkinson, R. K. (2007). Interactive learning environments: Contemporary issues and trends. An introduction to the special issue. *Educational Psychology Review, 19*, 235-238.

Wittwer, J., Nückles, M., & Renkl, A. (2010). Using a diagnosis-based approach to individualize instructional explanations in computer-mediated communication. *Educational Psychology Review, 22*, 9-23. doi: 10.1007/s10648-010-9118-7.

Wittwer, J., & Renkl, A. (2008). Why instructional explanations often do not work: A framework for understanding the effectiveness of instructional explanations. *Educational Psychologist, 43*, 49-64.

Eye Movement Modeling Examples in Medical Education

*H. Jarodzka[1,2]**
T. Balslev[3]
K. Holmqvist[4]
K. Scheiter[2]
M. Nyström[4]
P. Gerjets[2]
B. Eika[5]
[1]Open University of the Netherlands, [2] Knowledge Media Research Center, Germany; [3]Viborg Hospital, Pediatrics Department, Denmark;
[4]Lund University, Sweden; [5]Aarhus University, Center of Medical Education, Denmark
**Halszka.Jarodzka@ou.nl*

Abstract. Perceptually demanding tasks, like diagnosing seizures based on patient video cases, not only require the acquisition of conceptual but also of perceptual skills; like visually searching and interpreting relevant features. Showing the eye movements of a didactically behaving expert conveyed perceptual skills in a perceptually demanding, but conceptually simple task. The current study applied this method to medical education – a conceptually complex task – by example videos, which were verbally explained by an expert. In addition the experimental groups saw a display of the expert's eye movements recorded, while he performed the task. Results show that blurring non-attended areas of the expert guides the attention of the students during example study, leads to enhanced visual search and interpretation of relevant features in contrast to displaying attended areas as a circle and to a control group without attention guidance. Thus, spotlight attention guidance fosters learning of perceptual skills in medical diagnosis.

Keywords: eye tracking; instructional design; example-based learning; medical education.

Medical diagnosis often requires to detect diseases that manifest in occasionally occurring behavioral patterns, like seizures, and thus is very difficult on a perceptual level: It is crucial to recognize the important features relevant for the diagnosis, which, however, might be short-term, subtle, time-sensitive, and not salient compared to other features. This ability was referred to as perceptual skills (e.g., Manning, Gale, & Krupinski, 2005). In medical education diagnosing such diseases is often taught by the use of so called patient videos cases (PVC), where patients are taped on video while displaying behavior that is suspected to be diseased. Medical students, however, show severe difficulties when diagnosing based on those videos, in particular on a perceptual level (Balslev et al., in prep.). Thus, this study aimed conveying perceptual skills in medical diagnosis.

Perceptual skills may be conveyed via eye movement modeling examples (EMME; Jarodzka, Van Gog, Dorr, Scheiter, & Gerjets, in preparation; Van Gog, Jarodzka, Scheiter, Gerjets, & Paas, 2009). EMME base on example-based learning (Sweller, Van Merriënboer, & Paas, 1998) and cognitive modeling research (Collins, Brown, & Newman, 1989). To learn from examples students must attend to the relevant features at the right time (Bandura, 1977), which is unlikely for novices in perceptually demanding PVCs (cf. eye tracking research in other comparably complex domains: Canham & Hegarty, 2010; Jarodzka et al., 2010; Underwood, Chapman, Brocklehurst, Underwood, & Crundall, 2003). Thus, novices need attention guidance. One common form of attention guidance in instructional design is cueing. Research on cueing, however, (for a review: de Koning, Tabbers, Rikers, & Paas, 2009) has either highlighted features in an unclear manner and thus, with diverse success, or, when based on experts' gazes, it concerned insight problem solving of one task, instead of learning (Grant & Spivey, 2003). Contrarily, EMME guide attention using expert's pre-recorded gazes and verbal explanations during task performance, which are replayed to students as videos, and enhance learning (Jarodzka et al., in preparation).

An important question is how to design the display of the expert's eye movements. Displaying gazes directly has shown impose high cognitive demands onto learners (Van Gog et al., 2009). On the other hand, it has also shown to increase the ability to interpret relevant features (Jarodzka et al., in preparation). Blurring non-attended areas instead has shown to foster visual search (Jarodzka et al., in preparation) and has a high viewer acceptance (Nyström & Holmqvist, 2007). Thus, no design has yet proven to be superior.

The here presented study applied EMME to medical education in the example of pediatric neurology (epileptic seizures). In that, the crucial perceptual skills are to visually detect the relevant features of the infant patient from other random behavior and to interpret it correctly based on PVCs. We recorded a didactically behaving expert pediatrician's eye movements and verbal explanations while he was diagnosing two patients taped on video. The eye movements were either displayed as circles, which allow for looking through them, or as a very subtle spotlight display, which still allowed for a holistic overview over the entire scene.

Method

Participants and Design

Participants were 60 medical students in their final year of the University of Aarhus (age: M = 26.57 years, SD = 2.03; 41 female), who had no prior knowledge on the task and had normal or corrected-to normal vision. They had been randomly assigned to one of three conditions (n = 20 each): (1) control condition with no attentional guidance, (2) attentional guidance by a circle on fixated areas based on the model's eye movements (circle display), (3) attentional guidance by blurring non-attended areas and leaving fixated areas sharply displayed (spotlight display).

Procedure

The recording ran in individual sessions of approximately 30 minutes each. In the learning phase, participants studied two PVCs that were explained by an expert. Depending on the condition the PVCs included an overlay of the expert's eye movements. Participants studied these PVCs while their eye movements were recorded. In the testing phase, participants watched three novel PVCs while their eye movements were recorded. After each PVC participants had to answer multiple-choice questions on those PVCs that are crucial for diagnosis: (1) body parts, which were moving, (2) indicating the type of the movement, (3) indicating, whether the face was involved and whether or not this was important for the diagnosis, (4) indicating, whether touching the child would change the movement, and (5) indicating the level of consciousness of the infant.

Results

Results show that the spotlight display guides the attention of the medical students during example study significantly stronger compared to the other two conditions ($F(2,59)=3.60$, $p=.03$). Moreover, when studying the novel patient videos cases, medical students of the spotlight condition looked longer on features relevant for diagnosis ($F(2,59)=3.64$, $p=0.3$) and they interpreted those features more correctly ($F(1,59)=4.71$, $p=.01$) compared to the other two condition.

Discussion

These findings show that guiding students' attention during studying modeling examples based on an expert's attention allocation may foster learning of perceptual skills in medical diagnosis in the example of patient video cases of epileptic seizures if implemented in a subtle spotlight manner. These results show the need to take perceptual skills into account, when considering education of medical diagnosis based on medical images. Moreover, the EMME approach seems to be a reasonable way to

address this need. The question is, whether it may also be used for other medical images. So far, we have only considered dynamic, realistic scenes (i.e., videos). However, there is a large body of novel medical images that are very likely to present medical students with problems in terms of perceptual skills. These medical images are often artificial animations or a combination of static pictures. Further research should investigate, which features of medical images are problematic for students on a perceptual level and whether EMME might foster the necessary perceptual skills.

References

Balslev, T., Jarodzka, H., Holmqvist, K., de Grave, W. S., Muijtjens, A., Eika, B., et al. (in prep.). The influence of experience and training on attention and clinical reasoning in pediatrics.

Bandura, A. (1977). *Social learning theory*. Englewood Cliffs, NJ: Prentice-Hall.

Canham, M., & Hegarty, M. (2010). Effects of knowledge and display design on comprehension of complex graphics. *Learning and Instruction, 20,* 155-166.

Collins, A. F., Brown, J. S., & Newman, S. E. (1989). Cognitive apprenticeship: Teaching the craft of reading, writing, and mathematics. In L. B. Resnick (Ed.), *Cognition and instruction: Issues and Agendas* (p. 453–494). Mahwah, NJ: Erlbaum.

Grant, E. R., & Spivey, M. J. (2003). Eye movements and problem solving: Guiding attention guides tought. *Psychological Science, 14,* 462-466.

Jarodzka, H., Van Gog, T., Dorr, M., Scheiter, K., & Gerjets, P. (in prep.). Guiding attentions guides thought, but what about learning? Eye movements in modeling examples.

De Koning, B. B., Tabbers, H. K., Rikers, R. M. J. P., & Paas, F. (2009). Towards a framework for attention cueing in instructional animations: Guidelines for research and design. *Educational Psychology Review, 21,* 113-140.

Manning, D. J., Gale, A., & Krupinski, E. A. (2005). Perception research in medical imaging. *The British Journal of Radiology, 78,* 683-685.

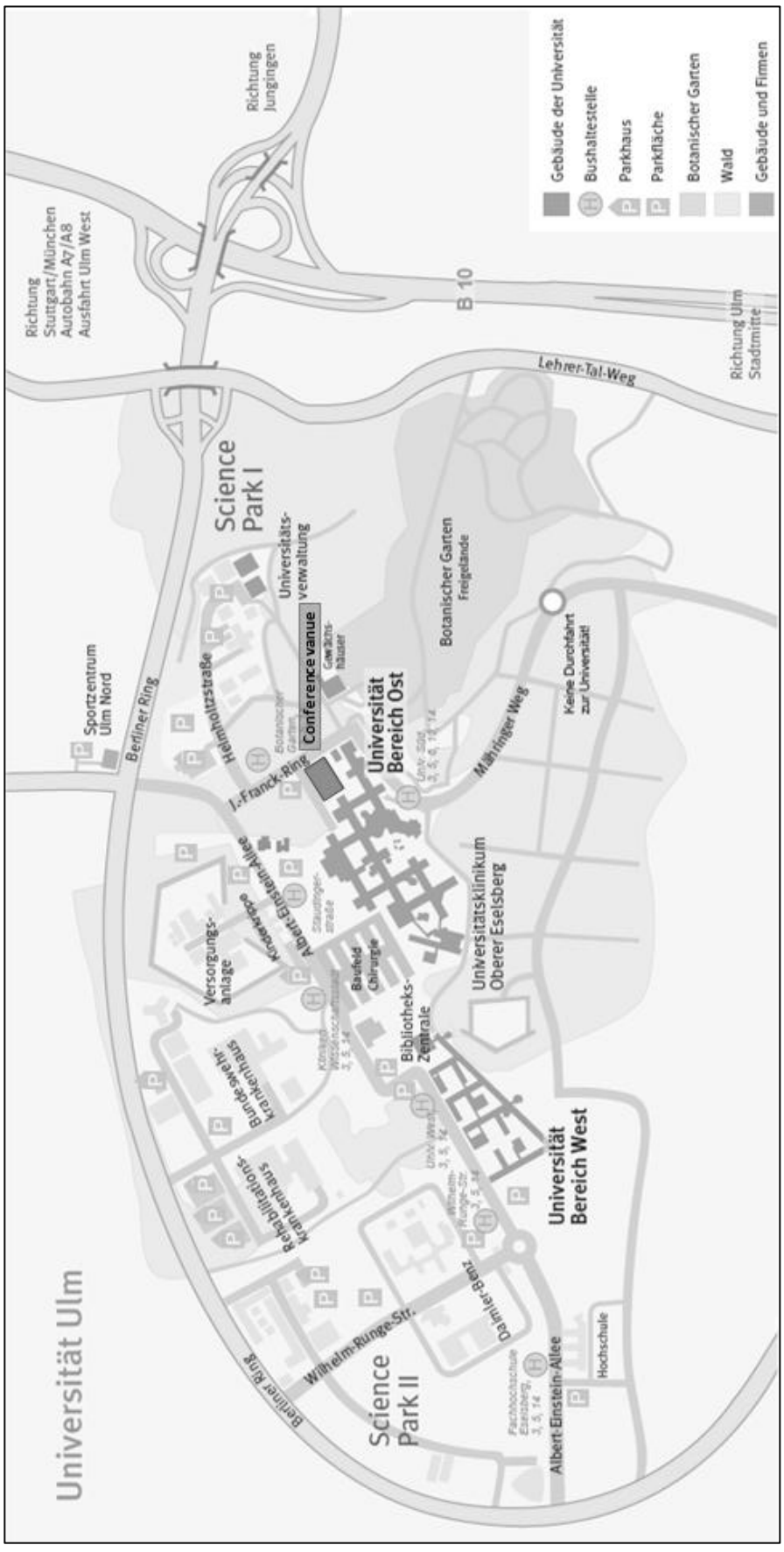
Nyström, M., & Holmqvist, K. (2007). Deriving and evaluating eye-tracking controlled volumes of interest for variable-resolution video compression, *Journal of Electronic Imaging, 16,* 013006.

Sweller, J., Van Merriënboer, J. J. G., & Paas, F. (1998). Cognitive architecture and instructional design. *Educational Psychological Review, 10,* 251-296.

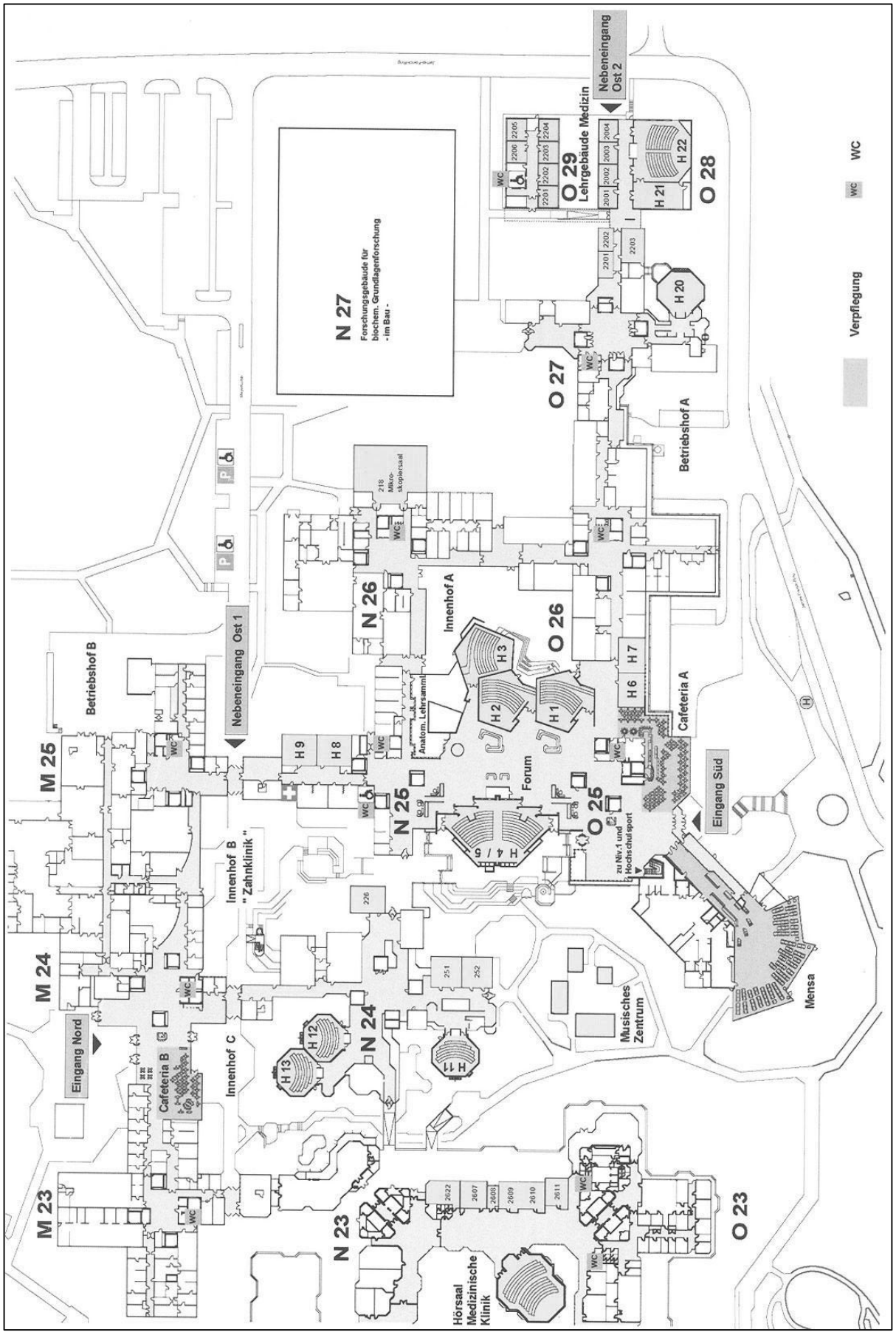
Underwood, G., Chapman, P., Brocklehurst, N., Underwood, J., & Crundall, D. (2003). Visual attention while driving: Sequences of eye fixations made by experienced and novice drivers. *Ergonomics, 46,* 629-646.

Van Gog, T., Jarodzka, H., Scheiter, K., Gerjets, P., & Paas, F. (2009). Attention guidance during example study via the model's eye movements. *Computers in Human Behavior, 25,* 785-791.

Ulm University



Ulm University: eastern district



List of presenters

Ayres	Paul	University of New South Wales	Australia
Baadte	Christiane	University of Koblenz-Landau	Germany
Baars	Martine	Erasmus University Rotterdam	The Netherlands
Baetge	Ingmar	University of Ulm	Germany
Berthold	Kirsten	University of Bielefeld	Germany
Brahm	Taiga	University of St. Gallen	Switzerland
Bruneel	Steven	Katholieke Universiteit Leuven	Belgium
Cattaneo	Alberto	Swiss Federal Institute for Vocational Education and Training (SFIVET)	Switzerland
Coens	Joke	Katholieke Universiteit Leuven	Belgium
Damsa	Crina	InterMedia, University of Oslo	Norway
Deimann	Markus	FernUniversitaet in Hagen	Germany
El-Refai	Walid	Ludwig-Maximilians-University (LMU) München	Germany
Escofet	Anna	University of Barcelona	Spain
Filsecker Wagner	Michael K.	Duisburg-Essen University	Germany
Fund	Zvia	School of Education, Bar-Ilan University	Israel
García	Victoria	University of Valencia	Spain
Glogger	Inga	University of Freiburg	Germany
Grell	Petra	University of Potsdam	Germany
Hauss	Cornelia	University of Education Freiburg	Germany
Hettmannsperger	Rosa	University of Koblenz-Landau	Germany
Hickey	Dan	Indiana University	USA
Hofmann	Lena	Ludwig-Maximilians-University (LMU) München	Germany
Jarodzka	Halszka	Knowledge Media Research Center Tübingen	Germany
Jiang	Lai	Katholieke Universiteit Leuven	Belgium
Juarez Collazo	Norma Araceli	Katholieke Universiteit Leuven	Belgium
Kämmerer	Frauke	University of Erfurt	Germany
Kammerer	Yvonne	Knowledge Media Research Center Tübingen	Germany
Kapp	Felix	Dresden University of Technology	Germany
Kennedy-Clark	Shannon	University of Sydney	Australia
Kicken	Wendy	Open University of the Netherlands	The Netherlands

Kollar	Ingo	Ludwig-Maximilians-University (LMU) München	Germany
Könings	Karen	Maastricht University	The Netherlands
Kopp	Birgitta	Ludwig-Maximilians-University (LMU) München	Germany
Ligorio	Maria Beatrice	University of Bari	Italy
Lust	Griet	Katholieke Universiteit Leuven	Belgium
Magner	Ulrike	University of Freiburg	Germany
Matteucci	Maria Cristina	University of Bologna	Italy
Merkt	Martin	University of Tübingen	Germany
Nistor	Nicolae	Ludwig-Maximilians-University (LMU) München	Germany
Opfermann	Maria	Duisburg-Essen University	Germany
Otieno	Christine	University of Freiburg	Germany
Park	Babette	Saarland University	Germany
Rau	Martina A.	HCII Carnegie Mellon University	USA
Reisenhofer	Birgit	University of Salzburg	Austria
Rey	Günter Daniel	Julius-Maximilians-University Würzburg	Germany
Roelle	Julian	University of Bielefeld	Germany
Salmerón	Ladislao	University of Valencia	Spain
Schoor	Cornelia	Dresden University of Technology	Germany
Schrangl	Gerhard	University of Salzburg	Austria
Schwonke	Rolf	University of Freiburg	Germany
Seufert	Sabine	University of St.Gallen	Switzerland
Spanjers	Ingrid A. E.	Maastricht University	The Netherlands
Stalbovs	Kim	University of Tübingen	Germany
Svirko	Elena	University of Oxford	UK
Taxis	Silja-Susann	University of Ulm	Germany
Tulis	Maria	University Bayreuth	Germany
van Gog	Tamara	Erasmus University Rotterdam	The Netherlands
van Meeuwen	Ludo	Open Universiteit in The Netherlands	The Netherlands
Vandercruysse	Sylke	Katholieke Universiteit Leuven	Belgium
Vandewaetere	Mieke	Katholieke Universiteit Leuven	Belgium
Vogel	Markus	University of Education Heidelberg	Germany
Wagner	Felix	University of Ulm	Germany
Wichmann	Astrid	Ruhr University Bochum	Germany
Wu	Xiaoli	Katholieke Universiteit Leuven	Belgium
Zottmann	Jan	Ludwig-Maximilians-University (LMU) München	Germany
Zumbach	Joerg	University of Salzburg	Austria