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Chapter 12

Motivation and Self-Regulation While Learning with Hypermedia: Results from a Thinking Aloud Protocol Study with Wikipedia

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Since its emergence three decades ago, learning with digital media has evolved into a widespread and commonplace activity. This is particularly true for learning with hypermedia and the internet, which are of great importance for informal learning processes. Many people regularly search for information using various net resources, such as search engines (Judd & Kennedy, 2010). Also, online encyclopedias have become a standard and commonly used tool for many people, whereby the first name that comes to mind is the online encyclopedia Wikipedia, whose services are made possible by a large community of authors who volunteer their time and insight to expanding the site (Niederer & van Dijck, 2010).

Offering a good deal of freedom of choice and interactivity, learning with digital media often provides learners with a much higher degree of autonomy than learning environments which are structured by a single instructor. Freedom of choice pertaining to learning content, learning sequence as well as the type of learning activities engaged create opportunities for *self-regulated learning* (SRL; summarized in Hadwin, Winne, & Nesbit, 2005). Many authors find a wealth of opportunities for SRL in computer-based learning (e.g. Azevedo & Cromley, 2004). Current theoretical models also agree that learning in environments which enable autonomous learning activities will only enable substantial increases in knowledge accumulation when learners self-regulate their learning processes sufficiently (summarized in Boekaerts & Corno, 2005). Moreover, in many current models which aim to explain achievement excellence and/or the processes that underlie the transformation of high abilities and talents into excellence, SRL and similar constructs (such as volition) are considered to be core factors (e.g. Heller, 2005; Heller, Perleth, & Lim, 2005; for an overview see Heller, Mönks, Sternberg, & Subotnik, 2002). Clearly computer-based learning environments, which provide learners with a myriad of freedoms, not only facilitate SRL, they also demand it.

However, the prerequisite conditions for SRL with digital media have not yet been fully clarified. Derived from research conducted on SRL in the context of learning processes in secondary and tertiary education, one can formulate the assumption that motivational components most likely play a significant role here (for an overview see Schunk, Pintrich, & Meece, 2007). To date, however, only a few studies have examined the influence exerted by learning motivation on SRL in computer-based learning and, consequently, the quality of media-driven learning (for an exception see Haugwitz & Dresel, 2007).

The aim of the present work is, therefore, to contribute to the general understanding of the motivational conditions underlying the quality and effects of SRL with hypermedia. To this end, the results of a study are depicted in which undergraduates used Wikipedia for 45 minutes to learn about a specific topic. The focus was on expectancy and value-related components of learners' motivation to learn in the digital media environment (self-efficacy, expectancy of suc-

cess, task value, mastery goals), and the resulting effects on SRL and knowledge acquisition.

1.1 Processes and Components of SRL

In essence, SRL can be defined as autonomous efforts undertaken by learners to initiate activities targeted towards a learning goal, performed as effectively as possible and while adhering to other conditions (see Boekaerts & Corno, 2005; Winne & Hadwin, 1998; Zimmerman, 2000). In the ideal case SRL entails: setting learning (sub-)goals which are congruent with current knowledge levels, planning learning activities including the selection of adequate learning strategies for the cognitive processing of the learning material, the effective application of these learning strategies, monitoring and evaluating learning progress and the outcomes of the learning process, as well as implementing adaptations to the process should difficulties arise (see Zimmerman, 2000). Therefore SRL comprises both *cognitive learning strategies*, which directly target information processing (e.g. elaboration of the learning material), as well as *metacognitive strategies*, which focus on the evaluation of the current state of knowledge and therefore, in turn, also include the planning, monitoring and adaptation of the application of cognitive learning strategies (rf. Pintrich & Garcia, 1991). With respect to different cognitive strategies, research (rf. Schunk et al., 2007; Weinstein & Hume, 1998) has shown that, in most cases, elaboration strategies (e.g. generating links to prior knowledge, generation of examples), are more effective than rehearsal strategies (e.g. verbal repetition). Since the application of cognitive learning strategies which directly target information processing and learning are regulated through metacognitive control, one can assume that the latter will not have a direct effect on learning gains. This assumption is supported by the results of studies which have simultaneously examined the effects of cognitive and metacognitive strategies on learning outcomes (e.g. Artelt, 1999). Nevertheless, empirical evidence documenting the direct effects that metacognitive strategies have on knowledge acquisition also exists (see Bannert, 2005, for a study in the context of learning with digital media).

1.2 SRL with Digital Media

The great deal of importance ascribed to the self-regulation of learning with digital media, described previously, continues to stand in strong contrast to the relatively modest number of findings published on the characteristics of SRL in this particular context. Hadwin et al. (2005) criticize the fact that computer-based learning environments, despite their capacity for experimental control, have been insufficiently investigated in the past. According to Hadwin et al., the degree to which learners use the opportunities of digital media to self-regulate their learning has not yet been adequately clarified and factors which determine the quality of SRL are unclear. If anything, hypermedia learning environments have been relatively frequent subjects of research as they have been ascribed, on

the basis of their non-linearity, a great potential to stimulate SRL – particularly informative in the corresponding literature are the studies conducted by Azevedo and his research group (e.g. Azevedo, 2002, 2005; Azevedo & Cromley, 2004; Azevedo, Cromley, & Seibert, 2004; Azevedo, Guthrie, & Seibert, 2004; Azevedo & Jacobson, 2008; Greene & Azevedo, 2009). These studies analyzed, among other things, the multitude of choices which learners need to make with regard to type of content and representation as well as process sequence and intensity, while they are working in hypermedia environments. They characteristically provide a broad spectrum of information that may be presented in various formats (e.g. text, graphics, animation, audio, and video) and a non-structured fashion. The investigations conducted by Azevedo and his colleagues demonstrate that some learners make extensive use of the self-regulatory potential of computer-based learning environments and are actually capable of sufficiently regulating their learning processes on their own, but in many cases learners do demonstrate an inadequate self-regulation of their learning activities (see also Hill & Hannafin, 1997). Evidence was provided for ineffective cognitive information processing as well as deficits with regard to the metacognitive control of learning (e.g. Azevedo & Hadwin, 2005; Jonassen & Wang, 1993; Hill & Hannafin, 1997; for an overview see also Fischer & Mandl, 2002). Against this background, the self-regulatory practices of many learners are considered to be deficient. This is also reflected by the utilization of media-specific strategies: It could be demonstrated, for example, that some learners frequently deploy free searches in the media environment, which have been shown to be less than effective (Greene & Azevedo, 2009). The relevance of self-regulatory strategies during learning with digital media is underpinned by the positive effects they have been proven to have for knowledge acquisition (e.g. Azevedo & Cromley, 2004; Dresel & Haugwitz, 2008; Kauffman, 2004). Overall, the findings on learning with hypermedia show that many learners, when utilizing hypermedia, do not seem to be capable of exploiting the inherent freedoms in terms of goal-oriented and effective learning activities.

1.3 Motivational Preconditions of SRL (with Digital Media)

In addition to context features (which basically enable SRL) and self-regulatory competences (e.g. metacognitive knowledge; Flavell, 1979), various components of learning and achievement motivation are considered to be fundamental for self-regulatory activities (e.g. Boekaerts & Cascallar, 2006; Pintrich, 1999; Pintrich & Garcia, 1993; Pintrich & Zusho, 2007; Wolters, Yu, & Pintrich, 1996). Due to the central role played by learner motivation in the initiation, control, and maintenance of self-regulated learning, in some theoretical models it is even considered an integral component of SRL (e.g. Zimmerman, 2000). Theoretically, learning motivation and its sub-components can be conceptualized as moderators of the relationship between self-regulatory competences and their actualization during specific learning activities in the form of self-regulatory processes (e.g. Hasselhorn, 1992).

Learner motivation in complex learning environments is not a single construct, but a multidimensional phenomenon (e.g. Pintrich & Zusho, 2007). Accordingly, in order to adequately describe the effects of learning and achievement motivation on SRL with digital media, it is necessary to establish a comprehensive concept of the learning and achievement motivation engaged by persons working with digital information and learning applications, one which comprises distinct motivational components (for an overview see Schunk et al., 2007). Comprehensive expectancy-value models of achievement motivation have proven to be effective in their classification and integration (rf. Eccles & Wigfield, 2002). They specify two primary groups of motivational dimensions: (1) Constructs classified in the group of *expectancy-related components* refer to assumptions pertaining to one's own capacities. Major components are *expectancy of success*, which refers to the subjective probability of having success on a given task, as well as *self-efficacy*, which refers to the subjective belief of being able to execute specific learning or achievement activities (rf. Bandura, 1997; Eccles & Wigfield, 2002). (2) Motivational constructs in the group of *value-related components* refer to the subjective appeal of the learning process and its results. Important here is the subjective value of the task or the domain (*task value*; rf. Eccles & Wigfield, 2002), which is understood as the value associated with the implementation of the task or the domain itself (intrinsic value, e.g. experiencing positive emotions such as fun), the utility of the task with reference to an individual's superior goal (instrumental value), as well as the significance the task or domain holds for the individual's self-definition (attainment value). Furthermore, achievement goals also play a central role (for an overview see Maehr & Zusho, 2009). In the case of individual learning with digital media (e.g. the individual search for information in a hypermedia environment) mastery goals, which are directed towards gaining knowledge and developing skills, are of particular significance. Recently, a distinction was proposed between mastery approach goals and mastery avoidance goals, that is between a focus on goals which are directed towards the acquisition of knowledge and those which focus on the avoidance of incorrect and/or incomplete knowledge (Elliot & McGregor, 2001; Moller & Elliot, 2006).

A large number of empirical findings, mainly with reference to learning processes in secondary and tertiary education, suggest that the application of cognitive and metacognitive self-regulatory strategies are dependent on both of these main motivational groups (for an overview see Pintrich & Zusho, 2007). For instance, it could be demonstrated that cognitive and metacognitive strategies are utilized more frequently in the presence of higher intrinsic value, stronger mastery approach goals, higher expectancies of success and more positive self-efficacy beliefs. For mastery avoidance goals, the findings are rather mixed (rf. Moller & Elliot, 2006). In one of the few studies which have investigated the effects of learning motivation on SRL with digital media, it was shown that the application of metacognitive learning strategies among sixth graders working with a Mathematics learning software was dependent on both

the expectancy of success maintained towards learning with the digital media environment as well as the value held by the learners concerning media-based learning (Haugwitz & Dresel, 2007). Nevertheless, the research deficits here are even larger than those for SRL with digital media in general. These gaps involve the consideration of a comprehensive conception of learning and achievement motivation as well as learning with different types of digital media (in particular hypermedia).

1.4 Measuring SRL

SRL incorporates the execution of complex, dynamic and situation-specific processes during learning (e.g. Winne & Hadwin, 1998). Therefore, measuring SRL is challenging (Winne & Perry, 2000; see also Schmitz, 2006; Wirth & Leutner, 2008). The difficulties encountered when assessing SRL are primarily attributed to the low level of validity associated with global self-report questionnaires, in particular regarding the description and prognosis of individual learning behaviors (rf. Spörer & Brunstein, 2006). Process-oriented methods of assessment are better suited here, for example using diaries (Schmitz & Wiese, 2006) or thinking aloud techniques (Ericsson & Simon, 1993; Greene, Robertson, & Croker Costa, 2011). Nevertheless, much research on the topic of SRL, with and without digital media, is based on more or less global self-reports about the use of SRL strategies. This casts doubt on results obtained with this research regarding the preconditions, processes, and functions associated with SRL. Once again, regarding SRL with hypermedia environments, the research conducted by Azevedo and his colleagues research, which is based to a large degree on thinking aloud protocols (e.g. Azevedo & Cromley, 2004), stands out positively.

1.5 Research Questions

The primary question driving the present research concerns how relevant the individual components of learning and achievement motivation are for SRL with hypermedia. The focus in this case was directed towards motivational components, which have proven a great deal of explanatory power in the context of general learning (self-efficacy, expectancy of success, task value, mastery approach goals). Since relatively little is known about the effects of mastery avoidance goals, these were also addressed. Cognitive and metacognitive SRL strategies (assessed in a process-oriented fashion), as well as objective and subjective learning gains, were considered as potential consequences of more or less advantageous media-related learning motivation. Based on prior research, it was expected that ample self-efficacy, a sufficient expectancy of success, a high subjective valuing of the learning content and a considerable pursuit of mastery approach goals would lead to an extensive use of cognitive and metacognitive strategies as well as sizable learning growth (Pintrich & Zusho, 2007). With respect to the effects of cognitive and metacognitive strategies on learning

growth, positive effects of elaboration, rehearsal, and metacognitive strategies were expected (e.g. Azevedo & Cromley, 2004). In light of the ambivalent effects of mastery avoidance goals and the use of search strategies reported in the literature (Greene & Azevedo, 2009; Moller & Elliot, 2006), no specific effect direction was expected; their effects were tested non-directionally.

2 Method

2.1 Overview and Procedure

In the study, a 45-minute learning period using the online encyclopedia Wikipedia (German version) was realized in which participants were requested to think aloud in order to assess SRL in a process oriented manner. The participants were undergraduates who worked independently on a PC in the departmental computer lab. Wikipedia was used, because it is probably the most recognizable online encyclopedia, and is considered a standard work of reference. Despite criticisms on the quality of information offered, it is widely used and broadly accepted (Judd & Kennedy, 2010). Therefore Wikipedia was chosen in order to attain a high level of ecological validity with regard to self-regulated learning processes with digital media. The topic to be investigated by the participants was the "Roman Empire". It was communicated to the participants that the main goal was to "acquire as much knowledge as possible about the Roman Empire". As historic benchmarks, the subjects were to limit themselves to the period of time between the founding of Rome and the fall of the Western Roman Empire. This topic enjoys comprehensive representation in Wikipedia. At the point in time when the studywas conducted, the main article consisted of 7000 words and 19 static and animated illustrations (e.g. an animated illustration of the extent of the expansion of the Roman Empire over the course of its history). At least 16 other articles were strongly related to the topic.

As a first step in the procedure, prior knowledge on the target topic as well as expectancy-related components of motivation to learn with the digital media environment, which are future-directed by definition (self-efficacy, expectancy of success), were assessed with paper-and-pencil-tests. In the next step, a five minute warm-up period for the thinking aloud procedure was implemented. This was directly followed by the 45-minute learning period in which participants were requested to accomplish the aforementioned main goal. Two blank sheets of paper and a pencil were placed next to the computer stations to provide the learners an opportunity to make notes of what they found. The participants were requested to think aloud throughout the entire learning period. The statements made during the think aloud period were recorded on audiotape. Additionally, interactions made by the participants with their computer screen were videotaped (screen captured) in order to clarify any potential ambiguities on the audio tapes. When a participant was silent for longer than three seconds, the experimenter requested the subject to continue with the statement "please express

your thoughts audibly". Following the completion of the learning period, topic knowledge was again assessed using the same test employed in the first step of the procedure, in order to estimate the amount of knowledge acquired within the 45-minute period. At this point, the value-related motivational components were also assessed (post-hoc reports of their subjective valuing of the content and the strength of their mastery goals while learning).

2.2 Participants

The participants were fifty undergraduate students (27 male, 23 female) attending a German university, majoring predominantly in subjects in the areas of Mathematics, Science or Engineering. Their mean age was 23.5 years (SD = 2.9) and they were, on average, in the third year of their studies (M = 2.7; SD = 1.9). All participants volunteered to take part in the study and received 10 Euros each as compensation for their time.

2.3 Paper and Pencil Measurements

2.3.1 Components of the Motivation to Learn with the Digital Media Environment

Unless otherwise noted, the items were to be answered along a six-point Likert-type response scale ranging from 1 *(absolutely false)* to 6 *(absolutely true)*. Basic psychometric properties (including Cronbach's α) for all paper and pencil measurements can be found in Table 1.

Assessments were made of two expectancy-related components of the undergraduates' motivation (prior to the 45-minute learning period). *Self-efficacy* was measured by asking the participants how sure they were that they would be able to successfully define each of ten different terms relating to the Roman Empire, which varied in difficulty (e.g. "Gladiator", "Tetrarchy"). These were presented with a six-point Likert-type response scale ranging from 1 *(completely unsure)* to 6 *(completely sure)*. Moreover, *expectancy of learning success* was assessed using the three items "I am confident that I will be able to learn the material on the Roman Empire", "I am capable of learning the material on the Roman Empire", and "I will be able to achieve the goals I want to accomplish with the online encyclopedia".

Also, two value-related components of the subjects' motivation to make use of the online encyclopedia were assessed (after the 45-minute learning period). To measure *task value* specifically with respect to the digital media learning session, six items developed by Ziegler, Dresel, Stoeger, and Schober (2005) were adapted to reflect the context of the topic chosen for the learning session. With this scale three significant value components were assessed, in accord with conceptualizations advanced by Eccles and Wigfield (2002), with two items each: intrinsic value (sample item: "I think learning about the Roman Empire is a lot of fun"), attainment value ("It is very important for me to know a lot about the

Roman Empire"), and instrumental value ("Knowing a lot about the Roman Empire is very useful").

Table 1. Descriptive Statistics for Motivational and Knowledge Variables

				Range		
	M	*SD*	α	Potential	Actual	Skew
Self-efficacy	3.53	1.23	.87	1–7	1.0–5.7	–0.04
Expectancy of success	4.67	0.69	.86	1–6	3.0–6.0	–0.21
Task value	3.49	0.92	.91	1–6	1.7–6.0	0.16
Mastery approach goals	4.29	0.73	.62	1–6	2.7–6.0	0.10
Mastery avoidance goals	3.49	0.99	.76	1–6	1.3–5.7	–0.63
Pre-test knowledge	49.8	22.1	.78	0–100	0–88	–0.23
Post-test knowledge	69.3	22.2	.82	0–100	19–100	–0.61
Subjective knowledge gain	4.43	0.84	.86	1–6	1.5–6.0	–1.27

Note. $N = 50$.

In order to assess the adoption of *mastery goals* during the learning process a questionnaire, developed by Elliott and McGregor (2001), was administered which allows one to assess mastery approach goals and mastery avoidance goals separately. The questionnaire was translated into German and adapted specifically to the context of the digital media learning sessions (item stem: "What was important to you while learning with the online encyclopedia? While working with the online encyclopedia ..."). Mastery approach goals (sample item: „... I wanted to learn as much as possible") and mastery avoidance goals ("... I was sometimes afraid that I may not understand the content as thoroughly as I'd like") were each measured with three items.

2.3.2 Content Knowledge

Content knowledge relating to the learning topic was assessed by presenting the participants with 16 terms related to the Roman Empire (e.g. "Triumvirate", "Collegiality"), with the request that they match them to their corresponding definitions (e.g. "Alliance of three persons", "Double occupation for all offices"). The test was administered in advance of the 45-minute learning period as a test of prior knowledge, and again after the termination of the learning period. In all analyses the percentages of correct responses obtained were used.

2.3.3 Subjective Learning Gain

The extent to which participants perceived that they had learned topical knowledge during the 45-minute learning session was assessed with four items. The items all started with an identical stem, "By working with the online encyclopedia ...", which was followed by: "... I was able to expand my knowledge of facts on the history of the Roman Empire", "... I was able to much better under-

stand the historical context of the Roman Empire", "... I was able to learn a lot about the history of the Roman Empire", and "... I was able to gain a better understanding of the historical context of the Roman Empire". The items were presented along six-point Likert-type response scales ranging from 1 *(absolutely false)* to 6 *(absolutely true)*.

2.4 Coding of Verbal Protocol Data

The basis for the verbal protocol data coding were the audio-taped verbalizations of the thoughts made by the participants and, when ambiguities arose, videotaped interactions with the computer (screen capturing). Altogether these audio and videotape recordings comprised 2250 min (37.5 hr) of data. In the first step, student assistants transcribed the audio recordings collected for each participant, whereby verbatim repetitions of text passages published on Wikipedia were not transcribed. The transcription process resulted in a total of 712 double-spaced pages (M = 14.2 pages per participant) with a total of 182010 words (M = 3640 words per participant).

A hierarchical category system was developed for use in the second step. On the top level, cognitive strategies were differentiated from metacognitive strategies. Purely navigational activities were weeded out and not included in the analysis. On the second level, a few broad categories were drawn in a deductive manner, using literature on self-regulated learning with digital media as a basis (e.g. Azevedo & Cromley, 2004). Within cognitive strategies differentiations were made among elaboration strategies, rehearsal strategies and (media-learning specific) search strategies. Within metacognitive strategies, again three subcategories of strategies were defined, that is goal-setting/planning, monitoring/self-evaluation and content evaluation. Coding examples for these categories can be found in Table 2. Within these six categories, on a third level, the verbal data were partially coded in accordance with inductive data driven categories. An event based coding was realized. Therefore, every occurrence of a self-regulation strategy was coded, independently from the duration of the occurrence.

Inter-rater agreement was ensured by an organized training for all student assistants involved in the transcription and coding of verbal protocol data. To estimate inter-rater agreement, the transcripts of five randomly selected participants were coded twice. This analysis yielded an agreement of ρ = .90 for both the total frequencies of the use of cognitive strategies and the total frequencies of the use of metacognitive strategies. On the subjacent, second coding level, inter-rater agreement was somewhat lower and ranged between ρ = .56 and ρ = 1.00 (Md = .80). Nevertheless, categories on the second level were included in all analyses in order to produce differentiated evidence with regard to the use of self-regulation strategies.

Table 2. Descriptive Statistics and Frequencies of Verbal Protocol Indications of Strategy Use in 45 Minutes of Learning with Wikipedia

Strategy	*M*	*SD*	Range	Skew	*f*%	Example
Cognitive strategies						
Elaboration strategies	34.9	19.1	1–84	0.3	8%	"So we could summarize by saying that here, around 200 BC... ummm *their influence in the Hellenistic* region increased greatly"
Rehearsal strategies	28.8	15.2	4–66	0.2	14%	"340 to 338 BC... 340 to 338 BC..."; "The Twelve Tables, let me write that down, *The Twelve Tables, 450 BC, a* book of laws."
Search strategies	13.7	10.7	0–43	1.0	36%	"Mmm ... ok ... I want to find something with a good overview, not too much text ... maybe I can get something like that here"
Total	77.4	28.5	30–163	0.5	0%	
Metacognitive strategies						
Goal-setting/ planning	3.3	4.3	0–20	2.2	92%	"First I'll take a look at the whole picture, then go through specific sections"
Monitoring/ self-evaluation	10.3	8.8	0–35	1.1	56%	"Aah, now I know where Carthage is! Ok. Great. South of the, of the, of the, of the boot. Good!"
Content evaluation	22.7	15.0	0–76	1.0	18%	"Nah, that's not really very important now ... then ..."
Total	36.2	24.3	1–104	0.7	14%	
Total	113.6	45.3	36–233	0.6	0%	

Note. $N = 50$. *f*% = Percentage of persons with less than 1 coding per 5 minutes.

3 Results

3.1 Descriptive Statistics and Differences in the Use of Strategies

Descriptive statistics calculated for all motivational components, as well as those for the two measurements of topic knowledge and subjective learning gains, are displayed in Table 1. The 45-minute learning session with Wikipedia resulted, on average, in a relatively large increase in knowledge about the Roman Empire, as demonstrated by a comparison between pre-test and post-test knowledge ($t(49) = 8.036$; $p < .001$; $d = 1.14$). Nevertheless, large inter-individual differences in knowledge acquisition were observed, as indicated by the wide dispersion of the differences between pre-test and post-test knowledge ($M = 19.5$; $SD = 17.2$).

Next, in order to estimate the extent of self-regulatory learning strategy implementation, an analysis was made of the mean occurrence frequencies found for the different strategy categories within the verbal protocols (see Table 2). On average, somewhat more than 100 occurrences of strategy use were coded per subject (M = 2.5 codings per minute). In the verbal protocols twice as many indications for the use of cognitive strategies were registered than those found for the use of metacognitive strategies ($F(1,49) = 113.255$; $p < .001$; $\eta^2 = 0.70$). A detailed inspection of the frequencies revealed that a considerable proportion of the participants used metacognitive strategies rather rarely, as indicated by less than one coding per five minute interval (14% of the subjects), while all participants used cognitive strategies more often than once per five minute interval.

There were also statistically significant differences within the group of cognitive strategies pertaining to the use of the different strategies coded on the second level ($F(2,98) = 26.742$; $p <. 001$; $\eta^2 = 0.35$). These differences indicated that elaboration strategies were used somewhat more frequently than rehearsal strategies which, in turn, were used much more frequently than search strategies. Also, substantial differences occurred with respect to the use of the different metacognitive strategies ($F(2,98) = 77.483$; $p <. 001$; $\eta^2 = 0.61$). These reflect the observation that "classic" metacognitive strategies such as goal-setting and planning, and also monitoring and self-evaluation, were seldom used and significantly less frequently than the more context-specific strategy of information evaluation. Nearly all of the participants made particularly infrequent use of goal-setting and planning (less than once per five minute interval: 92% of the subjects), which may be expected due to the diminishing importance of these strategies over the course of a learning episode. It is, however, striking that the strategies of monitoring and self-evaluation, which can improve the effectiveness of learning activities over the whole course of a learning episode, were only used sporadically by more than half of the participants.

3.2 Prediction of Strategy Use

In order to analyze the effects of components of the motivation directed towards learning with Wikipedia on the use of cognitive and metacognitive strategies, separate regression analyses for each verbal protocol strategy indicator on the second level were performed. The five components of learning motivation were specified as predictors (Table 3).

Learner self-efficacy proved to be a relatively strong predictor. This motivational component positively predicted the use of elaboration strategies, the use of search strategies, and the use of metacognitive strategies of monitoring and self-evaluating. With respect to content evaluation, an effect of self-efficacy was observed at the 10%-level of statistical significance ($p = .06$).

The second motivational component with respect to own capacities, expectancy of success, also predicted strategies of content evaluation positively.

Table 3. Prediction of Strategy Use

	Cognitive strategies			Metacognitive strategies		
Predictor	Elaboration strategies	Rehearsal strategies	Search strategies	Goal-setting/ planning	Monitoring/ self-evaluation	Content evaluation
Expectancy-related motivation components						
Self-Efficacy	.29*	–.10	.47**	.15	.34*	.25^{+}
Expectancy of success	–.12	–.18	–.11	.11	.12	.29*
Value-related motivation components						
Task Value	.01	.13	–.06	–.14	–.18	–.07
Mastery approach goals	.03	.31*	.02	–.14	–.18	–.07
Mastery avoidance goals	–.28^{+}	.10	.11	.04	–.27^{+}	–.12
R^2	.20	.14	.16	.06	.26	.20

Note. N = 50. Presented are standardized regression coefficients (β s). The effects of mastery avoidance goals were tested with two-sided tests; the effects of the remaining predictors were tested with one-sided tests. ** $p < .01$. * $p < .05$. $^{+}p < .10$.

Concerning the pursuit of mastery goals by learners, a positive effect of mastery approach goals on the use of rehearsal strategies could be observed. Moreover, the results revealed negative effects, on the 10%-level, for mastery avoidance goals on elaboration strategies (p = .06) as well as monitoring and self-evaluation (p = .06). With respect to the subjective value learners ascribed to the learning content (task value), no statistically significant effects could be proven.

Overall, only small to moderate proportions of criterion variance were explained through predicting the use of cognitive and metacognitive strategies from the components of learner motivation (rf. Table 3). In particular, the use of the metacognitive activities of goal-setting and planning could not be predicted whatsoever by any of the components of learning motivation.

In order to test the assumption that learners regulate the use of cognitive strategies by means of metacognitive control, the regression models for the three cognitive strategies were expanded to include the indicators for the use of the three metacognitive strategies. Here, the metacognitive processes of goal-setting

and planning predicted the use of elaboration strategies ($\beta = .38$; $p < .01$) and rehearsal strategies ($\beta = .30$; $p < .05$), but not the use of search strategies. The media-specific metacognitive activity of content evaluation predicted the use of elaboration strategies ($\beta = .23$; $p = .09$) and the use of search strategies ($\beta = .57$; $p < .001$), but not the use of rehearsal strategies. Monitoring and self-evaluation did not predict any of the cognitive strategies. Proportions of criterion variance increased considerably and significantly for the use of elaboration strategies ($R^2 = .41$; $\Delta R^2 = .21$; $p < .01$) and search strategies ($R^2 = .50$; $\Delta R^2 = .34$; $p < .001$), but not significantly for the use of rehearsal strategies ($R^2 = .20$; $\Delta R^2 = .06$; n.s.).

3.3 Prediction of Objective and Subjective Learning Gains

Hierarchical regression analyses using post-test knowledge and subjective learning gain as dependent variables were performed to test the effects of motivation and strategy use on learning with the online encyclopedia (Table 4).

In the first step, pre-test knowledge was inserted as a predictor; therefore, in the case of post-test knowledge as a dependent variable, objective learning gains were predicted in subsequent analysis steps. In the second step, the expectancy and value related components of the motivation undergraduates summon to learn with the online encyclopedia were incorporated into the regression models. Finally, in the third step, the six verbal protocol indicators of cognitive and metacognitive strategy use were inserted.

The objectively ascertainable increase in knowledge accumulation was significantly dependent on learning motivation: Self-efficacy could substantially predict learning gains as measured with the knowledge tests. In addition, both mastery approach goals and mastery avoidance goals had positive effects on knowledge acquisition (the two-sided test of the effect of mastery avoidance goals was only significant at the 10%-level; $p = .09$). The positive effects of learning motivation remained stable, to a large degree, after inserting the strategy use indicators. This third step revealed that the use of elaboration strategies is a positive predictor of knowledge acquisition. The effects of none of the other strategies were significant.

Subjective learning gain was also, to a large degree, dependent on learning motivation. Remarkably, only value-related components were of importance here. Task value and mastery approach goals turned out to be positive predictors, mastery avoidance goals predicted (when controlling for the two aforementioned effects) subjective learning gains negatively. The consideration of strategy use again revealed the use of elaboration strategies to be the only significant predictor. With the exception of mastery avoidance goals, the effects of learning motivation remained significant after inserting the indicators of strategy use. Analyses of criterion variance explanations showed that considering motivational aspects explained both learning indicators to a considerable degree, while the additional consideration of strategy use led to only small (and non-

significant) increases in the proportions of variance explained for both objective as well as subjective learning gains.

Table 4. Prediction of Knowledge Acquisition

	Post-test knowledge			Subjective knowledge gain		
	Step 1	**Step 2**	**Step 3**	**Step 1**	**Step 2**	**Step 3**
Pre-test knowledge	.70***	.53***	.48***	.15	.15	.12
Expectancy-related motivation components						
Self-efficacy		.42***	.45**		−.13	−.12
Expectancy of success		−.15	−.10		−.10	.01
Vaiue-related motivation components						
Task value		−.12	−.14		.45***	.42**
Mastery approach goals		.19*	.18^{+}		.36**	.33**
Mastery avoidance goals		.19^{+}	.23^{+}		−.27*	−.20
Cognitive strategies						
Elaboration strategies			.24*			.30*
Rehearsal strategies			−.06			.03
Search strategies			−.04			−.02
Metacognitive strategies						
Goal-setting/planning			.02			−.08
Monitoring/self-evaluation			−.13			.00
Content evaluation			−.12			−.22
R^2	.49	.61	.66	.02	.50	.58
(ΔR^2)	(.49***)	(.12*)	(.05)	(.02)	(.48***)	(.08)

Note. N = 50. Presented are standardized regression coefficients (βs). The effects of mastery avoidance goals and the use of search strategies as well as content evaluation were tested with two-sided tests; the effects of the remaining predictors were tested with one-sided tests. *** $p < .01$. ** $p < .01$. * $p < .05$. $^{+}p < .10$.

4 Discussion

Learning with hypermedia and information made available through the internet not only facilitates self-regulated learning, but also demands it. Prototypical for hypermedia information systems in the internet are online encyclopedias, such as Wikipedia, which many people frequently utilize (Judd & Kennedy, 2010). The aim of the present study was to shed light on SRL with online encyclopedias, considered here as prototypical hypermedia environments, and to analyze its dependencies on learner motivation as well as its effects in terms of knowledge improvement.

Analyses of verbal protocols revealed a rather low application of SRL strategies for a considerable number of learners. This was particularly the case for the use of metacognitive strategies. For example, for more than half of the learners no sufficient indications of monitoring learning progress and self-evaluation were found in the verbal protocols. Moreover, large inter-individual differences were also observed for the use of cognitive strategies. Working under the assumption that SRL can be assessed validly with thinking aloud procedures (see below), these results indicate that many people do not effectively self-regulate their own learning when they search for information in hypermedia and on the internet. This confirms the findings of earlier studies on learning with digital media (rf. Azevedo & Cromley, 2004; Bannert, 2005; Haugwitz & Dresel, 2007). In principle, the reason here could lie in a lack of abilities for self-regulation, which has often been shown among younger children (Hasselhorn, 1992). For the majority of adult learners, this is less plausible. A more obvious explanation here is that a deficient use of existent self-regulation competencies is responsible for the seldom occurrence of cognitive and metacognitive strategy use (rf. Dresel & Haugwitz, 2005). In accordance with previous findings (e.g. Artelt, 1999) the analyses of verbal protocol data could show that the application of cognitive strategies (elaboration strategies, search strategies) is dependent on the use of metacognitive strategies, which themselves had no direct effect on knowledge acquisition. This result pattern underpins the overriding regulatory function of metacognitive control for the context of learning with digital media (see also Bannert, 2005).

Against the background of theoretical premises and empirical evidence on learning processes in secondary and tertiary education, it was assumed that both the quantity and quality of SRL engaged depend heavily on certain motivational preconditions (for an overview see Pintrich & Zusho, 2007). In contrast, surprisingly small degrees of variance could be explained by the prediction of strategy use from five relevant components of learning motivation, which were in the lower part of the range of the proportions of explained variance in studies using global self-report to assess SRL (e.g. Dresel & Haugwitz, 2005). The self-efficacy reported by the learners proved to be the relative best predictor, which was in accordance with prior research (e.g. Pintrich, 1989; Pintrich & Garcia, 1991; Pintrich & Schrauben, 1992). Remarkable, in terms of mastery avoidance goals, is that indications were found that these goals are negatively related to the

use of adaptive strategies (elaboration strategies, monitoring/self-evaluation) after controlling for the effects of mastery approach goals and other components of learning motivation. This finding supplements the relatively sparse literature on the ambivalent effects of mastery avoidance goals in the context of media-based learning (rf. Elliot & McGregor, 2001; Maehr & Zusho, 2009; Moller & Elliot, 2006). Verbal protocol data of strategy application while learning with Wikipedia also predicted objective and subjective learning progress only to a small degree. After controlling for the effects of learner motivation, incremental proportions of explained variance of both criteria of knowledge acquisition were small and not significantly different from nil. Although the use of elaboration strategies fostered knowledge acquisition (and its subjective representation), which is in accord with the existing literature (e.g. Azevedo et al., 2004, for the context of learning with hypermedia), this effect was only small to moderate.

The reasons behind the rather low interrelations found between strategy application with learning motivation and knowledge acquisition could well be traced to the data collection method based on recording verbalized thoughts (rf. Ericsson & Simon, 1993). The thinking aloud procedure is non-reactive in terms of non-altering performance (see Fox, Ericsson, & Best, 2011, for a meta-analysis on this topic), is, in contrast to global self-reports of SRL, adequate to assess the dynamic and situation-specific processes of SRL (rf. Spörer & Brunstein, 2006), and can result in objective and reliable data (as was the case here, cum grano salis). However, the thinking aloud procedure has the limitation that it is rather incapable of capturing automatic, unconscious or inchoate cognitions (e.g. Wilson, 1994; see also Schooler, 2011). It can be assumed that processes of self-regulation may be executed automatically and remain unconscious in many cases (e.g. Garner, 1990). As Dresel and Haugwitz (2005) argued, the degree of consciousness may even vary from strategy to strategy (for example the meta-cognitive selection of a highlighting strategy may be less conscious than its application) and from task to task (for example dependenton task difficulty). Winne (2010) pointed out further limitations of thinking aloud protocols in measuring SRL which address SRL contextualization. On the other hand, in previous research on SRL with digital media, thinking aloud protocols revealed insightful results which are hardly questionable in terms of different aspects of their validity (e.g. Azevedo & Cromley, 2004). Therefore future research should clarify for which aspects of SRL the thinking aloud procedure is suitable and for which aspects it is not (rf. Azevedo, Moos, Johnson & Chauncey, 2010; see also Greene et al., 2011).

In contrast to the low predictive power of verbal protocol indicators of strategy use, learner motivation turned out to be much more relevant for the objective and subjective amount of knowledge acquisition – also after indicators of strategy use were inserted into the regression models. Beyond the limitations of thinking aloud protocols already discussed, this is in line with the results of a recent meta-analysis in the context of work-related training which indicate that self-efficacy and goal level are stronger predictors than strategy use itself

(Sitzmann & Ely, 2011). From a theoretical perspective, it is worth noting here that both expectancy-related components as well as value-related components of learning motivation were of importance. This leads to the conclusion that in the context of individual learning and information search with hypermedia – which at first does not seem to be an achievement or a social context – a comprehensive understanding of learner motivation utilizing a social-cognitive view of learning and achievement motivation is necessary in order to appropriately model motivational effects. Similar to the findings for strategy use, learner self-efficacy proves to be a good predictor of objective knowledge increases while learning with Wikipedia. Moreover, mastery goals were of importance. Interestingly, the pattern of relevant predictors of subjective knowledge gains differed from that for objective knowledge gains: value-related components were of predominant importance here and mastery avoidance goals functioned as a negative predictor of subjective learning gain. The latter, again, points to the ambivalent nature of this type of goal (rf. Maehr & Zusho, 2009). In general, the result pattern indicates that subjective inferences of learning progresses, the accuracy of which is highly important for an adequate regulation of own learning, are often incorrect and biased in dependence on an individual's motivation (rf. Narciss, Koerndle, & Dresel, in press). This leads to an apparently paradoxical constellation: Good learning motivation has positive effects in terms of initiating and maintaining strategy application, but can have negative effects in terms of biasing self-evaluation. This paradox is somewhat offset, if one takes into account that different components of motivation (according to the present data) are involved in these two processes. Nevertheless, more comprehensive research on the topic of processes and effects of different components of learner motivation in the context of learning with digital media would be desirable.

This research desideratum can also be attributed to the fact that the present investigation is subject to some limitations. In addition to the relatively small sample size (and the subsequent reduced power rates), the value-related components of motivation could only be measured retrospectively, following the learning phase. In addition the knowledge test used here operationalized descriptive knowledge exclusively, and did not address conceptual shifts (e.g. Azevedo et al., 2004).

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