Does Adaptation to Task Complexity Guarantee Success in Learning? Processes and Conditions of Beneficial Adaptation in Self-Regulated Learning

Stephanie Pieschl (pieschl@uni-muenster.de),
Rainer Bromme (bromme@uni-muenster.de),
Torsten Porsch (t.porsch@uni-muenster.de)
Department of Psychology, University of Muenster,
Fliednerstr. 21, 48149 Muenster, Germany

Elmar Stahl (elmar.stahl@ph-freiburg.de)
University of Education,
Kunzenweg 21, 79117 Freiburg, Germany

Abstract

Most theories of self-regulated learning (Winne & Hadwin, 1998) assume that adaptability is one key competency of self-regulation that should be associated with success in learning. Within previous studies, learners indeed demonstrated significant adaptation to task complexity; however, empirical results so far do not indicate a straightforward positive relationship with learning success (Pieschl, Bromme, & Stahl, submitted). In this study, students (n = 129) solved three differently complex tasks within a hypertext. Their learning process was captured in detail and showed significant adaptation to task complexity on all variables. For example, students spent most time on the most complex task. Additionally, we analyzed two important but independent indicators of learning success: *quantity* and *quality*. In both cases, successful students strongly adapted their learning to task complexity. Additionally, quantitatively successful students followed a high-speed strategy whereas qualitatively successful students followed a deep-elaboration strategy, especially for the most complex task.

Keywords: Adaptation, Self-Regulated Learning, Task Complexity.

Theoretical Introduction

Most theories of self-regulated learning assume that adaptation to external characteristics is a key competency of good self-regulation and thus should be beneficial for learning (Pintrich, 2004; Zimmerman, 2002).

More specifically, we refer to the COPES model of studying (Winne & Hadwin, 1998) as guiding heuristic. This model emphasizes the pivotal influence of given learning tasks, learners' (metacognitive) monitoring of task features, and corresponding task interpretations on learning (also see Butler & Cartier, 2004): In the first stage of studying, good learners are assumed to form a thorough *task definition*. This task definition should be influenced by the task itself, for example by the complexity of the task. In addition, learners' should generate hypotheses about missing or ambiguous information, for example they may assume suitable learning strategies based on their metacognitive knowledge. All subsequent stages are impacted by these task definitions: Good learners are assumed to generate idiosyncratic goals and construct an elaborate plan for addressing the tasks during *goal setting and planning*. In the *enactment* stage they are assumed to execute this plan and within the *adaptation* stage they may revise it. To summarize: Learning is influenced by external conditions (task complexity) as well as by internal conditions (learners' metacognitive knowledge).

In accordance with this model, empirical studies show that learners adapt their learning process substantially to task complexity: For example, they plan more deep processing learning strategies (Bromme, Pieschl, & Stahl, submitted) and access more hypertext pages (Pieschl, Bromme, & Stahl, submitted) for more complex tasks.

However, opposed to the idealized COPES model, empirical results also show that learners demonstrate less adequate self-regulation, use of fewer learning strategies, and imprecise information search for complex tasks (Rouet, 2003; Veenman & Elshout, 1999; Winne & Jamieson-Noel, 2003). Furthermore, so far no consistent positive relationship between adaptation to task complexity and learning success could be demonstrated (Pieschl, Bromme, & Stahl, submitted).

Based on these conflicting findings, we will address the following research questions in this study: (1) Do learners adapt their learning to task complexity? (2) Is adaptation to task complexity beneficial for learning success? For the second question, we will analyze two independent but equally important aspects of learning success: *quantity* (large number of correctly solved tasks) and *quality* (best written argumentative essays). In order to answer these questions, our participants had to solve differently complex tasks within a hypertext about genetic fingerprinting.

Method

Participants

Participants of this study were students (n = 129, 35 males, 94 females) with a mean age of 24 years (SD = 4.48). On average they studied in the fifth semester (SD = 3.26) psychology (n = 51), other humanities (n = 40), sciences (n = 17), or miscellaneous other majors (n = 21).

Materials

Questionnaires about Learner Characteristics We measured students' *prior domain knowledge* about genetics. We captured their *epistemological beliefs* with a domain-general questionnaire (Wood & Kardash, 2002) and a domain-dependent questionnaire (Stahl & Bromme, 2007). Furthermore, we measured their *motivational orientation* (Balke & Stiensmeier-Pelster, 1995) and their *need for cognition* (Bless, Wänke, Bohner, Fellhauer, & Schwarz 1994). None of these variables elicited any effects; therefore, we will report no further information.

Tasks of Different Complexity Task complexity varied according to Bloom's revised taxonomy, which is based on a hierarchy of cognitive operations as underlying rationale (Anderson et al., 2001). Students worked on between 3 and 10 tasks. In our analyses we focus on three consecutive tasks that were solved by more than 90 % of students: Task A is a simple factual "remember" task with a multiple-choice format ("Which steps are not part of the mtDNA analysis?" correct answer out of five alternatives: "Determining a band pattern with gel electrophoresis."), task B is a complex "evaluate" task in an open-answer format ("Imagine that you study biology. As part of a term paper you have to discuss the suitability of Y-STR analysis and STR analysis for paternity testing." (excerpt)), and task C is a factual "remember" task in an open-answer format ("Your family is into genealogy and had mtDNA profiles of all family members made. The experts speak of 'matches'. What does this term mean?" (excerpt)). Note that task complexity in this sense is not necessarily related to task difficulty as determined by the percentage of correct solutions in a population: A task could be very simple in the sense of Bloom (require a "remember" operation) but still be very difficult because only few people know the answer (example: What is the capital of Mongolia? Ulanbaataar).

We used task complexity as exemplified by tasks A through C as within-subject repeated-measure variable in our analyses. These three tasks enabled us to investigate all aspects of students' adaptation to task complexity (research question 1): Do students enhance their processing if confronted with a more complex task after a simple task (A vs. B)? Do students decrease their processing if a simple task requires less elaboration after a complex task (B vs. C)?

Learning Success We distinguish two desirable properties of learning success: high *quantity* and *quality*.

More specifically, on the one hand, we consider students' number of correctly solved tasks (NCT) as an indicator of solution *quantity*. The best student was able to solve 10 tasks correctly and the worst students solved zero tasks correctly ($M = 4.34$; $SD = 1.84$). Note that we analyzed all tasks to compute NCT, not only tasks A through C. In our analyses regarding research question 2, we compare extreme groups of quantitatively successful students who solved five or more tasks correctly (NCT+; $n = 47$) with students who were quantitatively unsuccessful and solved three or fewer tasks correctly (NCT-; $n = 44$).

On the other hand, we consider students' score on the most complex evaluate essay task B (CET) as an indicator of solution *quality* (sample sub-scores: number of discussed methods and quality of argumentation). The best students received 14 points for the essay and the worst students three points ($M = 8.54$; $SD = 2.52$). In our analyses regarding research question 2, we compare extreme groups of qualitatively successful students who received eleven points or more (CET+, $n = 30$) with qualitatively unsuccessful students who received six points or less (CET-, $n = 29$).

Hypertext Logfiles The hypertext about genetic fingerprinting was created with MetaLinks (Murray, 2003) and contains 106 pages. The hierarchical structure of the hypertext offers introductory material that is comprehensible for laypersons as well as further details on multiple levels which require expert understanding – at least on the deepest hierarchical level. All technical terms are explained in a hyperlinked glossary.

During task solution, logfiles of students' navigation were automatically generated. We computed multiple scores for each of the three tasks: We analyzed students' *number of accessed pages or nodes* (NAN) and their *time for task completion* (TTC) as rough indices of their elaboration. Furthermore, we analyzed their use of *hierarchical commands* (HC; example: go to the next deeper hierarchical level for further details) as an indicator of how much students follow the given structure of the hypertext and their use *"jump" commands* (JC; example: use the table of content to access any page) as an indicator of how much students purposefully select content. We assumed that students would demonstrate adaptation with regard to task complexity on these variables (research question 1).

Task-Specific Questionnaire Students answered a task-specific questionnaire for each of the three tasks; to remind students of each specific task these tasks were always visible on the page opposite the questions: We extracted three scales: *judged task complexity* (9 items, $\alpha = .91$; sample item "This task was simple – complex."), self-reported *task satisfaction* (5 items, $\alpha = .82$; sample item: "My strategies were inefficient – efficient."), and self-reported *depth of processing* (10 items, $\alpha = .85$; "The strategy of critically evaluating hypertext pages is unimportant – important."). We assumed that students would demonstrate adaptation with regard to task complexity on these variables (research question 1).

Procedure

Students were recruited by a posting at the University and received 18 € as reimbursement for participation. They were invited via e-mail and filled in an internet questionnaire about their learner characteristics. It took approximately 15 minutes and measured their epistemological beliefs, motivational orientation, and need for cognition. The main part of the study was conducted with groups of 2 – 10 students and lasted approximately 2 hours: First, students' prior domain knowledge was tested. Second, they received a short training about hypertext navigation and read a printed introduction to molecular biology on high school level (for example about the structure of DNA). Third, students had one hour time to solve tasks with the hypertext about genetic fingerprinting. They were told that they should concentrate on high-quality solutions rather than on speed. At the beginning they were given a booklet with the first five tasks. Upon request, they could get further booklets with further tasks. Fourth, students had to fill in the task-specific questionnaire for tasks A through C.

Results

We report only significant effects with $p < .05$. At first, we analyzed our measures of learning success: Solution *quantity* (NCT) proved to be independent of solution *quality* (CET) (r = .01, n.s., n = 129). This is underlined by the differential effects of these variables with regard to the number of worked tasks (not necessarily solved correctly): While NCT+ students worked on significantly more tasks (M = 7.45, SD = 1.73) than NCT- students (M = 4.07, SD = .97; t (89) = -11.38, $p < .001$), CET+ students' number of worked tasks (M = 5.40, SD = 1.59) did not differ significantly from CET- students' (M = 5.93, SD = 2.23). If we compared *quantitatively* successful NCT+ students' number of worked tasks (M = 7.55, SD = 1.78) with *qualitatively* successful CET+ students' number of worked tasks (M = 4.77, SD = 1.07), this difference was also significant (t (58) = 6.65, $p < .001$). For this analysis students who were part of both successful groups, NCT+ as well as CET+ (n = 8), were excluded; however, the same results were obtained if these students were included in either the NCT+ or the CET+ group. To conclude, our two measures of learning success turned out to be independent and students who solved many tasks correctly (NCT+) worked on significantly more tasks than less successful NCT- students and qualitatively successful CET+ students.

To answer our research questions, we computed repeated-measure ANOVAs for all questionnaire and logfile variables separately; task complexity was used as repeated-measure factor (tasks A, B, and C); groups with different learning success were included as factor in each analysis (NCT or CET). Significant adaptation (research question 1) was diagnosed if the simple tasks A and C differed significantly from the complex task B (effects of the repeated-measure factor). A significant relation between adaptation and learning success (research question 2) was diagnosed if groups with either different *quantitative* (NCT) or *qualitative* (CET) learning success differed significantly.

NCT: Quantitative Learning Success

Task-Specific Questionnaire For the scale *judged task complexity* we found an effect of the repeated-measure factor task complexity (F (2,78) = 118.72, $p < .001$, η_p^2 = .75) and a main effect of NCT groups (F (1,79) = 5.86, p = .018, η_p^2 = .07): The corresponding graph (Figure 1, left) indicates that students judged task B to be more complex than tasks A or C and that NCT+ students considered all tasks less complex than NCT- students.

For the scale *task satisfaction* we found an effect of the repeated-measure factor task complexity (F (2,78) = 22.06, $p < .001$, η_p^2 = .36) and a main effect of NCT groups (F (1,79) = 6.81, p = .011, η_p^2 = .08): The corresponding graph (without Figure) indicates that students reported less task satisfaction for task B than for tasks A or C and that

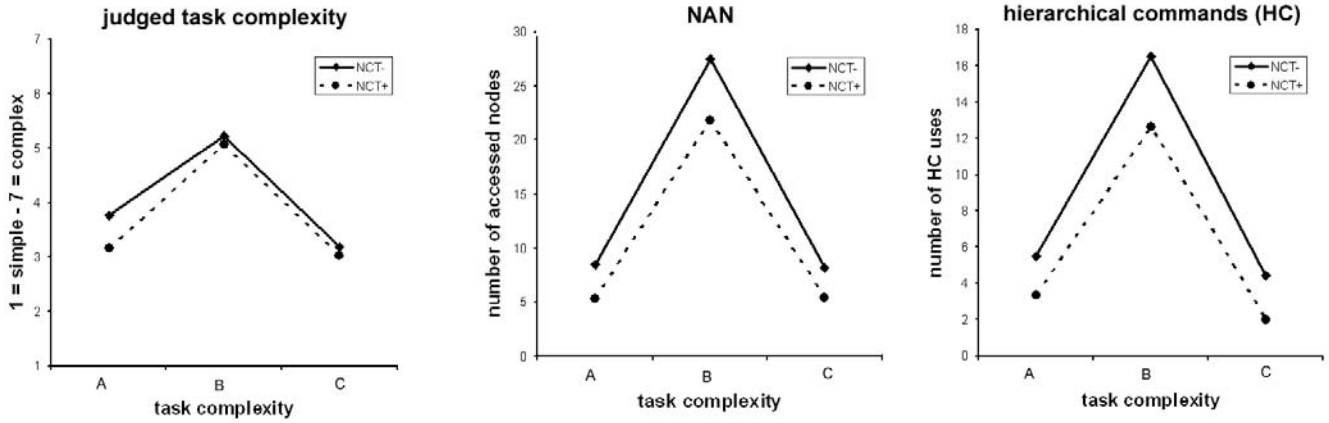

Figure 1: Students *judged task complexity* (left), their *number of accessed nodes* (middle), and their use of *hierarchical commands* (right) as a function of task complexity (x-axis) and *quantitative* learning success (NCT groups).

NCT+ students indicated higher task satisfaction for all tasks than NCT- students.

For the scale *depth of processing* we found an effect of the repeated-measure factor task complexity (F (2,78) = 87.73, p < .001, , η_p^2 = .69): Students indicated deeper processing for task B than for tasks A or C.

Hypertext Logfiles For students' *number of accessed nodes* (NAN) we found an effect of the repeated-measure factor task complexity (F (2,77) = 70.95, p < .001, η_p^2 = .65) and a main effect of NCT groups (F (1,78) = 7.56, p = .007, η_p^2 = .09): The corresponding graph (Figure 1, middle) indicates that students accessed more nodes for task B than for tasks A or C and that NCT+ students accessed less nodes across all tasks than NCT- students.

For students' *time for task completion* (TTC) we found an effect of the repeated-measure factor task complexity (F (2,77) = 201.08, p < .001, η_p^2 = .84), a main effect of NCT groups (F (1,78) = 30.18, p < .001, η_p^2 = .28), and an interaction between task complexity and NCT groups (F (2,77) = 3.95, p = .023, η_p^2 = .10): The corresponding graph (without Figure) indicates that students needed more time for task B than for tasks A or C, that NCT+ students needed less time across all tasks than NCT- students, and that this effect was most pronounced for task B.

For students' use of *hierarchical commands* (HC) we found an effect of the repeated-measure factor task complexity (F (2,77) = 64.55, p < .001, η_p^2 = .63) and a main effect of NCT groups (F (1,78) = 7.53, p = .008, η_p^2 = .09): The corresponding graph (Figure 1, right) indicates that students used more hierarchical commands for task B than for tasks A or C and that NCT+ students used less hierarchical commands than NCT- students.

For students' use of *"jump" commands* (JC) we found an effect of the repeated-measure factor task complexity (F (2,77) = 15.55, p < .001, η_p^2 = .29) and an interaction between NCT groups and task complexity (F (2,77) = 3.47, p = .036, η_p^2 = .08): The corresponding graph (without Figure) indicates that students used more "jump" commands for task B than for tasks A or C and that NCT+ students used more "jump" commands for the complex task B than NCT- students.

CET: Qualitative Learning Success

Task-Specific Questionnaire For the scale *judged task complexity* we found an effect of the repeated-measure factor task complexity (F (2,51) = 57.95, p < .001, η_p^2 = .69) and an interaction between CET groups and task complexity (F (2,51) = 4.76, p = .013, η_p^2 = .16): The corresponding graph (Figure 2, left) indicates that students judged task B to be more complex than tasks A or C and that CET+ students considered tasks A and C less complex and task B more complex than CET- students.

For the scale *task satisfaction* we found an effect of the repeated-measure factor task complexity (F (2,51) = 14.47, p < .001, η_p^2 = .36): The corresponding graph (without Figure) indicates that students reported less task satisfaction for task B than for tasks A or C.

For the scale *depth of processing* we found an effect of the repeated-measure factor task complexity (F (2,51) = 65.99, p < .001, η_p^2 = .72) and an interaction between CET groups and task complexity (F (2,51) = 7.97, p = .001, η_p^2 = .24): The corresponding graph (without Figure) indicates that students reported deeper processing for task B than for tasks A or C and that CET+ students indicated more deep processing for task B than CET- students.

Hypertext Logfiles For students' *number of accessed nodes* (NAN) we found an effect of the repeated-measure factor task complexity (F (2,51) = 54.76, p < .001, η_p^2 = .68) and an interaction between CET groups and task complexity

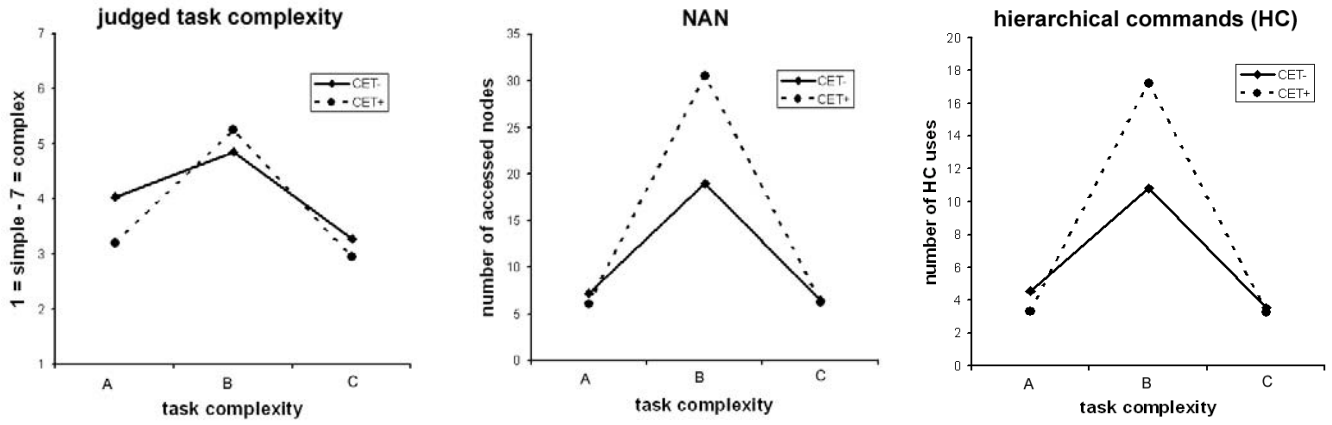

Figure 2: Students *judged task complexity* (left), their *number of accessed nodes* (middle), and their use of *hierarchical commands* (right) as a function of task complexity (x-axis) and *qualitative* learning success (CET groups).

(F (2,51) = 5.99, p = .005, η_p^2 = .19): The corresponding graph (Figure 2, middle) indicates that students accessed more nodes for task B than for tasks A or C and that CET+ students accessed more nodes for task B than NCT- students.

For students' *time for task completion* (TTC) we found an effect of the repeated-measure factor task complexity (F (2,51) = 127.26, p < .001, η_p^2 = .83), a main effect of CET groups (F (1,52) = 13.52, p = .001, η_p^2 = .21), and an interaction between CET groups and task complexity (F (2,51) = 11.59, p < .001, η_p^2 = .31): The corresponding graph (without Figure) indicates that students spent more time on task B than on tasks A or C and that CET+ students spent more time on task B than NCT- students.

For students' use of *hierarchical commands* (HC) we found an effect of the repeated-measure factor task complexity (F (2,51) = 41.65, p < .001, η_p^2 = .62) and an interaction between CET groups and task complexity (F (2,51) = 5.25, p = .008, η_p^2 = .17): The corresponding graph (Figure 2, right) indicates that students used more hierarchical commands for task B than for tasks A or C and that CET+ students used more hierarchical commands for task B than NCT- students.

For students' use of *"jump" commands* (JC) we found an effect of the repeated-measure factor task complexity (F (2,51) = 9.53, p < .001, η_p^2 = .27): The corresponding graph (without Figure) indicates that students used more "jump" commands for task B than for tasks A or C.

Discussion

Do Learners Adapt to Task Complexity?

Students adapted their whole learning process significantly to task complexity: We found significant effects of the repeated-measure factor task complexity in all our analyses. More detailed analyses comparing the different levels of this repeated-measure factor (not reported) as well as the Figures show that the simple remember tasks A and C differ significantly from the complex evaluate task B on all variables: Students considered task B more complex, they reported less task satisfaction but more deep processing for task B, and they used more pages (NAN), more time (TTC), more hierarchical (HC) and jump commands (JC) for the solution of task B. Thus, they significantly enhanced their processing from a simple to a complex task (A vs. B) and they significantly decreased their processing from a complex to a simple task (B vs. C). Therefore, we can answer our first research question affirmative.

Furthermore, these results build on results from other studies: They replicate results from strictly controlled experimental research (Luwel, Verschaffel, Onghena, & De Corte, 2003) within a more ecologically valid learning scenario. And they expand results from the preparatory planning stages of self-regulated learning (Bromme, Pieschl, & Stahl, submitted) to the whole process of learning (Winne & Hadwin, 1998). Additionally, these results go beyond a mere diagnosis of time-dependent "fluctuation" (Moos & Azevedo, 2006) by systematically relating students' judgments and actions to an external criterion such as task complexity (Pieschl, in press).

Is Adaptation to Task Complexity Beneficial?

NCT: Quantitative Learning Success *Quantitative* success indicated by the number of correctly solved tasks was significantly related to the learning process; the NCT factor elicited six main effects and three interaction effect: More successful students (NCT+) considered tasks simpler, indicated higher task satisfaction, accessed less pages (NAN), spent less time on the complex task B (TTC), used less hierarchical commands (HC), and used more jump commands for the complex task B (JC) than their less successful counterparts (NCT-).

As can be seen in Figure 1, the quantitatively successful (NCT+) as well as the unsuccessful (NCT-) students strongly adapted their learning process to task complexity. Successful students (NCT+) were just more selective and faster on all tasks (see main effects above); they seem to follow a "less is more" and a "faster is better" heuristic. We assume that these students initially set quantitative learning goals in the preparatory stages of learning (for example: "I want to solve as many tasks as possible.") and selected corresponding strategies to reach these goals in the enactment stage (for example: "I only look at the most essential information for each task."). Consequently, quantitatively successful students seem to be well-adapted to their goals as well as with regard to task complexity.

CET: Qualitative Learning Success *Qualitative* success indicated by the score of the essay for the complex evaluate task was significantly related to the learning process; the CET factor elicited six interaction effects and two main effects: More successful students (CET+) considered task B more complex, indicated more deep processing for task B, accessed more pages for task B (NAN), spent more time on task B (TTC), and used more hierarchical commands for task B (HC) than their less successful counterparts (CET-).

As can be seen in Figure 2, the qualitatively successful (CET+) as well as the unsuccessful (CET-) students adapted their learning process to task complexity. However, this adaptation was much stronger for successful students: Their judgments and actions differed much more between the simple remember tasks A and C and the complex evaluate task B (interaction effects). They seem to follow a "put special effort in complex tasks" heuristic. We assume that these students initially set qualitative learning goals in the preparatory stages of learning (for example: "I want to give elaborate answers on complex questions.") and selected corresponding strategies to reach these goals in the enactment stage (for example: "I exhaustively collect all relevant information before answering a complex task.").

Consequently, qualitatively successful students seem to be well-adapted to their goals as well as with regard to task complexity.

Conclusion and Implications

All successful students adapted their learning strongly to task complexity and tailored their whole learning process in a meaningful way to their specific goals. Furthermore, *quantitatively* unsuccessful students also adapted their learning to task complexity but were slower and less precise in their search for information. *Qualitatively* unsuccessful students failed to adequately perceive differences in task complexity and therefore did not adapt their learning processes sufficiently. Thus, research question two can be answered in the following way: For *quantitative* success no relation between adaptation and success could be found, differences were rather due to different speeds of task solutions. For *qualitative* success on the other hand adaptation to task complexity was clearly beneficial.

These results have implications for educational practice: First, quantitative and qualitative success proved to be independent and seemed to require different tactics. Educators therefore should be aware of this distinction and explicitly communicate task demands to students. Second, quantitatively and qualitatively less successful students might need different kinds of support: While quantitatively unsuccessful students might profit best from repeated practice to speed up their learning process, qualitatively unsuccessful students additionally need scaffolding with regard to adequate task interpretations.

Acknowledgments

This study was funded by the German Research Foundation (DFG). We thank our student research assistants of this project: Leoni Pytlik and Janina Wolters.

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