COMPARING THE EFFECTIVENESS OF ROTE AND MEANINGFUL INSTRUCTION AND
EXERCISES FOR LEARNING TOPOGRAPHICAL FACTS

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Abstract

This study compared the effectiveness of rote and meaningful topography instruction and exercises for learning topography facts on short (t₁) and long term (t₂). An experiment was conducted among 97 Dutch 7th-graders, using a 2 (instruction: meaningful or rote) by 2 (exercises: meaningful or rote) factorial design. At t₁, the meaningful instruction/rote exercises condition proved to be less effective than all other conditions. Moreover, pupils who received a rote instruction outperformed those who received a meaningful instruction. On the contrary, pupils who performed meaningful exercises outperformed those who performed rote exercises. At t₂, no significant differences between the conditions were found. Difference scores (decline between t₁ and t₂) were calculated and rote exercises were associated with less decline than meaningful exercises. The results of this study query the effectiveness of meaningful instruction and exercises for acquiring knowledge on the absolute location of topographical elements. Rote instruction and exercises proved to be at least as effective as meaningful instruction and exercises on the long term, probably even more effective. However, more research needs to be conducted to explore the effectiveness of rote and meaningful topography education for acquiring knowledge of the relative location of topographical elements.
Introduction

News reader: “There has been an earthquake in France. The epicentre was near Lille, but the shock was also registered in Calais and Gent, Belgium.”

To grasp the significance of a news item like this, it is necessary to know the distances between Lille, Calais and Gent. Lille is about 100 kilometres away from both Calais and Gent. A listener who is not aware of these distances might underestimate the magnitude of the earthquake. On the other hand, a listener might overestimate the magnitude of this earthquake based on the fact that it was also registered in Gent, Belgium, if he does not know that Lille is situated near the border of France and Belgium.

This example shows the importance of topographical knowledge. “A central tenet of geography education is that ‘location matters’ for understanding a wide variety of processes and phenomena” (National Research Council, 1997, p. 3). We use topographical knowledge every day, from navigating to a certain destination to interpreting news items. Topography is an indispensable frame of reference for pupils (Van der Vaart, 1990), nevertheless the topographical knowledge of pupils is very limited. Dutch research among eight-grade pupils found that merely 25 per cent is capable of pointing the correct location of 200 topographical elements on a blank map, out of 300 elements to be known. The average eighth-grader is incapable of pointing the correct location for 200 elements (Notté, Van der Schoot & Hemker, 2003). In the United States research among 18- to 24-year olds has shown that topographical knowledge is limited, even though the elements asked for had been in the news often. For example, on a map of the Middle East, 63 per cent of these young adults could not find Iraq or Saudi Arabia, 75 per cent could not find Iran or Israel and 44 per cent could find neither of these (National Geographic Education Foundation, 2006).

These figures are not very promising. Although little research has been done on factors that make topography education effective, Notté et al. (2003) attribute the lack of factual, topographical knowledge to the inefficiency of the ‘unilateral topography education’, referring to reproduction-oriented education. In line with this resistance to reproduction-oriented topography education, in educational materials a shift to more meaningful topography education is visible, integrating topography in geography education.
Approaches to Learning

The ‘unilateral topography education’, to which Notté et al. (2003) refer, is in accordance with the view of learning as knowledge acquisition (Mayer, 2002) in which reception is the keyword (Kanselaar & Andriessen, 2000). On the other hand, the shift to more meaningful topography education fits in with the current constructivist view on learning, in which knowledge is constructed by learners upon the foundation of previous learning (Kanselaar, 2002; Mayer, 2002). In educational practice the constructivist view is expressed in deliberately making connections, explaining phenomena, acquiring insights, and assigning meaning and interpretations to events (Kanselaar & Andriessen, 2000). On the contrary, the knowledge acquisition view is consistent with a focus on rote learning (Mayer, 2002). Kember (1996) refers to this contrast as a deep versus surface approach or meaningful versus rote learning.

In meaningful learning new information is related in a meaningful way to knowledge the learner already possesses (Peterson, 1988). Learning thus can be seen as knowledge construction in which learners seek to make sense of their experiences through active cognitive processing, such as mentally organizing information into a coherent representation and integrating information with existing knowledge (Mayer, 2002; Kember, 1996). Through elaboration in encoding new information, the number of access routes to the memory for the learned information is increased so that it can be retrieved more easily (Cuddy & Jacoby, 1982; Driscoll, 2005). Another characteristic of meaningful learning is that the learner is interested in the task at hand and derives enjoyment from carrying it out (Kember, 1996). This interest is related to achievement, with higher interest leading to better results (Krapp, 1999).

Rote learning has been characterized as a less effective learning strategy than meaningful learning. For example the learner who adopts such an approach to learning sees the task as a demand to be met (Kember, 1996), thus not being intrinsically motivated (Murphy & Alexander, 2000). The rote learner relies on memorization to reproduce the surface aspects of the task (Kember, 1996), which can be accomplished by a process labelled either drill and practice (Tennyson, 1988), maintenance rehearsal, or repetition (Driscoll, 2005).
Remembering and Forgetting

Driscoll (2005) claims that remembering is most effectively achieved by encoding, in which information is related to what the learner already knows. Encoded information is stored in long-term memory, whereas rehearsed information is stored in working memory. However, as ineffective as rote learning might be for learning complex and meaningful information, it might be an effective strategy for learning “highly overlearned material, such as arithmetic facts, spelling words, or a memorized script” (Driscoll, 2005, p. 89). Cuddy and Jacoby (1982) also harbour the possibility that repetition produces a strength-like effect on memory. That is, if repetition is variable. According to Cuddy and Jacoby both elaboration and repetition are most effective when memory of an earlier presentation of the information is not readily accessible. Forgetting can enhance remembering, because the information has to be processed again.

Topography learning can be seen as the learning of pure factual information, although one might argue that at least some comprehension is necessary in order to learn these facts (Gagné, 1972; Bransford, Brown & Cocking, 1999), so it is concerned with remembering facts. Important factors influencing recall are an individual’s experience, knowledge and interest (Ericsson & Kintsch, 1995). Especially (prior) knowledge has received much attention in literature on remembering. Greenhoot (2000) describes the constructivist view of memory, in which knowledge has a primary role in processing new information. Relevant knowledge is used to guide interpretation and make inferences and elaborations, in order to comprehend new information and encode it into memory. However, knowledge can also impair remembering. Interference, in which other information gets in the way of effective retrieval, is one of the causes of forgetting. Interference may be caused by either prior knowledge or information that is learned later (Driscoll, 2005). Other reasons for forgetting are: failure to encode information in the first place; failure to retrieve the information (Driscoll, 2005); time (referred to as trace decay theory); and the information crumbling into parts followed by loss of separate components (Baddeley, 1997). Moreover, what is remembered depends on encoding and retrieval cues. Cues that are used during encoding will also serve as the best retrieval cues, a principle termed encoding specificity (Driscoll, 2005).
Interest and Learning

As mentioned above, higher interest in the educational task leads to better results, and meaningful and rote educational settings may differ in the interest they provoke (Krapp, 1999). Interest may be seen as a key variable in intrinsic motivation for learning (Ainley, 2006; Schiefele, 1991). Collative motivation is another factor in intrinsic motivation (Reeve, 1989). Collative motivation, a term coined by Berlyne (1978), is dependent on properties of educational settings such as novelty, complexity, change, and variability. Activities are intrinsically motivating if they attract attention, curiosity, and interest because of their novelty. Collative properties of an educational setting affect its interestingness and thereby pupils’ motivation (Reeve, 1989), thus a lesson that is very different from what pupils are used to, could lead to a higher interest and motivation, which could lead to better results.

The Present Study

Since Driscoll (2005) argues that rote learning can be an effective strategy for learning highly overlearned material, learning of topography facts might be effectively achieved by drill and practice. However, there is also much to be said for more meaningful learning, considering pupils then might better encode and retrieve the learned information. Moreover meaningful learning might result in higher interest, leading to better results. The aim of the present study was to compare the effectiveness of meaningful and rote topography instruction and exercises for learning the absolute location of topographical elements, by conducting an experiment with four conditions. The study considered interaction and main effects of instruction and exercises, in order to compare differences between mean test scores of pupils who received either meaningful or rote instruction and performed either meaningful or rote exercises. Both short and long term scores were compared, as well as decline between these scores. In addition, attention was devoted to the interest and novelty aspects of meaningful and rote topography instruction and exercises, by considering differences in these aspects among pupils in different conditions and by controlling test results for these aspects.
Method

Design

For this study a two (instruction: meaningful or rote) by two (exercises: meaningful or rote) factorial design was used, resulting in four conditions (see Table 1).

Table 1

Research conditions

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Exercises</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Meaningful</td>
</tr>
<tr>
<td>Meaningful</td>
<td>1</td>
</tr>
<tr>
<td>Rote</td>
<td>3</td>
</tr>
</tbody>
</table>

Participants

The research sample consisted of 97 pupils, 49 boys and 48 girls, from four elementary schools with diverse backgrounds, all pupils were in seventh grade. A convenience sample was taken from schools in Soest (the Netherlands) who were willing to participate. In each class the pupils were equally divided over the four research conditions. This was done by ranking pupils by their former topography results, forming groups of four pupils with comparable results and then dividing each group of four over the conditions (paired sampling), also dividing as equally as possible by gender, resulting in four heterogeneous but similar groups (see Table 2).

Procedure

Instruments were first tested in a pilot study and adjusted accordingly. Data were collected during two visits to each school. On the first occasion pupils were told what to expect of the lesson before the lesson started. They were given a 30 minute instruction about the topography of France, consisting of 16 topographical
Table 2
Descriptive statistics of participants per condition (in per cent)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Gender</th>
<th>Descent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boy</td>
<td>Girl</td>
</tr>
<tr>
<td>Meaningful instruction/meaningful exercises</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>Meaningful instruction/rote exercises</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Rote instruction/meaningful exercises</td>
<td>46</td>
<td>54</td>
</tr>
<tr>
<td>Rote instruction/rote exercises</td>
<td>46</td>
<td>54</td>
</tr>
</tbody>
</table>

elements. Pupils in conditions 1 and 2 received a meaningful instruction from their teacher in their own classroom. For the consistency of the instructions, teachers had to follow a strict protocol and their lessons were taped on video. Consistency of instruction between these teachers was checked by analysing the videotapes, but no major differences were found. Pupils in conditions 3 and 4 were taken to another classroom where they received a rote instruction from the researcher. The instruction was immediately followed by an exercise period of 30 minutes, in which pupils worked individually. Pupils in condition 1 and 3 were given meaningful topography exercises, pupils in condition 2 and 4 were given rote exercises. At the end of the exercise period, all pupils filled in a questionnaire, measuring pupils' interest and novelty of the experimental instruction and exercises. Finally all pupils were administered a topography test to measure their knowledge of the French topography on short term (t1).

The second visit to the schools took place two weeks later and was unbeknownst to the pupils, in order to prevent them from taking extra exercise time. During this visit pupils were administered the same topography test again, to measure their knowledge of the French topography on long term (t2). The two weeks term was chosen based on forgetting curves, which show that forgetting takes place in the first five or six days after learning, whereafter forgetting stagnates (Thompson & Madigan, 2007; Bower, 2000). Considering the aim of the study was to explore which instruction and exercises are more effective in the long term, this six day term has been extended to fourteen days.
Materials

Instruction. Both instructions were based on a PowerPoint presentation. The meaningful instruction consisted of 35 sheets, with 2 sheets for every topographical element. First the element was shown on the map of France, provided by the teacher’s instruction of location (north, south, east or west) and spelling of difficult names (for example: Marseille is located in the south of France, on the coast. It is a difficult name to spell, it is ending with e-i-l-e-e). On the second sheet more information on the element was given and a picture was shown, the teacher elucidated the sheet (for example: Nice is located on the coast of the Mediterranean Sea in the south of France. Because it is situated in the south, it’s a sunny place, and therefore it is a tourist attraction. Nice is a port town. There are 347,000 people living in Nice, that is little less than the number of people living in The Hague. On the picture you can see that Nice is located on the Côte d'Azur). All elements were exposed once, but pupils were able to see all elements on each map. The teacher was explicitly instructed to keep with the instruction as developed by the researcher. The rote instruction consisted of sheets with blank maps of France, with only dots and lines representing the elements to be learned. On each sheet one of the topographical elements was shown. First, all elements were exposed one by one, while the researcher pronounced each name and referred to the spelling. Then pupils rehearsed the position and spelling of the elements several times, the amount of rehearsal depending on the pace of the pupils.

Exercises. The meaningful exercises consisted of a variety of exercises paying attention to the relative location of the elements (for example: Name all port towns in France from south to north). Pupils were provided with a map of France with all elements named on it. The rote exercises were based on a blank map of France, on which the elements were given a label (numbers for cities, letters for waters and Roman numbers for mountain chains). The exercises consisted of naming the element when the label was provided, naming the label when the element was provided, and finding the names in letters which were mixed up (for example: h n R ô e). The main differences between meaningful and rote instruction and exercises can be found in Table 3.
Table 3

Brief overview of main differences between conditions

<table>
<thead>
<tr>
<th></th>
<th>Meaningful</th>
<th>Rote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction</td>
<td>Elements were exposed once</td>
<td>Elements were exposed several times</td>
</tr>
<tr>
<td></td>
<td>Elements were elucidated extensively</td>
<td>Location and spelling of elements was dealt with</td>
</tr>
<tr>
<td>Exercises</td>
<td>Dealt with relative location of elements</td>
<td>Dealt with absolute location of elements</td>
</tr>
<tr>
<td></td>
<td>Pupils used a complete map</td>
<td>Pupils used a blank map with labelled elements</td>
</tr>
</tbody>
</table>

Questionnaire. The questionnaire consisted of two scales, using a five point Likert scale. The first scale consisted of seven items and measured interest, it was based on the interest/enjoyment subscale of the Intrinsic Motivation Inventory, a well-validated instrument to measure subjective experience related to a target activity in experiments (Deci & Ryan, n.d.). This subscale was translated into Dutch and slightly adjusted to fit the educational situation. The other scale, 'novelty', was developed by the researcher and measured the novelty of the experimental lessons as compared to 'regular' topography lessons, it consisted of four items. Examples of questionnaire items and reliability figures are displayed in Table 4. Both scales were assessed twice in one questionnaire, once for the instruction and once for the exercises.

Table 4

Examples of questionnaire items and reliability of the scales

<table>
<thead>
<tr>
<th>Scale</th>
<th>Example</th>
<th>Cronbach’s α</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest</td>
<td>This lesson was fun</td>
<td>.91</td>
</tr>
<tr>
<td>Novelty</td>
<td>This topography lesson resembles the normal topography lessons</td>
<td>.63</td>
</tr>
</tbody>
</table>

Test. To test the pupils’ knowledge of the French topography a traditional topography test was developed by the researcher. On a blank map all sixteen elements were displayed by dots and lines. Ten of these elements were labelled with numbers, letters and Roman numbers, just like in the rote exercises.
However, elements were given new labels to prevent recall of labels instead of names. The test consisted of five names that had to be labelled, and five labels that had to be named. Internal consistency of the test was good (Cronbach’s $\alpha = .77$). Administered tests were corrected by the researcher, giving a mark between 1 and 10, with 10 being the highest mark. Tests were first corrected in two ways, strict and compliant, however these different ways of correcting did not produce different results in the analyses. Therefore one correction method was chosen, in which one point was subtracted from the highest possible mark for each wrong or missing answer, half a point was subtracted if one or more spelling mistakes were made (except for pupils who were indicated as dyslectic by their teacher), and half a point was subtracted if capital(s) were not used correctly. In some cases the wrong/right distinction was not obvious, for example when Marseille was spelled as Mikelle, in those cases half a point has been subtracted per element.

Results

Note that data of test and scale scores with a $z$-score $>|2.58|$ were considered outliers and excluded from analyses. An alpha level of .05 was used for all statistical tests, unless stated otherwise.

Short Term

The mean short term scores of the conditions are plotted in Figure 1. Additionally Table 5 displays the mean scores, standard deviations and sample sizes in the conditions at $t_1$. Preliminary checks were conducted to ensure that there was no violation of the assumptions for analyses of variance and T-tests. A two-way between-groups analysis of variance was conducted to explore the impact of instruction and exercises on topography knowledge. A significant interaction effect was found between instruction and exercises on test results at $t_1$, $F(1, 89) = 12.39, p < .01$, with a large effect size (partial eta squared = .12). Moreover significant main effects of both instruction, $F(1,89) = 6.29, p = .01$, and exercises, $F(1,89) = 5.98, p = .02$, were found, with moderate effect sizes (partial eta squared = .07 and .06, respectively).

To further explore the impact of the interaction effect of instruction and exercises on topography knowledge, a one-way between-groups analysis of variance with Bonferroni correction was conducted. The
Figure 1. Plot of the mean short term test scores ($t_1$). The numbers in the plot refer to the conditions as mentioned in Table 1.

Table 5

Descriptive statistics of pupil scores on short term ($t_1$) and long term ($t_2$)

<table>
<thead>
<tr>
<th>Condition</th>
<th>$M$</th>
<th>$SD$</th>
<th>$N$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$t_1$</td>
<td>$t_2$</td>
<td>$t_1$</td>
</tr>
<tr>
<td>Meaningful instruction/meaningful exercises</td>
<td>8.34</td>
<td>6.65</td>
<td>1.59</td>
</tr>
<tr>
<td>Meaningful instruction/rote exercises</td>
<td>6.09</td>
<td>5.15</td>
<td>2.33</td>
</tr>
<tr>
<td>Rote instruction/meaningful exercises</td>
<td>7.96</td>
<td>6.28</td>
<td>1.67</td>
</tr>
<tr>
<td>Rote instruction/rote exercises</td>
<td>8.36</td>
<td>6.78</td>
<td>1.60</td>
</tr>
</tbody>
</table>
mean score of pupils in the conditions rote instruction/rote exercises, rote instruction/meaningful exercises, and meaningful instruction/meaningful exercise were all significantly higher than in the meaningful instruction/rote exercises condition, F(3, 89) = 7.94, p < .01. No significant differences in mean scores were found between the other conditions.

The main effects of instruction and exercises were further explored by conducting independent samples T-tests. Pupils who received a rote instruction (M = 8.15, SD = 1.63) performed significantly better than pupils who received a meaningful instruction (M = 7.29, SD = 2.26), t(84) = -2.12, p = .04. Conversely, pupils who performed rote exercises (M = 7.23, SD = 2.29) scored significantly lower on the test than pupils who performed meaningful exercises (M = 8.15, SD = 1.63), t(77) = 2.23, p = .03.

Since interest and novelty might influence pupil achievement (Krapp, 1999; Reeve, 1989), an analysis of covariance was planned to control test scores for these covariates. However, correlation between pupil scores at t1 and the covariates interest (r = -.07, p = .52) and novelty (r = .06, p = .60) was virtually nonexistent, therefore the analysis was not executed.

Long Term
The mean long term scores of the conditions are plotted in Figure 2. In addition, Table 5 displays the mean scores, standard deviations and sample sizes in the conditions at t2. Preliminary checks were conducted to ensure that there was no violation of the assumptions for analyses of variance. The same as at t1, on test results at t2 a two-way between-groups analysis of variance was conducted, to explore the impact of instruction and exercises on topography knowledge on long term. A significant interaction effect was found between instruction and exercises, F(1, 89) = 4.14, p = .05, with a small effect size (partial eta squared = .04). No significant main effects of instruction, F(1, 89) = 1.67, p = .20, and exercises, F(1, 89) = 1.03, p = .31, were found.

A one-way analysis of variance with Bonferroni correction was conducted to compare the mean scores of the four conditions. Again pupils in the meaningful instruction/rote exercises condition scored lower than pupils in the other conditions, however none of the conditions differed significantly from each other F(3, 89) = 2.27, p = .09.
Just like on short term test scores, on long term scores an analysis of covariance was planned to control test scores for interest and novelty. However, correlation between pupil scores at t₂ and the covariates interest (r = -.10, p = .34) and novelty (r = .07, p = .54) was virtually nonexistent again, therefore the analysis was not executed.

Retention

To explore retention of topographical knowledge from t₁ to t₂, difference scores have been calculated by subtracting t₁-scores from t₂-scores. The mean difference scores of the conditions are plotted in Figure 3 and descriptive statistics of this new score are displayed in Table 6. Preliminary checks were conducted to ensure that there was no violation of the assumptions for analyses of variance and T-tests. A two-way analysis of variance was conducted to explore the impact of instruction and exercises on difference scores. A significant main effect for exercises was found with a moderate effect size (partial eta squared = .06), F(1, 87)
Figure 3. Plot of the mean difference scores ($t_2-t_1$). The numbers in the plot refer to the conditions as mentioned in Table 1.

<table>
<thead>
<tr>
<th>Condition</th>
<th>M</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meaningful instruction/meaningful exercises</td>
<td>-1.71</td>
<td>1.35</td>
<td>24</td>
</tr>
<tr>
<td>Meaningful instruction/rote exercises</td>
<td>-0.46</td>
<td>1.35</td>
<td>23</td>
</tr>
<tr>
<td>Rote instruction/meaningful exercises</td>
<td>-1.43</td>
<td>1.41</td>
<td>22</td>
</tr>
<tr>
<td>Rote instruction/rote exercises</td>
<td>-1.32</td>
<td>1.64</td>
<td>22</td>
</tr>
</tbody>
</table>
=5.12, \( p = .03 \). No main effect of instruction, \( F(1, 87) = .94, p = .34 \), or interaction effect, \( F(1, 87) = 7.4, p = .06 \), was found.

An independent samples T-test was conducted to explore the main effect of exercises. Pupils who performed rote exercises (\( M = -0.88, SD = 1.54 \)) declined significantly less than pupils who performed meaningful exercises (\( M = -1.58, SD = 1.37 \)), \( t(89) = -2.29, p = .03 \).

Furthermore a one-way analysis of variance with Bonferroni correction was conducted to find significant differences between the conditions. Pupils in the meaningful instruction/meaningful exercises condition declined significantly more than pupils in the meaningful instruction/rote exercises condition, \( F(3,87) = 3.28, p = .03 \).

An analysis of covariance was planned to control difference scores for interest and novelty scores. But since correlation between difference scores and the covariates interest (\( r = -.03, p = .77 \)) and novelty (\( r = .08, p = .47 \)) was virtually nonexistent, the analysis was not executed.

### Interest and Novelty

Descriptive statistics of interest and novelty, the scales measured in the questionnaire, are displayed in Table 7. In order to explore the impact of (combinations of) instruction and exercises on pupils’ interest and novelty scores, two-way and one-way between-groups analyses of variances have been conducted, results are displayed in Table 8. Preliminary analyses were conducted to check if the assumptions for analyses of variance were not violated. Since the assumption of homogeneity of variances was not met, a more stringent significance level of .01 has been used. No significant main effects, interaction effects or differences between conditions were found when exploring the data on pupils’ interest and novelty scores.
Table 7
Descriptive statistics of scale scores of interest (int) and novelty (nov)

<table>
<thead>
<tr>
<th>Condition</th>
<th>M</th>
<th>SD</th>
<th>N</th>
<th>int</th>
<th>nov</th>
<th>int</th>
<th>nov</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meaningful instruction/meaningful exercises</td>
<td>1.90</td>
<td>1.69</td>
<td>0.81</td>
<td>0.62</td>
<td>25</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Meaningful instruction/rote exercises</td>
<td>2.00</td>
<td>1.69</td>
<td>0.75</td>
<td>0.55</td>
<td>24</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Rote instruction/meaningful exercises</td>
<td>2.16</td>
<td>1.73</td>
<td>0.67</td>
<td>0.60</td>
<td>21</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Rote instruction/rote exercises</td>
<td>2.50</td>
<td>1.64</td>
<td>1.23</td>
<td>0.43</td>
<td>23</td>
<td>22</td>
<td></td>
</tr>
</tbody>
</table>

Table 8
Results of two-way and one-way analyses of variances

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Error</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest</td>
<td>3</td>
<td>88</td>
<td>1.98</td>
<td>.12</td>
</tr>
<tr>
<td>Instruction</td>
<td>1</td>
<td>88</td>
<td>3.24</td>
<td>.05</td>
</tr>
<tr>
<td>Exercises</td>
<td>1</td>
<td>88</td>
<td>1.10</td>
<td>.24</td>
</tr>
<tr>
<td>Instruction * Exercises</td>
<td>1</td>
<td>88</td>
<td>0.34</td>
<td>.52</td>
</tr>
<tr>
<td>Novelty</td>
<td>3</td>
<td>84</td>
<td>0.09</td>
<td>.96</td>
</tr>
<tr>
<td>Instruction</td>
<td>1</td>
<td>84</td>
<td>0.01</td>
<td>.94</td>
</tr>
<tr>
<td>Exercises</td>
<td>1</td>
<td>84</td>
<td>0.13</td>
<td>.73</td>
</tr>
<tr>
<td>Instruction * Exercises</td>
<td>1</td>
<td>84</td>
<td>0.16</td>
<td>.69</td>
</tr>
</tbody>
</table>
Discussion

Effects on Short and Long Term

The results of this experimental study show that, on short term, pupils who were given a meaningful instruction followed by a period of rote exercising, remembered significantly less of the learned topography than pupils in all other conditions. The variance in scores was partly explained (12 per cent) by an interaction effect of instruction and exercises. In addition, main effects of both instruction and exercises explained some variance in pupil scores. On long term an interaction effect was found as well, but no main effects were found. Most importantly, after two weeks the model accounted for merely 4 per cent of the variance in scores, and strikingly there were no significant differences between the conditions.

Based on the constructivist view on learning pupils in the meaningful instruction/meaningful exercises condition were expected to perform best, especially on long term (Peterson, 1988; Mayer, 2002; Kember, 1996). In the meaningful instruction and exercises pupils could relate the new information to what they already knew and organize it into a coherent representation, so that more routes to the item in memory were established (Driscoll, 2005), while in the rote instruction and exercises pupils were engaged in memorization of separate items (Kember, 1996). Nevertheless pupils in the meaningful instruction/meaningful exercises condition eventually did not score significantly better than for example pupils in the rote instruction/rote exercises condition.

While exploring t-scores, some significant differences did appear. Pupils in the meaningful instruction/rote exercises condition scored worse than pupils in all other conditions, indicating that this condition is least effective for topography learning on short term. This finding corresponds with two other findings on short term. First, pupils who performed meaningful exercises achieved higher scores on short term than those who performed rote exercises. This finding could be explained by the fact that some pupils had learned the labels appointed to topographical elements in the rote exercises. They consequently used the same labels in the test, in which labels were switched, thus making errors. Pupils who performed meaningful exercises did not learn labels. Second, contrary to this finding concerning the impact of exercises, pupils who received a rote instruction outperformed those who received a meaningful instruction. An explanation for this finding could be found in the number of times the topographical elements were
exposed to the pupils. In the rote instruction each element was exposed several times (the actual amount of
times depended on pupils’ pace), whereas in the meaningful instruction each element was brought to pupils’
attention once.

Despite these differences on short term, no differences were found on long term. Merely 4 per cent of
pupil scores on long term was explained by the intervention. This is however the most important finding of
the study, since what pupils remember two weeks after the intervention is more relevant for educational
practice than what they remember immediately after the intervention.

The results concerning long term test scores confirm Driscoll’s (2005) stand that rote learning might be
an effective approach for learning highly overlearned material. Yet it seems to contrast the need for
variability in repetition (Cuddy & Jacoby, 1982). Despite the lack of variability in instruction and exercises,
using the same labels and same kinds of questions constantly, pupils who received a rote instruction and/or
performed rote exercises eventually did not perform worse than their meaningfully learning peers. However
it is possible that pupils who were learning by rote would have performed better if variability in repetition
had been applied. As mentioned above, some pupils made errors because they had learned the labels
appointed to topographical elements in the rote exercises. It would be interesting to further investigate the
effectiveness of rote topography learning when more variability and spacing is applied, so that forgetting
might enhance remembering (Cuddy & Jacoby, 1982).

Retention

Remarkable results were found in the retention section. Pupils in the meaningful instruction/rote exercises
condition declined significantly less than pupils in the meaningful instruction/meaningful exercises
condition. Variance in difference scores was for 6 per cent accounted for by a main effect of exercises, with
pupils who performed rote exercises declining less than pupils who performed meaningful exercises. Thus
pupils who learned by rote (in exercises) forgot less of what they had known on short term. Returning to
the possible explanations of forgetting as mentioned in the introduction, one explanation might be the time
that passed between the first and the second test (Baddeley, 1997), but the factor time was constant in all
conditions. Another explanation might be a failure to retrieve encoded information (Driscoll, 2005). In view
of the results, the meaningfully learning pupils seem to have had more difficulty in retrieving than pupils learning by rote. Although in meaningful learning more routes to an item in memory are established, contextual information might as well interfere with the learned information (Driscoll, 2005). Yet the meaningful exercises were not provided with contextual information, rather they were aimed at learning the relative position of topographical elements (i.e. the location of elements relative to other elements). Thus failure to retrieve does not seem to be the best explanation for the established differences in retention between pupils who performed rote and those who performed meaningful exercises.

A more plausible explanation concerns the information crumbling into parts, followed by loss of separate elements (Baddeley, 1997). In the meaningful exercises pupils acquired an integrated entity of information, whereas in the rote exercises pupils learned separated items. What was learned while performing the meaningful exercises might have crumbled into parts over time, and as a consequence information got lost. In that way time may after all have played a part in explaining the difference in retention, considering the same amount of time may have had a different impact on pupils who performed different kinds of exercises.

Another plausible explanation for the difference in retention could be found in encoding specificity (Driscoll, 2005). The test resembled the rote exercises (except labels were switched) and was quite different from the meaningful exercises. Since cues that are used in encoding serve as good retrieval cues, pupils who performed the rote exercises were favoured.

Interest and Novelty

Neither of the test scores or difference scores was substantially correlated with pupils’ interest and novelty scores, therefore no analyses of covariance needed to be conducted. This can be explained by the finding that there were no significant differences between the conditions in pupils’ interest and novelty scores, indicating that neither of the conditions was experienced as more or less interesting or innovating than either other. This contrasts with Kember’s (1996) position that the learner is more interested in the case of meaningful learning than in the case of rote learning. An explanation could be found in the theory on collative motivation, which relates novelty to interest (Reeve, 1989; Berlyne, 1978). Participating in a study
can be quite extraordinary to pupils, which could explain why pupils in all conditions found their lesson rather novel. This novelty might have been a primary source of interestingness awarded to the lesson, causing all conditions to be almost equally interesting.

Herewith a limitation of the study comes across. The lesson was novel to all pupils, therefore raising interest for all. It is questionable whether lessons like the ones in the experiment will remain interesting to pupils when they are no longer novel. In the long run, some conditions may be more interesting than others, most likely the meaningful instruction and exercises will be considered more interesting (Kember, 1996). A longitudinal study is needed to rule out the effect of novelty on interest, in order to find the real relation between interest and meaningful or rote instruction and exercises. In that way the possible indirect influence of the intervention on test scores as mediated by interest may be found.

Conclusion

The distinction between rote and meaningful instruction and exercises seems to have a rather small predicting value for what is eventually remembered from a topography lesson. Some significant differences were found directly after the lesson, but in the long run there were no significant differences between the conditions. Nevertheless, it can be concluded that rote exercises are slightly more effective than meaningful exercises, since pupils performing rote exercises forgot less of what they remembered right after the intervention than pupils who performed meaningful exercises.

While interpreting the results it must be kept in mind that the operationalization of meaningful and rote learning in an experimental study like this is disputable. In educational materials these terms can of course be operationalized in several ways and the operationalization chosen in this study is just one possibility. In this sense it would be valuable to test several operationalizations of meaningful and rote learning in order to find the most effective application.

Moreover, this study was concerned with learning the absolute location of topographical elements, which is reflected in the test used. A traditional topography test was used to test all pupils, in order to be able to compare results. If a more ‘meaningful test’ had been used, with questions comparable to the meaningful exercises, the results of the study could have been totally different though. It depends on the
aim of topography education what kind of instruction, exercises, and tests are suitable. Biggs (1996) refers to this principle as instructional alignment. In line with the findings of this study, he asserts that mastery learning produces positive results when dealing with narrow, quantitatively defined performances. Yet “there is no evidence that mastery learning is of value to those interested in achieving broader outcomes” (p. 350). Another study needs to be conducted to explore what kind of instruction and exercises are effective for acquiring a functional mental map based on the relative location of topographical elements. Furthermore it is useful to explore whether absolute or relative topographical knowledge is more profitable as a frame of reference for pupils, since this is the reason why topography should be learned (Van der Vaart, 1990).

In sum, the results of this study query the effectiveness of meaningful instruction and exercises for acquiring knowledge on the absolute location of topographical elements. If topography education is aimed at this factual knowledge of absolute locations, there is no use in investing in meaningful instruction and exercises. On the contrary, rote exercises were more effective than meaningful exercises when it came to retention. However what kind of instruction and exercises are effective in acquiring knowledge of the relative location of topographical elements still needs to be investigated.
References


