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An Aptitude-Treatment-Interaction-Approach on Motivation and Student's Self-Regulated Multimedia-Based Learning

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Summary

The goal of this study was to develop the research basics for identifying individual differences in multimedia learning and motivation. Within this study, the effects of implementing motivational design of instruction within multimedia-based learning were tested. Motivational design of instruction was related to the ARCS-model and resulted in using instructional strategies for increasing attention and relevance of the learning material. In addition, an aptitude-treatment-interaction (ATI)-approach was developed which connected motivational design of instruction to mental resources management, motivational processing, pre-motivation, motivation to learn, and knowledge acquisition. For testing the theoretical assumptions, there were four types of a multimedia-based instructional system implemented: One instructional system had no ARCS strategies, one had attention strategies, another had relevance strategies, and one finally had both attention and relevance strategies. Four groups of elementary school students (n = 68) had to learn with the different instructional systems. The effects of learning with these instructional systems were measured on motivation to learn and on knowledge acquisition. Pre-motivation (outcome-valences), pre-knowledge, and cognitive load represented aptitude- and process-variables. Results indicated that a combination of both attention and relevance strategies improved motivation to learn, especially for those students with low levels of pre-motivation. Pre-knowledge increased and cognitive load decreased knowledge acquisition. Finally, open research questions and methodological aspects are outlined. In addition, suggestions for the design of instructional multimedia are given.

Keywords: motivational design of instruction, web-based training, multimedia, self-regulation, complex trait-treatment-interaction

Introduction

Within instructional psychology, there is a common goal to find instructional (training) procedures that result in overall improvement on learning and in the reduction of individual differences in abilities. The combinations of these approaches, first proposed by Cronbach (1957) as the study of aptitude-treatment-interaction (ATI), represent the search for treatments that are adapted to individual differences in aptitudes, that is, treatments that are optimally effective for students of different aptitude levels (see Caspi & Bell, 2004, for a recent integration of the ATI method). In the field of research on instructional multimedia, ATI plays a major role within delivering the basics for the development of “adaptive instructional systems” (Park & Lee, 2003; Shute & Towle, 2003). Instructional multimedia represents a special type of computer-based database system, in which objects (text, pictures, videos, animations, sound, etc.) are linked to each other and used for learning purposes. The aim is to tailor instruction on a micro level by diagnosing the student's specific learning needs during or before instruction and providing instructional strategies for the needs. The degree of adaptation is determined by how sensitive the diagnostic procedure is to the specific learning needs of each student. The instructional strategies can be made the more sensitive when knowledge from research is available which indicates what instructional strategy should be used for what kind of learner.

Related and combined ATI- and instructional multimedia-research was published mainly for cognitive aspects of learning, neglecting to a large degree motivational processes and influences on learning (e.g., Lai, 2001; Leutner, 1992; Lin, Liu, & Yuan, 2001; McInerney, McInerney, & Marsh, 1997; McManus, 2000). Most of ATI- and instructional multimedia-research which focused on motivation, however, did not relate to a sophisticated model of motivational design of instruction (e.g., Astleitner, 1997; Martens, Gulikers, & Bastiaens, 2004; Zumbach & Reimann, 2001). Only such a model can build comprehensively the bases for “motivationally adaptive multimedia-based instruction” (Astleitner & Keller, 1995).

The ARCS-Model for Motivational Multimedia Design and Indications of ATIs

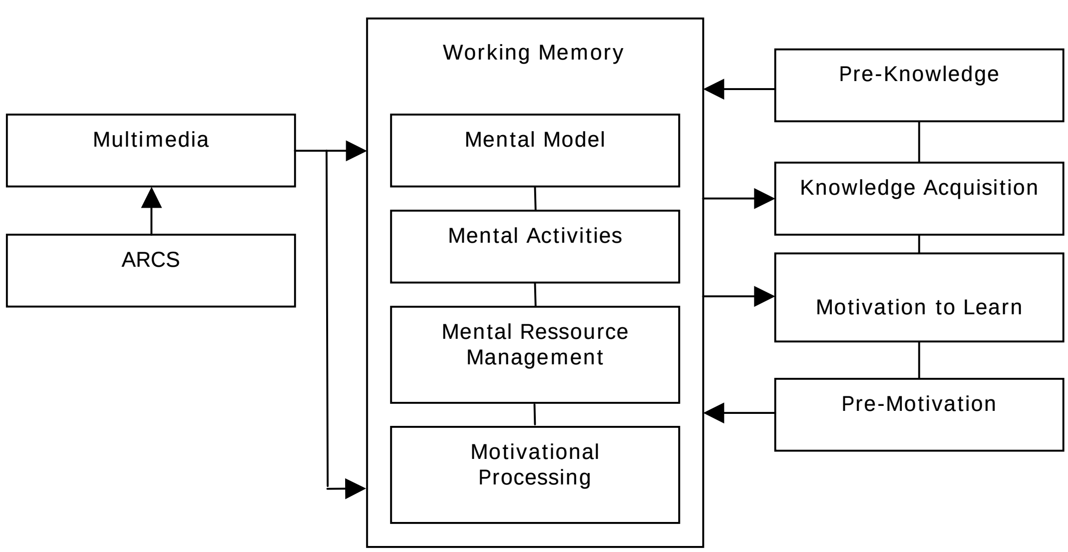
The ARCS-model from Keller (1997) represents an instructional model, which can influence motivational processes during multimedia-based instruction in a comprehensive and effective way. It assumes that strategies embedded in instructional materials can enhance the learner's attention (by perceptual and inquiry arousal, or variability), and perceptions of relevance (by familiarity, goal orientation, or motive matching), confidence (by influencing expectancy for success, challenge setting, or attribution molding), and satisfaction (by natural and positive consequences, or equity) about learning, what in turn enhances cognitive performance (see ARCS-strategies for instructional multimedia in Keller & Suzuki, 1988).

Shellnut, Knowlton, and Savage (1999) applied the ARCS-model to the design of computer-based modules. Evaluators found the ARCS-model effective in motivating learners, however pointed out, that more focus should be given to dynamic learner interactions, in particular to motivationally relevant personality characteristics. Song and Keller (2001) found that motivationally adaptive computer-assisted instruction was superior to motivationally not adaptive instruction for the enhancement of overall motivation and attention. Within motivationally adaptive instruction, students received motivation enhancing strategies only when they indicated motivational deficits on embedded surveys. In a study from Chang and Lehman (2002), video sequences were implemented in multimedia web-lectures and designed by using relevance-strategies from the ARCS-model. Results showed that students who used the enhanced relevance version had significantly higher perceptions of motivation and scored higher on a comprehension test. The authors stressed the importance to adapt relevance-strategies to the needs of learners. Astleitner and Hufnagl (2003) examined the effects of a prototype of a motivationally designed multimedia web-lecture on motivation and learning. Results showed that the ARCS-strategies led to higher perceived success estimates, higher general motivation, and better knowledge acquisition, but only for those students with motivationally advantageous expectancies (i.e., low situation-outcome-expectancies). Students with motivationally disadvantageous expectations did not profit from ARCS-strategies. Overall, there are indications that ARCS-strategies varied in their effects for different types of learners or aptitude-variables. However, those variations and indications of ATI are highly general, theoretically unspecified, not replicated by experimental studies, and must be anchored within a theoretical approach of multimedia learning and motivation.

An Approach of Multimedia Learning, Motivation, and ATI

Astleitner and Wiesner (2004) presented a theory of multimedia learning and motivation which is related to the prominent cognitive approach from Mayer (2001). The two theories of cognitive and motivational multimedia learning by Mayer (2001) and by Astleitner and Wiesner (2004) can be integrated into an approach of multimedia learning, motivation, and ATI (see Figure 1). This approach represents a framework for analyzing hypotheses which are integrated within ATI-related research in order to find and realize effective adaptive multimedia-based instruction.

Figure 1. ARCS, multimedia, and a theory of multimedia learning and motivation (modified from Astleitner & Wiesner (2004) and Mayer (2001, p. 44)).



Within this approach, it is assumed that there are mental resources management and motivational processing influencing Mayer´s (2001) mental activities (i.e., selection, organization, and integration of knowledge) and mental models (i.e., verbal and pictorial). All mental activities and processes are carried out within a working memory, and are related to long-term knowledge acquisition, i.e., learning, and are influenced by pre-knowledge. The working memory is the part of our cognitive architecture in which information, that is undergoing active processing, is held. Motivational processing, which is also situated within working memory, is related to pre-motivation and results in the motivation to learn. Mental activities depend on mental resources management which itself is influenced by motivational processing. Mental resources management is related to attention, engagement, and monitoring. Motivational processing consists of goal setting and action control. Attention represents the capacity of the working memory that is devoted to a certain task within a given period of time. Engagement concerns the number of mental activities in relation to a certain task within a given period of time. Monitoring has the function of changing attention and engagement based on standard-related evaluations of the success of mental activities in relation to a certain task within a given period of time. Goal setting concerns thinking about the expectancies and values related to a certain task and selecting that task for carrying out which shows the most favourable combinations of expectancies and values. Action control can shield an actually given intention (for fulfilling a certain goal and the corresponding task) from alternative intentions.

ATI-effects can be integrated within this approach by assuming interactions between ARCS-strategies and pre-knowledge or pre-motivation on learning and motivation to learn. Based on this approach, it is assumed that ARCS-strategies have different effects on learning and motivation to learn when different aptitudes (pre-motivation and pre-knowledge) are considered. These effects are for the decrease of prior given differences (compensation) or for the increase of prior given differences (polarisation):

a) Compensation: Learners with low pre-motivation should - in comparison to learners with high pre-motivation - profit the most from ARCS-strategies in respect to the motivation to learn. Also, learners with low pre-knowledge should profit more from ARCS-strategies for learning than learners with high pre-knowledge. Results of studies from Chang and Lehman (2002), Shellnut, Knowlton, and Savage (1999), or Song and Keller (2001) favor this compensation effect.

b) Polarisation: Learners with high pre-knowledge or high pre-motivation profit the most from ARCS-strategies, because these strategies deliver additional information about the learning process that can better be processed by advanced learners. Other learners might not have enough pre-motivation or pre-knowledge to work with the ARCS-strategies, which might increase cognitive load of the learners, effectively. The study from Astleitner and Hufnagl (2003) represents evidence for a polarisation effect.

However, compensation and polarisation could change in relation to different dependent variables or to time. ARCS-strategies could be “seductive details”, i.e., interesting, but irrelevant adjuncts in instructional materials, distract a learner or disrupt the coherence of a learning process (Harp & Mayer, 1997, 1998): ARCS-strategies might increase motivation, but decrease learning by taking the learner's selective attention away from important information (distraction hypothesis), by interrupting the transition from one main idea to the next (disruption hypothesis), and by building a coherent mental representation but not of structurally important ideas (diversion hypothesis). Also, Astleitner and Lintner (2004) found negative ARCS-effects on learning (with instructional texts) when considering short time knowledge acquisition. In the long run, however, ARCS-strategies had positive effects on knowledge acquisition. The negative results at a first test were attributed to the fact that an instructional material with ARCS-strategies took more time for learning, because implementing the ARCS-strategies increased the length of the instructional material by about 5 percent.

Goals and hypotheses

The goal of this study was to develop the research basics for identifying individual differences in motivational multimedia design. In order to achieve this goal, in a first step, a suitable approach of motivational multimedia design was selected (i.e., the ARCS-approach). Then, this approach was connected to an ATI-point of view in order to integrate systematically individual differences. Finally, theoretical assumptions related to this integration were tested within a controlled experiment in order to get first evidence about the relevance of the theoretical background. With this test, procedures, instruments, and measurements, which can be used in further studies, were developed.

Within this study, based on the presented model and on related evidence, the effects of ARCS-strategies (treatment) on motivation to learn and knowledge acquisition (dependent variables) were tested. As aptitude-variables, pre-motivation and pre-knowledge were considered. Also, cognitive load was measured as indicator of working memory activities. Cognitive load was also seen as a process-variable which can be treated as a covariable. It is defined as the number of elements that the learner must attend to simultaneously to understand the learning material (intrinsic load), as mental activities that contribute directly to learning (germane load), and as mental activities during learning that do not contribute directly to learning (extraneous load) (e.g., Renkl & Atkinson, 2003). The ARCS-strategies were implemented within an instructional multimedia system dealing with physics and chemistry. There were four different versions of the instructional multimedia system. A first version contained no ARCS-strategies, a second version had attention-related strategies and a third version included relevance-related strategies. A fourth version had both attention- and relevance-strategies. These four types of the instructional multimedia systems represented three levels of ARCS-implementation: low (first version), medium (second and third version), and high (fourth version).

It was expected, in general, that a high level of ARCS-implementation will have stronger effects on motivation to learn and on knowledge acquisition than a low level of implementation. It was - based on research from Means, Jonassen, and Dwyer (1997) - also expected that the version with relevance-strategies would have stronger effects than the version with attention-strategies. As, within the presented model, ARCS-strategies are primarily related to motivational processes, there should be stronger effects on motivation to learn in comparison to knowledge acquisition. However, as cognitive processes are assumed to be influenced by motivational processes, there should also be effects from ARCS-strategies on knowledge acquisition.

In respect to aptitude-variables, it was expected, that pre-knowledge and cognitive load would have an ATI-effect together with the ARCS-strategies on knowledge acquisition. It was also expected that pre-motivation should interact with ARCS-strategies on motivation to learn. As reported evidence is stronger for the compensation effect of ARCS-strategies, learners with low pre-knowledge, low cognitive load, and low pre-motivation should profit more from ARCS-strategies than learners with high levels of these variables. The benefit of low cognitive load for learning in multimedia-based learning was demonstrated repeatedly (see Mayer & Moreno, 2003). ATI-effects with cognitive load were reported, for example, by Lajoie (2003).

Method

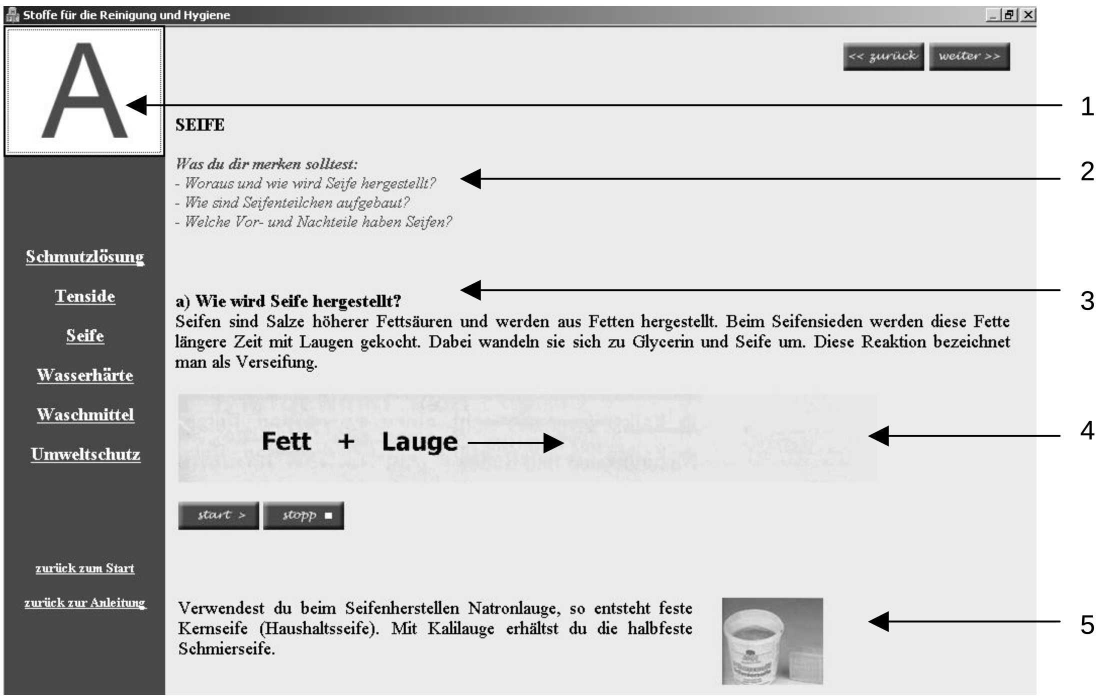
Participants, Design, and Procedures. Forty-six male and twenty-two female 8th grade students with an average age of 14 years participated in this experiment. All students attended an elementary school and were assigned to the experimental conditions randomly.

The experiment was based on a one-factorial-covariance-analytic design. As experimental condition, the motivational design of the instructional multimedia system was manipulated. One fourth of the students (control group, n = 17) was presented an instructional multimedia system without ARCS-strategies. A second group of the students (experimental group 1, n = 17) got the same instructional multimedia system with attention strategies; a third group (experimental group 2, n = 17) with relevance strategies; and a fourth group (experimental group 3, n = 17) with both attention and relevance strategies. Pre-knowledge, pre-motivation, and cognitive load served as covariables. As dependent variables, knowledge acquisition and motivation to learn were measured. As the two dependent variables were not correlated significantly (r = -.01, p > .10), two univariate analysis of covariance were computed, using the General Linear Model (Winer, Brown, & Michels, 1991, p. 739).

At the beginning of the experiment, the subjects were informed about their task (learning with an instructional multimedia system) and the duration of the experiment, i.e., about 50 minutes. Then they had to complete a questionnaire including general questions (age, sex, achievements in physics and chemistry, pre-knowledge, and pre-motivation). After that, they were told to learn as much as possible about the content of the instructional multimedia system, i.e., chemical and physical aspects of water, cleaning, and environmental protection. Participants were informed that, for measuring cognitive load during learning, the space bar had to be pressed when a large letter on the upper left side of the screen changed its color. Learning with the instructional multimedia system took about 45 minutes. After a short break, students had to answer questions concerning motivation to learn and knowledge acquisition. The whole experiment took place in a room with personal computers. Students wore headphones and used a mouse-device for navigating the instructional multimedia system.

Materials and Instruments. The instructional multimedia system was programmed by the co-author of the study using Dreamweaver- and Visual C-software on a standard PC. The content of the instructional multimedia system was based on textbooks for 8th grade students (e.g., Kaufmann & Zöchling, 2003). The first version of the instructional multimedia system (without ARCS) contained 12 screen pages, the second version with attention-strategies 16, the third version with relevance-strategies 15, and the fourth version with both types of strategies had also 16 pages. Figure 2 shows one example page from the fourth version with two kinds of ARCS-strategies for increasing attention and relevance.

Figure 2. Sample screenshot of the instructional multimedia system with features for measuring cognitive load and for implementing attention- and relevance-strategies.



1 = Feature for measuring cognitive load
2 = Relevance feature: Goal Orientation: Teaching objective
3 = Attention feature: Inquiry arousal: Questions
4 = Attention feature: Variability: Animation (of text)
5 = Relevance feature: Familiarity: Personal language

Pre-knowledge was measured with five questions about the content of the instructional multimedia system resulting in 0 to 8 points overall (M = 4.0, SD = 1.9). These questions were: “Which substances reduce the surface tension of water?, What is soap made of?, What advantages and disadvantages have soaps for cleaning?, How can hard water be recognized?, and Which chemical elements build washing powder?”. Knowledge acquisition was measured after the learning experience with 10 comparable questions resulting in 0 to 24 points (M = 7.0, SD = 5.0). Pre-knowledge and knowledge acquisition correlated by r = .30 (p < .01, one-tailed) what can be seen as good indicator of validity.

12 items from the sub-scale “outcome-valence” of the PMI(Potsdamer Motivations Inventar [Potsdam Motivation Scale]-questionnaire by Rheinberg and Wendland (2001) were used to measure pre-motivation with good reliability (*Cronbach's Alpha* = .82). The items had to be answered on a 5-point Likert-scale (from “is right” to “is wrong”). Three of these items were, for example: “To reach high achievements in physics/chemistry is important for me, because (1) I can

be proud of myself; (2) I can get appreciation by my peer group; or (3) I find this subject very interesting".

The measurement of cognitive load was taken by measuring the time students needed to change the red color of the letter "A" in its original black color by pressing the space bar. Every 20 to 55 seconds the black color changed to red randomly. This kind of measurement represents the "dual-task"-method for measuring cognitive load (Brünken, Plass, & Leutner, 2003).

The motivation to learn - as dependent variable - was measured with high reliability (*Cronbach's Alpha* = .90). 14 items had to be answered on a 5-point Likert-scale (from "I do not agree at all" to "I agree completely"). These items were: "The content of the instructional multimedia system was boring. The design of the environment offered a familiar atmosphere to me. To finish the instructional multimedia system successfully was important to me. The instructional multimedia system had elements, which made me curious. The presentation of the content helped me to sustain attention. From the beginning, I knew the goals of learning. I was excited to learn new contents. Learning the materials was of high value to me. I understood which contents were important. The content was designed in a way that it did not attract my attention. I was able to connect the contents with my experiences in life. I was stimulated to find answers to certain questions. The variations in examples, figures, etc. helped me to keep me motivated. I was addressed personally by the language within the instructional multimedia system".

Results

Motivation to learn. Results in respect to motivation to learn indicated that the instructional design (i.e., the versions with different ARCS-strategies) had a significant influence on learning ($F(3, 54) = 4.47$, $p < .01$; $R^2 = .20$) and that pre-motivation (outcome-valences) did not ($p > .10$) (see Table 1). Pair wise comparisons with adjustment based on the Bonferroni-method showed that the motivation to learn was significantly higher within the group with combined attention- and relevance-strategies in comparison to the group with no ARCS-strategies ($p = .05$). No other group differences were found ($p > .05$).

However, this effect of instructional design had to be related to a significant ATI-effect ($F(3, 54) = 3.78$, $p < .05$, $R^2 = .17$). Pre-motivation and motivation to learn were correlated positively ($r = .62$, $p < .01$, one-tailed) when no ARCS-strategies were used. Both variables were correlated negatively ($r = -.16$, $p > .10$, one-tailed) when attention- and relevance-strategies were implemented. When there were no ARCS-strategies, then subjects with high pre-motivation had a high probability to reach high levels of motivation to learn. When there were ARCS-strategies, all kind of students, and especially those with low pre-motivation, had a high probability to reach high levels of motivation to learn.

Knowledge acquisition. When considering knowledge acquisition during learning, then a significant effect of pre-knowledge and of cognitive load was found ($F(1,43) = 14.4$, $p < .01$, $R^2 = .25$; $F(1,43) = 7.8$, $p < .01$, $R^2 = .15$): The higher pre-knowledge, the higher knowledge acquisition ($r = .30$, $p < .01$, one-tailed); and the lower cognitive load, the higher knowledge acquisition (r = -

.32, p < .01, one-tailed) (see Table 1). The effect of instructional design and of an ATI-effect with cognitive load did not reach statistical significance (p > .05).

Table 1

Effects of Instructional Design and ATI on Motivation to Learn and Knowledge Acquisition

Motivation to Learn

Analysis of Covariance

Source	*SS*	*df*	*MS*	*F*	*p*	R^2
Outcome-Valence (OV)	339.85	1	339.85	2.73	.104	.05
Instructional Design (ID)	1669.56	3	556.52	4.47	.007	.20
ATI: ID * OV	1409.86	3	469.95	3.78	.016	.17
Error	6729.21	54	124.62			

Knowledge Acquisition

Analysis of Covariance

Source	*SS*	*df*	*MS*	*F*	*p*	R^2
Pre-Knowledge (PK)	278.23	1	278.23	14.41	.000	.25
Cognitive Load (CL)	150.48	1	150.48	7.80	.008	.15
Instructional Design (ID)	147.51	3	49.17	2.55	.068	.15
ATI: ID * CL	144.86	3	48.29	2.50	.072	.15
Error	830.05	43	19.30			

Instructional Design	Motivation to learn			Knowledge acquisition		
	*M**	*SD*	*n*	*M***	*SD*	*n*
No ARCS	36.2	14.1	15	7.6	6.0	13
With A	42.6	10.8	16	9.3	5.1	13
With R	40.9	11.8	15	8.4	6.3	13
With A+R	47.1	10.6	16	6.8	4.0	13

Note. * Covariates appearing in the model are evaluated at OV = 41.1

** Covariates appearing in the model are evaluated at PK = 3.8 and CL = 3826.1

Discussions

Within this study, the effects of an instructional multimedia system using ARCS-strategies were tested. Results showed that, as expected, the implementation of both attention- and relevance-strategies increased motivation to learn. In addition, there was an ATI-effect, which indicated that especially those students profited from ARCS-strategies, which had low levels of pre-motivation. Therefore, ARCS-strategies had - as assumed within hypotheses - a compensation effect.

Relevance-strategies did not have stronger effects on motivation to learn than attention-strategies. Knowledge acquisition was strongly affected by pre-knowledge and by cognitive load, but not significantly from ARCS-strategies. There were no ATI-effects, both with pre-knowledge and with cognitive load on knowledge acquisition.

Of course, the ARCS-model is focusing on motivation and therefore, in general, its effects are stronger for motivational consequences of learning. However, effects from the ARCS-model on cognitive aspects of learning were not as strong as expected. One reason might be that not all strategies of the ARCS-model were implemented: Strategies for the enhancement of confidence and satisfaction were not used in this study. A more comprehensive implementation of ARCS-strategies could increase motivational effectiveness and therefore cognitive learning.

However, there should be research on how the ARCS-model can be made more effective in respect to cognitive matters. There are, for example, several possible lines of research:

a) Based on the instructional design model from Astleitner and Wiesner (2004), motivational parameters of instructional multimedia systems can be manipulated according to the ARCS-model, but at the same time, cognitive parameters of an instructional multimedia system should be optimized by using cognitive design principles from Mayer (2001). Future research has to answer the question whether learning changes if different cognitive and motivational multimedia elements are used in combination at the same time. Learning processes are complex and dynamically interacting with each other. From that fact, it seems to be necessary that multimedia elements should be combined in order to solve many of the possible learning problems. However, when combining different elements, unknown side effects might occur that have to be given special attention. Such disturbances, which result from implementing at one time different multimedia elements and related instructional strategies, have to be clarified. There are, for example, some guidelines for motivational screen design in multimedia instruction by Lee and Boling (1999), however, these guidelines are not related to cognitive guidelines by Mayer (2001).

b) A certain instructional strategy can be developed which deals with cognitive and motivational parameters of learning in a parsimonious and integrated way (e.g., Reigeluth, 1999). One way can easily be realized by using different task difficulties (Astleitner & Keller, 1995). Strategies for presenting and selecting tasks with varying difficulties have to be found which assist each other in a complementary manner. For example, Herber and Vásárhelyi (2002) developed a research-based model of task-sets, which should stimulate learning and motivation at the same time. According to this model, learners should get - like proposed by the ARCS-model - access to tasks of varying difficulty levels together with different kinds of feedback for supporting knowledge acquisition. Learners should be stimulated to select easy and medium difficult tasks before they work with difficult tasks. After working with difficult tasks, learners should select easy tasks in order to experience success and maintain motivation. Easy tasks represent tasks, which are closely connected to prototypical tasks for stimulating stepwise low level knowledge acquisition. Difficult tasks concern tasks which are more complex for stimulating high level knowledge acquisition and which reflect individual interests of learners.

Some critical remarks about this study have to be made. First, the number of subjects was small what decreased the power of the empirical tests. Second, the time on task was restricted. If students had had the possibility to work longer, motivational and related learning effects might have proven to be stronger. Third, for enhancing the quality of measuring ARCS-related effects on motivation, the Instructional Material Motivational Survey (IMMS) could be used in future settings (e.g., Huang, Diefes-Dux, Imbrie, Daku, & Kallimani, 2004). This scale is based on the ARCS-model and makes it possible to measure even small motivational effects. A short version of this scale could be used within multimedia learning to diagnose changes in motivation during learning. Such a diagnosis could be the basis for establishing adaptive motivational multimedia instruction, which is based on fine-graded diagnosing motivational effects. In addition, measuring pre-motivation was based only on extrinsic aspects of motivation (i.e., outcome-valences). Other factors of motivation, especially expectancies and intrinsic action-related valences were not considered within this study (e.g., Rheinberg, Vollmeyer, & Rollet, 2000). Fourth, from a methodological perspective, in further studies, the problem of outliners within the data has to be addressed. Outliners influence, for example, the correlations of covariables and dependent variables, which are related to ATI-effects, especially when sample sizes are small. According to Tabachnick and Fidell (1996), it seems reasonable to exclude from further analysis univariate outliners with *z*-scores in excess of 3.20. Others suggest procedures that test the statistical models in different sub samples of a study in order to gain data about the stability of findings (e.g., Leutner & Rammsayer, 1995).

The design guidelines derived from this research have to be formulated in a rather preliminary way. The results of this study suggest for instructional multimedia designers to use combined attention- and relevance-strategies, especially for students with low level of pre-motivation. In addition, instructional elements for acquiring pre-knowledge should be implemented and low cognitive load should be achieved. Low cognitive load can be realized, for example, when presenting relatively few and stable instructional elements in multimedia systems.

In the future, it can be expected, that instructional multimedia systems will be implemented in web-based e-learning courses with an international audience (e.g., Keller & Suzuki, 2004). Motivational effects will not only be stimulated by computer-based instructional multimedia systems, but also by human communication. It is an open question, whether motivational effects could be achieved more easily and more effectively by a human tutor in comparison to a computer-based instructional multimedia system. That human tutors were able to influence motivation to learn - based on the ARCS-model - significantly were shown, for example, by Visser, Plomp, Amirault, and Kuiper (2002).

References

Astleitner, H. (1997). Effects of external learning aids on learning with ill-structured hypertext. *Journal of Educational Computing Research, 17,* 1-18.

Astleitner, H., & Hufnagl, M. (2003). The effects of situation-outcome-expectancies and of ARCS-strategies on self-regulated learning with web-lectures. *Journal of Educational Multimedia and Hypermedia, 12,* 361-376.

Astleitner, H., & Keller, J. M. (1995). A model for motivationally adaptive computer-assisted instruction. *Journal of Research on Computing in Education, 27,* 270-280.

Astleitner, H. & Lintner, P. (2004). The effects of ARCS-strategies on self-regulated learning with instructional texts. *E-Journal of Instructional Science and Technology, 7,* 1. Retrieved February, 12, 2006, from http://www.usq.edu.au/electpub/e-jist/docs/Vol7_No1/content.htm

Astleitner, H., & Wiesner, C. (2004). An integrated model of multimedia learning and motivation. *Journal of Educational Multimedia and Hypermedia, 13,* 3-21.

Brünken, R., Plass, J. L., & Leutner, D. (2003). Direct measurement of cognitive load in multmedia learning. *Educational Psychologist, 38,* 53-61.

Caspi, O., & Bell, I. R. (2004). One size does not fit all: Aptitude x Treatment Interaction (ATI) as a conceptional framework for complementary and alternative medicine outcome research. Part 1 - What is ATI research? *The Journal of Alternative and Complementary Medicine, 10,* 580-586.

Chang, M.-M., & Lehman, J. D. (2002). Learning foreign language through an interactive multimedia system: An experimental study on the effects of the relevance component of the ARCS model. *The CALICO Journal*, *20*, 81-98.

Cronbach, L. J. (1957). The two disciplines of scientific psychology. *American Psychologist, 12,* 671-684.

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,* 92-101.

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,* 414-434.

Herber, H.-J., & Vásárhelyi, E. (2002). Das Unterrichtsmodell ´Innere Differenzierung einschließlich Analogiebildung´ - Aspekte einer empirisch veranlassten Modellentwicklung. *Salzburger Beiträge zur Erziehungswissenschaft, 6,* 5-19.

Huang, D. W., Diefes-Dux, H., Imbrie, P. K., Daku, B., & Kallimani, J. G. (2004, October). *Learning motivation evaluation for a computer-based instructional tutorial using ARCS model of motivational design*. Paper presented at the 34th ASEE/IEEE Frontiers in Education Conference, Savannah, GA.

Kaufmann, E., & Zöchling, A. (2003). *Chemie.* Wien: ÖBV & HPT VerlagsGesmbH.

Keller, J. M. (1997). Motivational design and multimedia. Beyond the novelty effect. *Strategic Human Resource Development Review, 1,* 188-203.

Keller, J. M., & Suzuki, K. (1988). Application of the ARCS model to courseware design. In D. Jonassen (Ed.), *Instructional designs for microcomputer courseware design* (pp. 401-434). New York: Erlbaum.

Keller, J. M., & Suzuki, K. (2004). Learner motivation and E-Learning design: A multinationally validated process*. Journal of Educational Media, 29,* 229-239.

Lai, S.-L. (2001). Controlling the display of animation for better understanding. *Journal of Research on Computing in Education, 33*. Retrieved February 12, 2006, from http://www.iste.org

Lajoie, S. P. (2003). Individual differences in spatial ability. Developing technologies to increase strategy awareness and skills. *Educational Psychologist, 38,* 115-125.

Lee, S. H., & Boling, E. (1999). Screen design guidelines for motivation in interactive multimedia instruction. A survey and framework for designers. *Educational Technology, 39*, 19-26.

Leutner, D. (1992). *Adaptive Lehrsysteme. Instruktionspsychologische Grundlagen und experimentelle Analysen.* Weinheim: Beltz - Psychologie Verlags Union.

Leutner, D., & Rammsayer, T. (1995). Complex trait-treatment-interaction analysis: A powerful approach for analyzing individual differences in experimental designs. *Personality and Individual Differences, 19,* 493-511.

Lin, S., Liu, E., & Yuan, S. (2001). Web-based peer assessment: feedback for students with various thinking-styles. *Journal of Computer Assisted Learning, 17,* 420-432.

Martens, R. L., Gulikers, J., & Bastiaens, T. (2004). The impact of intrinsic motivation on e-learning in authentic computer tasks. *Journal of Computer Assisted Learning, 20,* 368-376.

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

Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist, 38,* 43-52.

McInerney, V., McInerney, D., & Marsh, H. W. (1997). Effects of metacognitive strategy training within a cooperative group learning context on computer achievement and anxiety. An aptitude-treatment interaction study. *Journal of Educational Psychology, 89,* 686-695.

McManus, T. F. (2000). Individualizing instruction in a web-based hypermedia learning environment: Nonlinearity, advance organizers, and self-regulated learners. *Journal of Interactive Learning Research, 11,* 219-251.

Means, T. B., Jonassen, D. H., & Dwyer, F. M. (1997). Enhancing relevance. Embedded ARCS strategies vs. purpose. *Educational Technology, Research & Development, 45,* 5-17.

Park, O., & Lee, J. (2003). Adaptive instructional systems. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 651-658). Mahwah, NJ: Erlbaum.

Reigeluth, C. M. (1999). (Ed.). *Instructional-design theories and models. A new paradigm of instructional theory*. Mahwah, NJ: Erlbaum.

Renkl, A., & Atkinson, R. K. (2003). Structuring the transition from example study to problem solving in cognitive skill acquisition. A cognitive load perspective. *Educational Psychologist, 38,* 15-22.

Rheinberg, F., Vollmeyer, R., & Rollet, W. (2000). Motivation and action in self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 503-529). San Diego, CA: Academic Press.

Rheinberg, F., & Wendland, M. (2001, March). *Das Potsdamer Motivations-Inventar (PMI). Ein Fragebogen zur Erfassung fachspezifischer Lernmotivation.* Poster presented at the 35. Jahrestagung der Gesellschaft für Didaktik der Mathematik, Ludwigsburg.

Shellnut, B., Knowlton, A., & Savage, T. (1999). Applying the ARCS model to the design and development of computer-based modules for manufacturing engineering courses. *Educational Technology, Research, and Development, 47,* 100-110.

Shute, V.J., & Towle B. (2003). Adaptive E-Learning. *Educational Psychologist, 38,* 105- 114.

Song, S. H., & Keller, J. M. (2001). Effectiveness of motivationally adaptive computer-assisted instruction on the dynamic aspects of motivation. *Educational Technology, Research, and Development, 49,* 5-22.

Tabachnik, B. G., & Fidell, L. S. (1996). *Using multivariate statistics* (3rd edition). New York: HarperCollins.

Visser, L., Plomp, T., Amirault, R. J., & Kuiper, W. (2002). Motivating students at a distance. The case of an international audience. *Educational Technology, Research, and Development, 50,* 94-110.

Winer, B. J., Brown, D. R., & Michels, K. M. (1991). *Statistical principles in experimental design.* New York: McGraw-Hill.

Zumbach, J., & Reimann, P. (2001). Hypertext-based argumentation. Role of tools, motivation, and cognition. In W. Frindte, T. Köhler, P. Marquet, & E. Nissen (Eds.), *Internet-based teaching and learning (IN-TELE 99)* (pp. 320-327). Frankfurt: Lang.