The role of expert feedback during a learning-by-drawing task

Master´s thesis

Psychology

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Date: 24.12.2012
Place: University of Twente, Enschede

Table of Contents

Abstract

This study investigates the role of feedback in form of expert-drawings during a learning-by-drawing task. Therefore 49 seventh graders from a German secondary school ("Gymnasium") took part in the research. One class was assigned to the control group, the other to the experimental group. The experiment took place within the biology lessons of the classes covering the domain of mushrooms and natural cycles with mushrooms. During the experiment both groups were asked to read text passages and then to create a drawing about the content of this text. Students from the experimental class achieved feedback in form of an expert-drawing (illustration) and had the chance to correct and enhance their own drawing with help of it. Data was gathered via a pre-, a post-, and a retention test. The tests consisted of a word recognition task and a multiple choice test. Students from the experimental group scored higher on the word recognition task than their counterparts from the control group. On the multiple choice test no significant difference between groups was found. This findings lead to the conclusion that support in form of illustrations may switch attention of the student to new issues of a task and therefore enhances at least the familiarity with the field of learning. This is in line with existing models of learner generated drawings.

I. Introduction

Learning by drawing

The use of representations in science education is not a new phenomenon in schools. Well known examples are models of a cell in a biology class, pictures of molecules in chemistry, or a plan of an electric circuit in physics. However, the self-creation of graphical representations, has the potential to enhance learning more than simply presenting students with given representations (van Meter & Garner, 2005; De Jong, 2005; van Dijk, Gijlers & Weinberger, in preparation).One way to do this is by constructing drawings of natural phenomena, that are presented to the students in text. This is referred to as a generative method (Mayer & Sims 1994). That means it helps to identify important components of a task, and further, makes it easier to translate information between different representational formats. This is in line with a constructivist point of view (e.g. Piaget, 1926). Various studies suggest that the creation of self-generated drawings from text can facilitate learning (van Meter, 2001; van Meter & Garner; 2005, Alesandrini, 1981; Linden & Wittrock, 1981). A recent review on learning by drawing (Ainsworth et al., 2011) identifies five reasons, why learning by drawing should be considered as a valuable approach for science instruction:

a) students take a more active role than via traditional learning styles. This seems to be motivating (Hackling & Prain, 2005) and therefore it enhances engagement.
b) drawing tasks help to build and to understand students´ own representations, which should lead to a better grasp about how and why representations are used in science (e.g. Gilbert, 2005).
c) when creating a drawing students learn how to reason in science. This occurs because they have to reflect about the selection of specific features, which should be used (e.g. Meter & Garner, 2005).
d) “drawing as learning strategy” (Ainsworth et al., 2011). It describes the fact that students should be able to organize, integrate, and transfer knowledge via effective learning strategies (e.g. Chi, Bassok, Lewis, Reiman, & Glaser, 1989). Creating drawings is such a strategy, because the learner has to understand, translate and represent a specific issue (Ainsworth et al., 2010).
e) creating an external representation helps students to discuss their own ideas and reasoning with others (Schwartz, 1995). In that case the drawings serve as a communication aid.

The reasons listed by Ainsworth and colleagues (2011) are in line with constructivist approaches towards learning as it stresses students´ activity in building their own representation, as well as in reasoning and reflection on the representation. Drawing is considered a learning strategy since we expect students to benefit from the process of translating textual information into a static representation.

The drawing task in the present study covers the first up to the fourth principle stated by Ainsworth (Ainsworth et al., 2011) by allowing students to create their own drawing based on a scientific text. Students in the experimental conditions will receive an illustration of an expert drawing that assists them in the process of creating a scientific drawing that covers the knowledge that is represented in the text.

Supporting drawing tasks

The best drawing tasks are just as good as the way they are supported (van Meter, 2001). There are several studies that address how information should be presented to the learner in the form of either a text or a graphical representation to enhance learning (Mayer, 2009). There are only a few studies that address how learning by drawing settings should be designed to support learning from text (Leopold & Leutner, 2012; Schwamborn, Mayer, Thillmann, Leopold, & Leutner, 2010; van Meter, 2001).

More specifically, results of a study by Leutner et al. (2009) revealed that unassisted tasks seem to lead to less comprehension and increased cognitive load. Unfortunately there are only a few studies on how to support text based drawing in the right way (van Meter & Garner, 2005). An attempt is made by van Meter, Aleksic, Schwarz, & Garner (2006) where a model of the learner-generated drawing process is presented. This model is based on both Mayer´s Generative Theory and Pavio´s Dual Coding and stresses the importance of external support. Based on their model van Meter and colleagues (2006) stated that there are at least three ways to support learning by drawing:

“Support may act to: (1) constrain the construction of drawings (e.g., Lesgold, Levin, Shimron, & Guttman, 1975); (2) prompt checking the accuracy of constructed drawings (Van Meter, 2001); (3) and/or direct learners´ attention to key elements and the relationships amongst these (Alesandrini, 1981).”

One way to achieve these goals involves the use of scaffolds. Scaffolds are tools that assist students in solving tasks or problems that are too difficult for the students to solve on their own (Mc Kenzie, 1999). An example of a scaffold is a tool that helps students with the process management of a larger learning task by formulating restrictions or smaller steps in a large and complex task. Swaak, van Joolingen, & de Jong (1996) successfully used this strategy in an inquiry learning setting. When students entered the inquiry environment they worked with a simplified version of the model. The complexity of the model was gradually increased during the learning session.

Another form of support can be offered via feedback. It offers a chance for students to appraise and rethink their own actions, which might be helpful to achieve a better understanding of a topic. Feedback can be given differently. For example through peers during collaboration (e.g. van Dijk, Gijlers, Weinberger, in preparation), through adaptive assistance in a computer based learning environment (e.g. Veermans, de Jong, & van Joolingen, 2000), or through experts via written text or descriptive representations (e.g. Schwamborn, Thillmann, Opfermann, & Leutner, 2011; van Meter et al., 2006). Students can also be supported by useful representations that allow them to inspect another view of the same object or data, or by expert guidance that is embedded in the learning environment (Quintana et al., 2004). The last one seems especially reasonable for a drawing task.
Therefore, present study will examine the value of feedback in form of illustrations. In the past some studies were engaged in the same field of research. They are discussed in the following section.

Supporting the drawing process

Schwamborn and colleagues (2011) tested with a 2x2- factorial design if there are possible effects of computer based picture generation and pictorial support on cognitive load and comprehension. 102 ninth and tenth graders read a computer-based text on chemical processes of washing and answered questions on cognitive load and comprehension. The results showed that support in form of provided pictures seems to have positive influence on comprehension tests and simultaneously reduces cognitive load. Picture generation also indicated main effects, but seemed to enhance cognitive load. According to the author these results are in line with cognitive load theory and generative theories of learning (Schwamborn et al., 2010). However, in this study picture generation occurred via a drag-and-drop method of elements. Thus, the student takes not the active part as it is described in the model of learner generated drawing (van Meter et al., 2006) and therefore seems to be engaged in less metacognitive processes.
In another study, which also used learner generated drawings to learn from content area text, van Meter et al. (2006) tested 135 fourth and sixth graders on four different versions of a “learning by drawing” task. Support varied between the four conditions:

a) Non-drawing control
b) Drawing
c) Drawing with illustration feedback
d) Drawing with illustration feedback and prompt questions

In all drawing conditions, participants read a two page science text about birds´ wings. After each page a drawing was constructed to represent the most important text features. Participants in the illustration condition (c+d) were provided with an illustration after each drawing task. That could be inspected to check the accuracy of the constructed drawings. In addition, participants from the prompt condition (d) answered a series of questions after achieving the illustration. Those questions should guide the process of comparing constructed drawings to provided illustrations. In the non-drawing control condition (a) participants also were provided with illustrations and prompt questions after each text page. In this condition prompt questions were designed to direct the comparison of text and illustrations. The study showed that the students of all drawing conditions (b+c+d) performed better than those of the control group. Participants with the most feedback (d) did it best; however, between drawing-only students (b) and those who had additional illustration feedback (c) no significant differences were found on both problem-solving and recognition. That raises the question if this kind of support is entirely needless. Current study will deal with this assumption. The setup of van Meter and colleagues (2006) might be criticized for the tests included very few items. In addition, the authors of the study make distinction between higher-order and lower-order assessments. Recognition is declared as lower order and was tested with a multiple choice test. However, recognition might also be divided in high- and low-order. "Recollection" seems to require different parts of the brain and deeper processing than "familiarity" (Medina, 2008). Van Meter et al. (2006) only address "recollection" when she is talking about a lower-order assessment. Maybe it would be interesting to see if at least the storage of memories regarding "familiarity" gets influenced by support. For this purpose a word recognition task might be appropriate.

Another criticism regards the absences of a retention measure, which makes it hard to say if information really got stored on long term (e.g.: the prompt questions directly referred to the post-test. Thus, it is not clear whether the information really got processed better or there was a kind of priming effect. A retention test after a period of time would help to answer this).

A further remark might be made on the fact that the gender of the participants did not matter during analysis. In addition, analyzing the quality of learner created drawings might give deeper insight in the usefulness of learning-by-drawing (van Dijk, 2010). The quality, on the one hand, might be assessed by examining if students used the right terms and relations in their drawings, thus by determining the "functionality" of a drawing. On the other hand, it might be investigated if esthetic issues, such as "beauty" of a drawing, play a role for learning. Current study tries to examine those issues.

Research Questions

From the issues described above arise the following research questions:

1. What are the effects of expert feedback (in form of an illustration) on knowledge construction during a learning-by-drawing task done by seventh-graders?
   1.1. Are there effects depending on gender?
   1.2. Does expert feedback influence the quality of drawing?
      1.2.1. Are there effects on the "functionality" of the drawing?
      1.2.2. Are there effects on the "beauty" of the drawing?

Knowledge construction is measured via a multiple choice test and a word recognition task. Based on the literature discussed above we expect that participants of both conditions will not differ in score on the multiple choice test, but maybe on the word recognition task. If gender differences will be found we expect better results from girls than from boys, due to age related and developmental issues. In addition, the "functionality" of a drawing should play a greater role in learning than the "beauty".

II. Method

Participants

The sample consisted of 49 seventh-graders (aged 12-14) from two different classes of a German secondary school preparing for higher education (Gymnasium). One of the classes had 27 students including 14 boys and 13 girls. They were assigned to the control group. The other class consisted of 22 students. The students had to participate in the study as it was part of the regular lesson. In advance the parents of the pupils had received an information letter (Appendix D) and were asked to indicate whether or not the gathered data of their children might be used. The data of one pupil from the experimental class had to be excluded from the analysis, because the parents of the student did not confirm with using it. This left seven boys and 14 girls for the experimental group. The age of both classes was relatively homogeneous. Most pupils were 13 years old: 21 from control-, 17 from experimental group. In addition, the control class included five students aged 12 and one aged 14. In the other class three pupils were 12 and two 14 years old. It has to be mentioned that cultural issues were not regarded beforehand. However, the researcher noticed that the classes had a huge difference in cultural (and maybe social) backgrounds. With respect to cultural and geological heritage the control group was relatively homogeneous, whereas the experimental group appeared heterogeneous.

Domain and Learning Material

Students worked on a drawing task on mushrooms and natural cycles with mushrooms. This is part of the standard curriculum of German Gymnasia. The topic was selected in close collaboration with a science teacher. To get acquainted with the topic students in all conditions received text fragments that covered the basics of the anatomy of a mushroom and their life cycle. This text was constructed by the author of this paper in collaboration with a science teacher and was based on the textbook and material from the mentoring teacher. The text fragments got part of a workbook (Appendix A), which also included instructions that should guide the students through the learning by drawing experience. The workbook consisted of four concrete drawing exercises concerning the topic. Each single exercise involved a text fragment (e.g. about the composition of a button mushroom) and an instruction for the student of what had to be done (e.g. "read the text and underline important information, then create a drawing of a button mushroom and label important parts"). In addition, students from the experimental group received expert feedback (Appendix C) in form of an illustration (e.g. a labeled button mushroom) after each drawing exercise.

Assessment

Knowledge construction was measured via a pre-test, a post-test, and a retention-test (Appendix B). Each consisted of a word recognition task and a multiple choice test.

The word recognition task had the aim to assess students' grade of "familiarity" with the learned content of the material. This test consisted of 24 words; only 13 of them were actually related to the domain at hand. Students were asked to circle the words that were related to the domain. The word recognition test was administered three times during the experiment. Cronbach's alpha for the post-test was weak with @= .42. The retention-test was implemented after one week. One of the 24 words (Symphonie) was excluded from analysis, because it was discussed by some students during the post-test.

The multiple choice test with ten questions was conducted to test students´ grade of "recollection" of the learned material. Each question offered four possible answers and the participants were asked to choose that answer, which seems "most correct" to them. This test also was administered three times during the experiment. The order of the items was changed after the post-test to avoid carryover effects. Cronbach´s alpha of the post-test was weak with @= .37.

The low values of both tests might be explained with the heterogeneity between and within the groups. Especially participants in the experimental class showed a strong distribution of scores. Due to cultural backgrounds there might even exist a difference in language skills between the members of both groups. Therefore a multiple choice test would obtain enhanced random answering of non-native speakers, which might lead to a low Cronbach´s alpha.

Procedure

The experiment leader taught the biology lessons of both classes that participated in this study. A lesson lasted 90 minutes and was accompanied by the responsible biology teacher. At the beginning students were told to fill in a pre-test to find out more about their prior knowledge about the topic. Therefore they had ten minutes. Afterwards, the experiment leader gave a short introduction in the task using the blackboard. This introduction included an example of a drawing (photosynthesis), how to label it, and how to draw relations. In addition participants were offered a timetable showing how long they were allowed to work on each single exercise (Appendix E). Then students were allowed to start working on the first task. Students had seven minutes to read a text, underline important passages and to make a drawing. After four minutes pupils from the experimental group got an expert-drawing and had the chance to improve their own picture with help of it. For the other three exercises the classes had 14 minutes each and the experimental group got feedback after eight minutes. At the end of the lesson students got another ten minutes to accomplish a post-test, which was implemented to reflect the knowledge gain of the participants. One week later the conductor visited the students again during their biology class. A retention-test was taken within ten minutes to find out more about knowledge decay in both groups.

Analysis

The pre-, post-, and retention-test were scored. At the word recognition task students earned one point for each correctly circled term and got one subtracted for each wrong circled term. On the multiple choice test only the correct answered items were scored. Wrong or multiple answered items were neglected. On the whole it was possible to score 23 points on each test. 13 points could be gathered on the word retention task and ten on the multiple choice questionnaire.

Repeated measure analysis was performed to examine knowledge construction of both groups related to the effect of condition and the effect of time. One analysis was accomplished for the whole tests and one for each subtest.

To find out more about the effect of drawing quality we analyzed students´ drawings with respect to their "functionality" and their "beauty". The first aspect refers to the number of correct terms and connections used in the drawings. Therefore a coding scheme was created based on the expert-drawings (Appendix F). For each of their four drawings the pupils got a rank based on the score of "functionality". Then the ranks got combined to an overall ranking. Same principle found its use in estimating the "beauty". It was determined by two different raters. Each judge ranked the drawings of all 48 participants. Criteria for the ranking were esthetic issues and attention to detail. The use of color should be ignored by the raters. Inter-rater reliability was calculated with a spearman correlation test: $\rho = .87$.

The same method of analysis was used to find correlations between "beauty", "functionality" and the results of the pre-, post,- and retention tests. Further, the mean ranks of control- and experimental group where compared via a t-test with regard to the "beauty" and "functionality" of their drawings.

III. Results

Improvement on test scores

Adding the results of the multiple choice test and the word recognition task a t-test showed that both experimental and control group had an improvement in test scores between pre- and post-test. On the pre-test the control group achieved a mean score of 8.26 from 23 possible points, whereas the post-test showed a mean score of 15.85 ($t=18.13$, $p<.001$, 2-tailed). The experimental group showed even more difference between pre- and post-test, with only 7.10 points on the first, but 17.14 on the latter one ($t=31.04$; $p<.001$, 2-tailed).

Effects of expert feedback on test scores

An analysis of repeated measures indicates that the experimental class had significantly ($F=6.240$, $p<.01$) more gain in score over all three tests than the control group. Figure 1 shows a graph of the number of mean points earned by both classes on pre-, post-, and retention-test.

Figure 1

Mean scores of pre-, post-, and retention-test

Note. Overall mean scores of control group (n=27) and experimental group (n=21) on pre-test, post-test, retention-test.

Examining the results of the word recognition task and a multiple choice test separately, a t-test shows that on the word recognition task the experimental group achieved significantly more points on post-test (t=2.15, p<0,05) and retention-test (t=3.18, p<.01). On the multiple choice test no significant difference was found. Table 1 shows mean scores and t-values for all three tests for both word recognition task and multiple choice test.

Table 1

T-values for differences in mean scores from control group (n=27) and experimental group (n=21)

Word Recognition Task			
Test	Condition	Mean score	t-value
Pre	Control	4.96	1.48
	Experimental	4.43	
Post	Control	9.96	-2.15*
	Experimental	11.05	
Retention	Control	8.59	-3,18**
	Experimental	10.57	
Multiple Choice Test			
Test	Condition	Mean score	t-value
Pre	Control	3.30	1.66
	Experimental	2.67	
Post	Control	5.89	-0.42
	Experimental	6.10	
Retention	Control	6.04	0.84
	Experimental	5.57	
Overall			

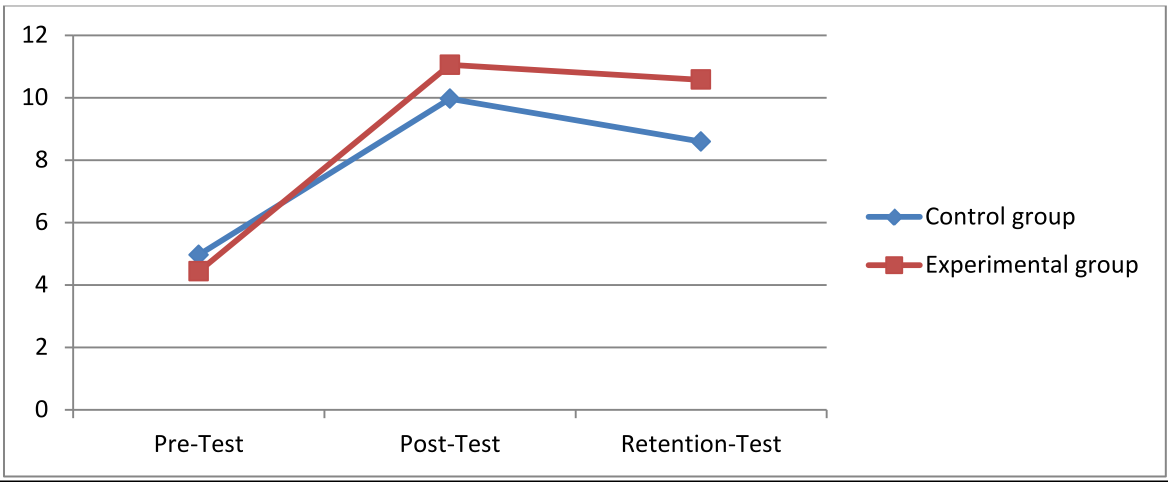
Test	Condition	Mean score	t-value
Pre	Control	8.26	1.72
	Experimental	7.10	
Post	Control	15.85	-1.60
	Experimental	17.14	
Retention	Control	14.63	-1.65
	Experimental	16.14	

Note. *p<.05, **p<.01

Still examining the word recognition task, an analysis of repeated measures shows also a significant (F=7.91, p<.005) difference in the increase of score between both classes over the three tests (Figure 2). A closer look on the data reveals that most of the difference in learning gain occurs between pre- and post-test (F=8.05, p<.01). Decay in both groups seems relatively even. Though they show a slight difference in loss of knowledge between post- and retention-test, it is not significant (F=2.45, p=.13).

Figure 2

Mean scores of the Word Recognition Task



Note. Mean scores of control group (n=27) and experimental group (n=21) on the Word Recognition Task.

On the multiple choice test the groups did not differ significantly on a t-test within the single tests (see table 1). Also the analysis of repeated measures makes a distinction difficulty (F=1.50, p=.23). Examining Figure 3 it seems that the experimental group has a higher gain in score between pre- and post test than the control group. However, that difference is not significant (F=2.57, p=.12). A little bit contradictory seem the results for the changes in score between post- and retention-test. Here the experimental group suffers the usual loss (ascribed to decay) from 6.10 points in average to 5.57. Whereas the control group even achieved a better score on the latter (from 5.89 to 6.04, see Figure 3). However, that difference is not significant, too (F=2.44. p=.13).

Figure 3

Mean scores of the Multiple Choice Test

Note. Mean scores of control group (n=27) and experimental group (n=21) on the Multiple Choice Test.

Effects of drawing quality on test scores

As mentioned above the four drawings of every students were assessed regarding “functionality” and ”beauty”. Then, corresponding to this rating, each participant was assigned to a rank within both criteria. Correlation between “beauty” and ”functionality“ was high with ρ=.51 (p<.01).

On “beauty” the control group achieved a mean rank of 26.67 (out of 48) and the experimental group one of 21.71. This difference was not significant neither on a Kruskal Wallis test for a non-parametric comparison of mean ranks nor on a t-test for independent samples (t=1.19, p=0.23, two-sided). However, a significant distinction could be made on “functionality” (t=2.97, p<0.01). Here the control class was ranked on a mean of 30.01, whereas the experimental class got one of 18.77 (see table2).

Table 2

Mean ranks of control and experimental group on "functionality" and "beauty" (n=48)

	Functionality	Beauty
Control (n=27)	30,01	26,67
Experimental (n=21)	18,77	21,71

A correlation analysis revealed a strong relation between the ranks on "functionality" and the post- (ρ=-.37, p<.01) and retention-test scores (ρ=-.43; p<.01) of the word recognition task. On the same task a significant correlation was found between "beauty" and the outcome of the post-test (ρ=.39, p<.01). No relations were found between the scores on any of the multiple choice tests and the both categories (table 4).

Table 4

Rank correlation (Spearman) of test results with "functionality" and "beauty" (n=48)

	Word recognition task			Multiple choice test		
	pre	post	retention	pre	post	retention
functionality	- .17	- .37*	-.43*	- .02	- .19	- .08
beauty	- .08	- .39*	- .27	- .14	- .18	- .11

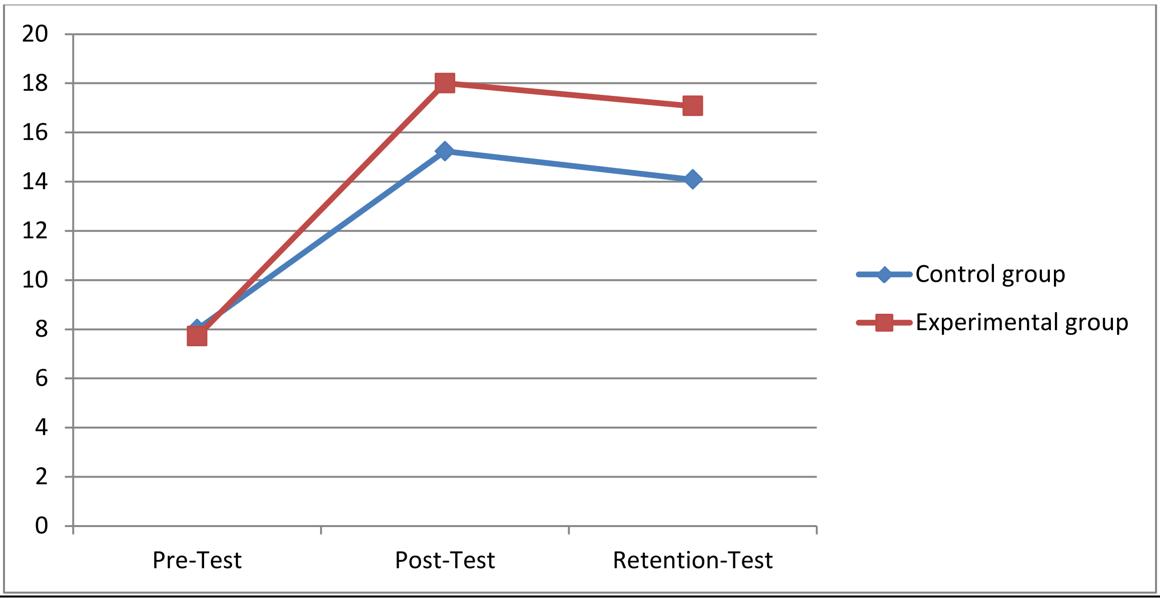
Note. *p<.01

Effects of gender on test scores

When testing all girls (n=27) from both conditions versus boys (n=21) no significant effects of gender were found. Neither with an analysis of repeated measures (F=.19; p>.75) nor with a look on the differences in means at the single tests. Though, girls who achieved feedback (n=14) had a higher increase in score than the controls (n=13) on both word recognition task and multiple choice test (F=5.19, p<.05; see figure 4).

Figure 4

Mean scores of girls on pre-, post-, and retention-test

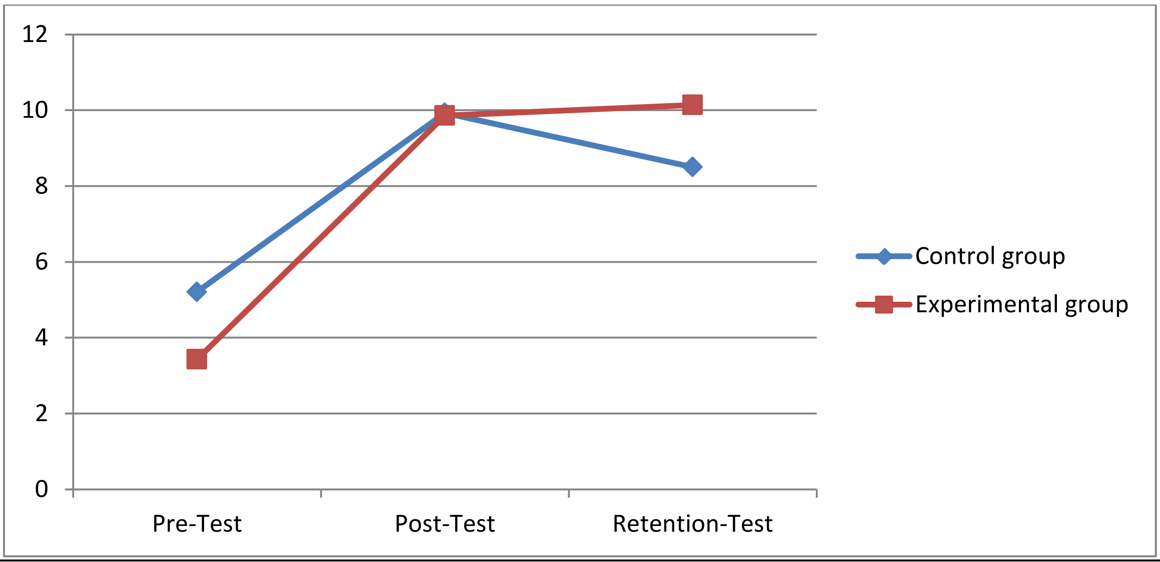


Note. Overall mean scores of girls from control group (n=13) and experimental group (n=14) on pre-test, post-test, retention-test.

In contrast, examined with an analysis of repeated measures, boys (n-control=14; n-experimental=7) only differ on the word recognition task (F=6.07, p<.01) as shown in Figure 5.

Figure 5:

Mean scores of boys on the word recognition task



Note. Mean scores of boys from control group (n=14) and experimental group (n=7) on the Word Recognition Task.

Quality and gender

Comparing drawing quality mean ranks of all girls with those of all boys, t-tests showed a significant difference in both "functionality" (t=2.85, p<.01) and "beauty" (t=4.56; p<.001). See table 3 for mean ranks.

Table 3

Mean ranks achieved on "functionality" and "beauty" divided by gender (n=48)

	Functionality	Beauty
Boys (n=21)	30.81	33.02
Girls (n=27)	19.96	17.87

It might be noteworthy that a strong difference between sexes was found on the correlation between "functionality" and the retention test scores of the word recognition task. Girls (n=27) showed a significant relation (ρ=-.46, p<.05), whereas boys had no connection at all (ρ=-.023; p=0,905).

IV. Discussion

In the first research question we asked for the effects of expert feedback (in form of an illustration) on a learning-by-drawing task done by seventh-graders.

At the beginning it should be mentioned that pupils aged 12-14 seem suitable for such an instructional approach. Both classes reached a huge gain of knowledge. This finding is in line with the finding of van Meter and colleagues (2006). In their study, only older students (sixth-graders) profited from translating text into a drawing, whereas younger students (fourth graders) did not. Subsequently they concluded that for such a task strategies of young children are not as effective as those of older ones.

However, the same research found marginal differences between drawing-only students and those, who additionally received feedback as illustration. Especially with regards to recognition, supported and unsupported participants showed no difference. Therefore, current study divided recognition in “recollection” and “familiarity”. The first one was tested with a multiple-choice test like in the research of van Meter (et al., 2006), but with more items. The results were identical to those of van Meter (et al, 2006), which suggests the assumption that low-order processes do not get influenced by support. However, the findings of the word recognition task, which had the aim to test “familiarity”, indicate something else. Here students from experimental class scored much better than the controls. Resultant might be concluded that support (at least feedback in form of illustrations) in a drawing task not only affects higher-order assessments. Given that particularly “familiarity” was enhanced by feedback, might be due to the fact that the material not necessarily was better processed and understood (which should affect higher-order thinking), but that it was processed more comprehensive. For example, it might happen that some terms got skipped while reading the text of a task. Then, the feedback is able to call attention to those terms. As a result they got processed and find a place in memory. This interpretation is in line with the model of the learner-generated drawing process from van Meter and colleagues (2006), which also states that support may act to direct learners´ attention to key elements of a task and the relationships amongst these.

Another explanation might be that through the feedback students had the chance to repeat important terms more often. That rehearsal led to a deeper stay in memory.

The second question addressed the effect of gender. At first sight there was no strong difference in test outcome for the sexes. Taken both conditions together, mean scores of pre-, post-, and retention test were nearly the same. Nevertheless, girls from the experimental class seemed to profit more from feedback than boys. Their increase in test scores compared to their counterparts from the control group was higher than the boys´ compared to their counterparts. On the one hand, this might be explained with the idea that drawing tasks are more appealing to girls. On the other hand, this might be a result of the heterogeneity of the experimental class. More insight could give a look on the results of drawing quality.

In the third research question we looked after the influence of expert feedback on the quality of drawing. Analysis showed that students from experimental class scored better on “functionality” but equal on “beauty”. This seems comprehendible as the feedback gave the opportunity to add missing terms or to correct wrong set relations (which both are described to “functionality”). Though, it was less made to help pupils to enhance the attractiveness of their drawings. “Functionality” showed strong relations with word recognition, but few with a knowledge test. This allows the conclusion, that creating drawings, which are rich of terms and relations, helps to identify topic related information on a later date. However, this is not necessarily an indicator for a greater store of testable knowledge. To achieve that, or even transfer of knowledge, seems to require a more active role of the learner while receiving feedback. For example, this might happen through answering prompt questions (van Meter et al, 2006) or via discussing own ideas with peers (van Dijk et al., in preparation).

To get back to the question why girls seem to profit more from feedback it should be mentioned that in the whole they had better ranks on both “functionality” and ”beauty”. Daring an interpretation, it might be that female students are more interested and motivated in drawing. The rating of the “beauty” suggests that girls draw more often and that they receive better reactions on their pictures. Hence, they could be more motivated when it comes to a drawing exercise. Another reason might be the age of the students as girls around an age of 13 seem to be of a greater maturity than boys. Therefore, they could act more conscientious. However, if the assumption of a higher motivation or conscientiousness is true, then it might be reasoned that girls make use of feedback more carefully than boys; and further, that they act more self-critical. This could have led to a better mean rank on “functionality” and hence, to some better test-results.

In conclusion, current study facilitates the finding of Schwamborn (et al., 2011) that feedback in form of illustrations might have positive effect on performance outcome. This seems to count for both computer environments and pen and paper tasks. The conclusions of van Meter and colleagues (2006) that support only enhances higher order assessments is not shared by the authors of this paper. Indeed, both studies did not find any changes in score on a multiple choice knowledge test. Van Meter et al. (2006) argued that this is due to the fact that such a lower order assessment like recognition gets not affected from support. However, dividing recognition in “recollection” and ”familiarity” current study discovered that illustrational feedback at least seems to affect the second one. The authors conclude from this finding that it seems hard to say whether support in a drawing task has no influence on lower order assessments, because at least it should guide attention deficits and/or lead to rehearsal. For following research we recommend conditions which leave the learner engaged in active thinking, while receiving feedback. That means that pupils not only compare and correct, but also that they discuss and reason. Collaborative settings seem especially suited for such a kind of support. Such an approach could be facilitated by illustrational feedback. For example, students could create a drawing, correct it with help of an illustration, and at the end discuss their results and changes with peers. This would be a suggestion for further research.

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V. Appendix

Appendix A

Arbeitsmaterial

I. Einführung

Auf den folgenden Blättern befinden sich 4 Aufgaben zum Thema Pilze und natürlicher Kreisläufe mit Pilzen. Zu jeder Aufgabe gibt es eine kurze Beschreibung. Du sollst in jeder Beschreibung wichtige Textstellen und Begriffe unterstreichen und danach ein Bild zeichnen, dass das beschriebene Material wieder gibt. Zum Malen dürfen Buntstifte verwendet werden. Die erste Aufgabe behandelt den Aufbau eines Pilzes am Beispiel des Champignons.

II. Aufbau eines Pilzes

Beispiel: Champignon

Beim Champignon kann man zwischen einem oberirdischen und einem unterirdischen Teil unterscheiden. Der oberirdische Teil des Pilzeswird Fruchtkörper genannt. Er besteht aus einem weißen Hut mit bräunlichen Lamellen auf der Unterseite und einem kurzen Stiel mit Ring. Der unterirdische Teil wird Mycel genannt. Dieses Gebilde besteht aus länglichen Zellen, den Pilzhyphen, die unter der Erde ein weit verzweigtes Geflecht bilden.

Aufgabe: Unterstreiche wichtige Begriffe im Text. Zeichne dann einen Champignon und beschrifte die einzelnen Teile.

III. Mykorrhiza

Symbiose zwischen Pilz und Baum

Viele Waldpilze leben in einer engen Beziehung mit den Bäumen des Waldes. Die feinen Seitenwurzeln der Waldbäume werden von einem dichten Geflecht von Pilzhyphen (Pilzwurzeln) umhüllt. Diese verbinden den Fruchtkörper des Pilzes mit den Baumwurzeln. Die Hyphen bilden einen Pilzmantel um die Wurzelspitzen. Dieses Zusammenleben bezeichnet man als Mykorrhiza.

Beide Seiten profitieren von diesem Zusammenleben. Pilze bekommen von den BäumenKohlenhydrate, wie z.B. Zucker. Da Bäume die Fähigkeit zur Photosynthese haben, also Wärmeenergie von der Sonne in Kohlenhydrate umwandeln können, besitzen sie diese im Überfluss. Im Gegenzug sorgt der Pilzmantel um die Baumwurzelspitzen dafür, dass der Baum besser Wasser und Mineralstoffe aus dem Boden aufnehmen kann. Dies wird möglich da die umwickelten Baumwurzeln eine größere Oberfläche haben und weiter ins Erdreich dringen können.

Aufgabe: Unterstreiche wichtige Textstellen. Male und beschrifte dann einen symbiotischen Kreislauf zwischen Pilz und Baum.

IV. Saprobionten

Andere Pilze wiederum zersetzen zur Nährstoffgewinnung tote Tier- und Pflanzenteile. Sie durchziehen diese mit ihrem Mycel und geben Verdauungsstoffe (Enzyme) ab. Diese Stoffe zersetzen das tote Material so lange, bis es der Pilz aufnehmen kann. Diese Pilzgruppe nennt man Fäulnisbewohner oder **Saprobionten**.
Auch Saprobionten bilden natürliche Kreisläufe mit Pflanzen. Wenn Pilze totes Material (z.B. Laub) zersetzen werden dabei Kohlenstoffdioxid (CO^2) in die Luft, und Wasser und Mineralien in den Boden abgegeben. Pflanzen in der Umgebung nehmen diese Stoffe aus Luft und Boden auf und wandeln Teile davon mit Hilfe von Sonnenenergie in Kohlenhydrate um. Stirbt die Pflanze ab oder verliert Teile, wie z.B. Blätter, kann der Pilz das tote Material wieder zersetzen und erhält dadurch Kohlenhydrate.

Aufgabe: Unterstreiche wichtige Textstellen. Male und beschrifte dann einen Kreislauf zwischen einem Saprobiont und einem Baum.

V. Parasitäre Pilze

Parasiten sind Pilze die einer Pflanze einseitig Nährstoffe (z.B. Kohlenhydrate) entziehen. Der Pilz dringt mit seinen Hyphen in die Zellmembran der Pflanze ein und kann so an die Nährstoffe gelangen. Meist sterben bei diesem Vorgang betroffene Pflanzenteile oder sogar die ganze Pflanze ab.
Auch wenn diese Pilze sehr zerstörerisch erscheinen ermöglichen sie dennoch einen natürlichen Kreislauf von dem auch andere Lebewesen wieder profitieren können: Wie bereits erwähnt bezieht ein parasitärer Pilz seine Kohlenhydrate von Pflanzen die sie befallen. Stirbt die Pflanze ab gelangen dadurch Wasser und Mineralien in den Boden die von anderen Pflanzen aufgenommen werden können. Zusätzlich entsteht Platz für jüngere Pflanzen die auch mehr Zugang zu Sonnenlicht erhalten. Werden diese neuen Pflanzen alt und krank können sie wieder von parasitären Pilzen befallen und abgetötet werden. Dadurch kann z.B. in einem Wald ein natürlicher Kreislauf zwischen alten und jungen Bäumen entstehen.

Aufgabe: Unterstreiche wichtige Textstellen. Male und beschrifte einen Kreislauf im Wald der durch den Parasit ermöglicht wird.

Appendix B

Word Recognition Task (Pre-test, order of items changed in post- and retention-test)

Nummer:

Umkreise von folgenden Begriffen diejenigen, die deiner Meinung nach mit dem Thema Pilze zu tun haben:

Symbiose

Glyphe

Stiel

Champignon

Saprobiont

Schloss

Symphonie

Parasit

Mykorrhiza

Helm

Mykene

Ring

Prokaryot

Stock

Hyphe

Knospe

Metabiose

Lamellen

Fruchtkörper

Mycel

Metamorphose

Hut

Pfifferling

Borsten

Multiple Choice Test (Pre-test, order of items changed in post- and retention-test)

Beantworte folgende Fragen indem du eine der 4 möglichen Antworten ankreuzt. Kreuze nur die Antwort an, welche dir am "richtigsten" erscheint, auch wenn du mehrere Antwortmöglichkeiten in Betracht ziehst.

1) Wenn man Pilze einteilt in Symbionten, Saprobionten und Parasiten, dann unterscheidet man sie nach der Art ihrer…

a) Lebensweise (z.B. oberirdisch/unterirdisch)

b) Ernährungsweise (z.B. von totem oder lebendem Material)

c) Ökologie (Wechselbeziehung zwischen Lebewesen und natürlicher Umwelt)

d) Essbarkeit (fuer Mensch/Tier, oder keines von beiden)

2) Wie unterstützt die Mykorrhiza (Pilzwurzel) die Nahrungsaufnahme des Baumes?

a) Sie lockert den Boden auf, wodurch die Baumwurzeln besser an Wasser kommen

b) Sie entzieht dem Baum Giftstoffe

c) Sie vergrößert die Oberfläche der Baumwurzel

d) Sie gibt Nährstoffe an den Baum ab

3) Was erhält der Pilz durch eine Symbiose mit einem Baum?

a) Sonnenlicht

b) Wasser und Nährsalze

c) Kohlenstoffdioxid (CO^2)

d) Kohlenhydrate (z.B. Zucker)

4) Was sind Saprobionten?

a) Fäulnisbewohner

b) Parasiten

c) Mykorrhiza- Pilze

d) Natürliche Kreisläufe

5) Was bekommt der Baum durch eine Symbiose vermehrt?

a) Sonnenlicht

b) Wasser und Mineralien

c) Kohlenstoffdioxid (CO^2)

d) Kohlenhydrate (z.B. Zucker)

6) Wie werden Pilze genannt die Pflanzen durch einseitigen Nährstoffentzug abtöten?

a) Symbionten

b) Parasiten

c) Saprobionten

d) Schmarotzer

7) Was kann ein Baum aus dem Zersetzungsprozess eines Saprobionten gewinnen?

a) CO^2 und Kohlenhydrate

b) Kohlenhydrate und Wasser

c) Zucker und Mineralien

d) Mineralien und CO^2

8) Welchen lebenswichtigen Stoff kann ein Pilz nicht selbst erzeugen (z.B. durch Photosynthese) und muss daher aus der Umgebung gewonnen werden?

a) CO^2

b) Zucker

c) Vitamin C

d) Salz

9) Welche Pilze fügen ihrer Umgebung ausschließlich Schaden zu und bringen daher der Natur keinen Nutzen?

a) Mykorrhiza- Pilze

b) Parasiten

c) Saprobionten

d) alle 3 können ihrer Umgebung von Nutzen sein

10) Wie werden die länglichen Zellen eines Pilzes genannt, die meist unterirdisch ein weit verzweigtes Geflecht bilden?

a) Hyphen

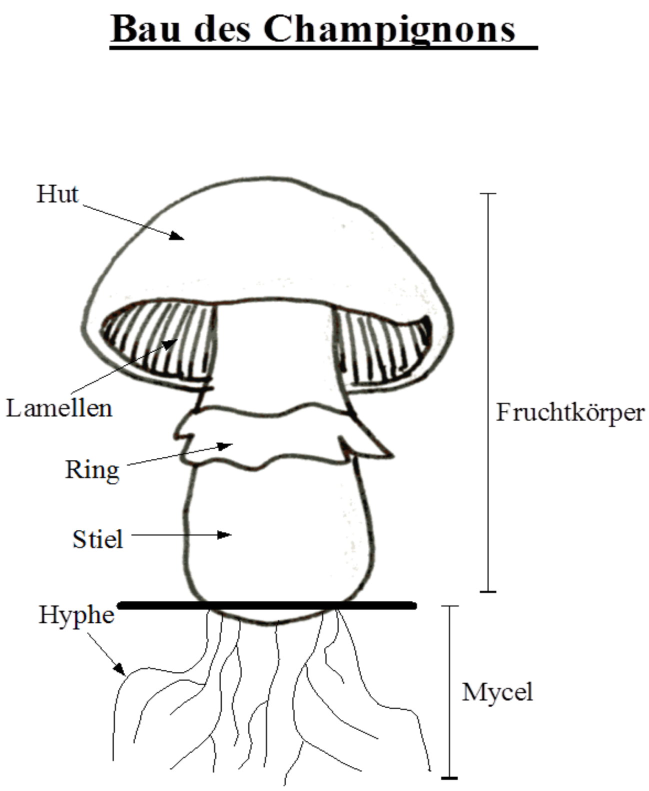
b) Mycel

c) Mykorrhiza

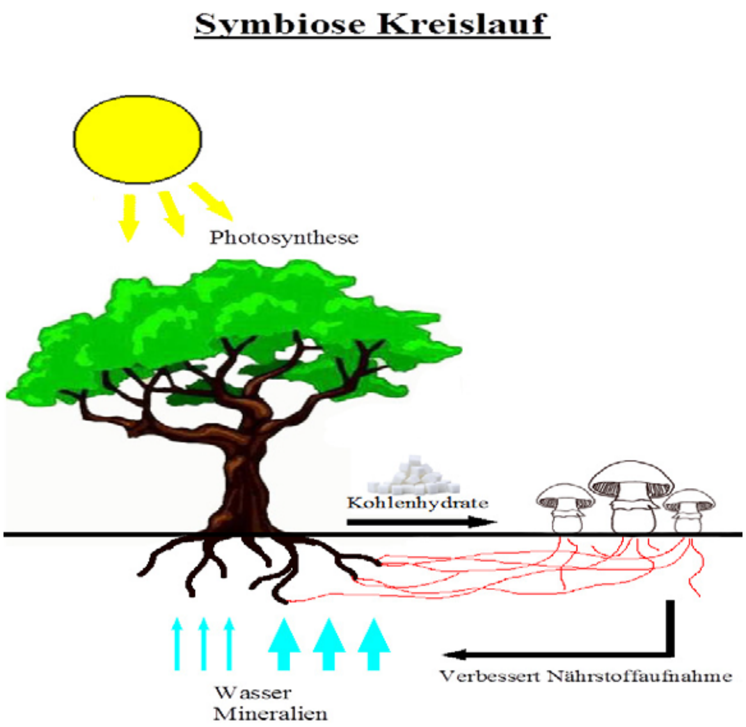
d) Lamellen

Appendix C

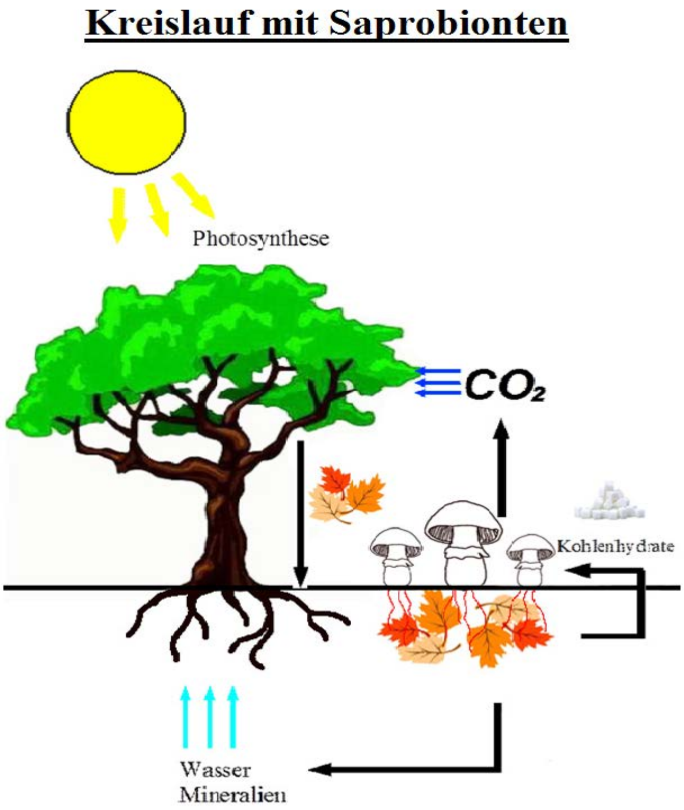
Feedback exercise 1



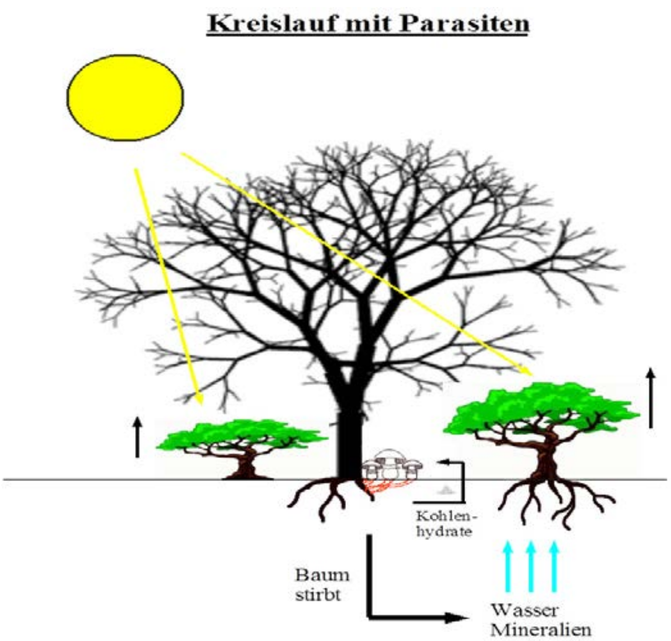
Feedback exercise 2



Feedback exercise 3



Feedback exercise 4



Appendix D

Elterninformation

An die Eltern
der Schülerinnen und Schüler
der Klasse 7b und 7e

Wörth, den 30.04.2012

Sehr geehrte Damen und Herren, liebe Eltern der Klassen 7b und 7e,

im Rahmen meiner Abschlussarbeit im Bereich Lern-Psychologie an der Universität Twente werde ich in Absprache mit der Schulleitung in der Woche vom 07.-13. Mai 2012 in den Klassen 7b und 7e des Europa-Gymnasiums Wörth den Biologie Unterricht leiten. Die dabei zu behandelnden Inhalte wurden zusammen mit der Biologielehrerin Frau Schmidt erarbeitet, die ebenfalls im Unterricht anwesend sein wird. Die Unterrichtsthemen sind Teil des Lernstoffs der 7. Klasse.

Ziel ist es herauszufinden, wie viel Wissen die Schüler aus meinem Unterricht mitnehmen. Um dies festzustellen, werde ich mehrere kleine schriftliche Tests abnehmen, die jedoch anonym behandelt werden. Lediglich Alter und Geschlecht der Schüler und Schülerinnen werden notiert und in meiner Examensarbeit dokumentiert. Falls Sie noch Fragen zu meiner Untersuchung haben, können Sie gerne über die folgende E-Mail-Adresse Kontakt zu mir aufnehmen: c.wuenstel@gmx.de.

Mit freundlichen Grüßen,

Christoph Wünstel

Susanne Schmidt

Bitte zutreffendes ankreuzen:

○ Ich habe den Informationsbrief zur Kenntnis genommen.

○ Die anonymisierten Ergebnisse meines Sohnes/ meiner Tochter dürfen im Rahmen der Examensarbeit von Herrn Wünstel verwendet werden.

____

Name des Schülers/ der Schülerin

Unterschrift Eltern/ Erziehungsberechtigter

Appendix E

<u>Timetable</u>

Control group:

Aufgabe 1)7 min für Lesen, Unterstreichen, Malen

Aufgabe 2) 14 min für Lesen, Unterstreichen, Malen

Aufgabe 3)14 min für Lesen, Unterstreichen, Malen

Aufgabe 4)14 min für Lesen, Unterstreichen, Malen

Experimental group:

Aufgabe 1) 4 min für Lesen, Unterstreichen, Malen + 3 min für Vergleichen, Verbessern

Aufgabe 2) 8 min für Lesen, Unterstreichen, Malen + 6 min für Vergleichen, Verbessern

Aufgabe 3)8 min für Lesen, Unterstreichen, Malen + 6 min für Vergleichen, Verbessern

Aufgabe 4)8 min für Lesen, Unterstreichen, Malen + 6 min für Vergleichen, Verbessern