More than Reading Literacy? The Evaluation of a Competence Model of Picture and Text Integration

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Abstract. Text with instructional graphics is often used in school, but the integrative comprehension of text and picture information is not systematically taught. To investigate students' skills to process text and picture information a competence model was developed. The evaluation of this theoretical model involved a pilot and a main study. Whereas the results of the pilot study were used to compile grade specific test booklets, the main study focused on verifying the theoretical assumptions. Because of its hierarchical nature the data was analyzed with a multilevel regression model. Beside several other findings a significant cross-level interaction is interpreted as an indication that the competence to integrate picture and text information includes more than reading literacy.

Keywords: picture text integration; competence model; school research; student assessment

Research Question

In school maps, graphs and schematic drawings sustain an important instructional function. To comprehend these pictures students have to process additional information that is typically provided by text. In spite of the frequent usage of graphics, the integrative comprehension of text and pictures is not systematically taught. Instead, the skills necessary to handle text with instructional graphics are put on a same level with reading literacy. In the PISA studies for example, tasks that contain mainly graphics with only few verbal annotations are indicated as non-continuous text and used to assess general reading competence.

There is no doubt that literacy is fundamental for the comprehension of text with instructional pictures, since students have to understand the text parts. However, it is also necessary to process the graphics and to integrate both information sources to form a coherent mental representation. Up to now the cognitive ability of integrating descriptive and depictive information is only marginally accounted for. To fill this gap a project was started to develop and evaluate a competence model of integrative text and picture comprehension.

Theoretical Foundation

The conjoint comprehension of text and graphics requires integration processes that take place in a working memory with limited capacity. According to the model of text and picture comprehension (Schnotz, 2005) integrative processing includes structure mappings between the propositional representation and the mental model. There are two basic mapping types that can be distinguished: element mapping and relation mapping.

Element mapping requires referential conjunctions of single informational entities that are built between the propositional representation and the mental model. This process takes place if students have to integrate words and graphical elements in order to read off detail information.

Relational mapping requires referential conjunctions of relations that are constructed between the propositional representation and the mental model. This process takes place if students have to integrate words and graphical elements in order to form semantic relations. The simplest relation consists of two entities with a referential connection. Complex relations require the integration of more than two informational entities and their referential connections.

On basis of these theoretical assumptions a model of text and picture integration was developed that consists of three competence levels: reading off detail information, reading off simple relations and reading off complex relations. These levels are hierarchically organized, which implies that the acquisition of a higher level competence requires the preceded development of a competence on a lower level. With increasing competence level, the number of elements to be processed simultaneously increases, demanding more working memory capacity. Therefore integration processes on a higher level will cause more cognitive load and will be more difficult (Sweller, van Merrienboer & Paas, 1998).

Test Development and Pilot Study

To test the theoretical model a longitudinal study was planed, assessing students' competence of picture-text-integration from grade 5 to grade 8. For this reason 48 tasks were developed each consisting of one or more graphics, related text and six multiple choice items reflecting three competence specifications. The topics of the tasks as well as the pictures originated from biology and geography schoolbooks.

Because no single student could handle 48 tasks with 288 items 60 different test booklets were compiled according to a Youden square design. These booklets were administered to 48 classes (16 classes from three different school types) that were randomly drawn from all schools in the federal state of Rhineland-Palatinate. In the end 1060 students from grade five to grade eight participated.

The main objective of the pilot study was to obtain reliable test items with known difficulty parameters. To estimate the item difficulties across booklets and grades the response patterns of all students were

calibrated according to the one parameter logistic (Rasch-) model. On basis of MNSQ t-statistics and the results of several DIF-analyses (gender, grade & school type) the best fitting items were selected (Wu, Andams & Wilson, 1998). In the end enough items remained to assemble four grade specific test versions.

Main Study

The longitudinal study to survey the developmental aspects of the competence of picture and text integration started in February 2009. Again 48 classes (16 classes from three different school types) were randomly drawn from all schools in the federal state of Rhineland-Palatinate. This time 1051 students from grade 5 and grade 6 participated. Beside the *picture-text-integration test*, developed on basis of the pilot study, *reading comprehension*, *reading speed*, *general cognitive abilities* and several *socio-economic indicators* were also part of the survey.

To analyze the data we used a multilevel regression approach, reflecting variables on student and class level. The number of parameters in multilevel models can easily become very large therefore a stepwise analysis strategy was applied. In a first step we analyzed the intercept-only-model that includes no explanatory variables but gives an estimate of the intra-class correlation ρ, which equaled 0.45. This result indicates that 45% of the variance of the picture-text-integration test score was located at the group level. Further more the intercept only model is a useful null-model that serves as benchmark with which other models are compared.

In line with this procedure we analyzed in a second step a model with all explanatory variables on the students' level and afterwards included the explanatory variables on the class level. After checking for random slopes and cross-level interactions, chi-square test statistics finally indicated the best fitting model that included several significant predictors. The variables *school type* and *grade* explained nearly all variance of the *picture-text-integration* test score on class level. On student level *reading comprehension* was the strongest predictor followed by *spatial abilities*, *verbal skills* and *reading speed*.

However, the most interesting result was a cross-level interaction indicating that the correlation between *reading comprehension* and the *picture-text-integration* test score is moderated by *grade*. From grade 5 to grade 6 the regression slope flattens, suggesting that the importance of reading literacy for processing text with instructional pictures declines. Indeed these findings are based upon the comparison of two cohorts and not the result of a longitudinal analysis. Nevertheless we interpret this cross-level interaction as an indication that the competence to integrate text and picture information includes more than reading literacy.

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