METACOGNITIVE MODEL FOR DEVELOPING SCIENCE, TECHNOLOGY AND ENGINEERING FUNCTIONAL LITERACY

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Abstract

Technology and engineering functional literacy should be intentionally developed in the school system – like any other competence, it does not develop spontaneously. For this purpose, a didactic model, the Metacognitive model for developing technology and engineering literacy (McM_T&E), was developed, implemented and evaluated. The results of evaluation show that focusing on technology and engineering literacy in Technology and Engineering classes using the McM_T&E model increases students' technology and engineering functional literacy.
Keywords: *functional literacy, metacognitive model, science functional literacy, technology and engineering functional literacy*.

Introduction

The term functional literacy does not reflect the essence of competence any more, since in today's complicated world each scientific field has created a specific language and a specific way of structuring texts, in order to present knowledge about the world and its nature. A consequence of this is that the school system has to develop specific literacies, including science, technology and engineering literacy in the frame of STEM literacy. When reading expository and explanatory texts, which are typical text forms in the field of STEM, it is essential that the reader pays attention to the text structure features. In turn, the reader has to evaluate the relevancy of information in relation to the task which is to be accomplished, to the problem which is to be solved, or to the product that is to be designed (Dreher, 2002). In this context – when focusing on text understanding on higher cognitive levels – general functional literacy overlaps with specific scientific literacies, among them with STEM literacies, and, in their framework, with science, technological and engineering literacy. The term *technological and engineering literacy* refers to, apart from an ethical use of scientific and engineering knowledge, also to the knowledge about science, technology and engineering and the competence of understanding and using science/technology/engineering knowledge as the applicative part of science. The competence of communicating about the scientific, technological and engineering topics is an essential part of STEM literacy. In this sense of the word, technology and engineering literacy is an integral part of STEM literacy.

Functional literacy in the field of STE, (and by way of analogy in other fields) should be understood (Aberšek, 2018; Dolenc, Aberšek, & Kordigel Aberšek, 2015) as:

- *information literacy in the field of STE* (finding and managing information, critically evaluating information, and being competent in using information in order to solve a problem);
- *functional literacy in the field of STE,* which means
- reading expository and/or explanatory texts from the field of STE, understanding such texts (in verbal and visual code), and using the knowledge acquired this way to solve problems;
- reading/writing certain text types, such as *description of a procedure*, *instructions for use*, *building/manufacturing instructions*, etc., understanding such texts and using what was read to successfully and safely use a new product, make a product, assemble furniture, and so on.

Research Methodology

In the first step, a metacognitive model for science, technology and engineering literacy (McM_T&E) was developed. After developing the McM_T&E model, an evaluation was necessary. The basic research and evaluation method applied in the present study was an experimental method of pedagogical research. The methods used to belong to the framework of quantitative and qualitative research. In the preparation and adaptation of the metacognitive model (McM_T&E), action research was used to collect data on how the lessons and schoolwork were conducted. Basic information about the students were obtained with a questionnaire and a non-experimental method. Students' knowledge and the efficiency of their work were tested quantitatively, by measuring reading time and reading understanding of an *expository text* from the field of engineering and technology and an example of *manufacturing instructions,* and qualitatively, by evaluating the quality of the manufactured product according to *manufacturing instructions* and according to the creativity of the solution (Cencelj, Kordigel Aberšek, Aberšek, & Flogie, 2019).

Research Procedure

After discussing and coordinating with teachers of the school subject Slovene language and literature, students learned about different reading strategies and were introduced to a variety of examples about how to use these strategies in their mother tongue class. Next, a test was carried out to identify the existing situation – the ability of transferring the general functional literacy, acquired in the mother-tongue classes, to the level of functional literacy in the field of engineering and technology. Reading speed and text understanding were tested in two reading situations: reading an expository text from the field of engineering and technology, and reading manufacturing instructions from the field of engineering and technology (Cencelj, Kordigel Aberšek, Aberšek, & Flogie, 2019).

The next step was the adoption of learning content about the materials needed in the working process, and the production of the product. Students were divided into two groups: the experimental group (EG) and the control group (CG). Students in the CG were taught using the traditional teaching method. Students in the EG were taught using the new, metacognitive model for developing *technology and engineering* functional literacy (McM_T&E), which is based on process-oriented instruction, focuses on developing functional literacy in the field of engineering and technology, and uses formative monitoring of the student's progress.

In the last phase, the reading comprehension of an expository text from the field of technology and engineering and of manufacturing instructions, was re-tested. By comparing the obtained results, the students' progress in reading speed and in understanding of the read text, was measured. In both examinations (both in the pre-test and at the end of the survey), the same text was used, and both groups were given the same criteria for evaluating work and the same content treatment, which in the end produced comparable results.

Sample

The research was carried out in classes of ‘Technology and Technique’ (TIT classes), as part of a thematic area called ‘making products from paper materials’. The survey included 108 students from a smaller town school, settled in a peripheral region of Slovenia, who attended the six and seventh grades at the same primary school in the school year 2017/2018. Out of these, 68 were students of three divisions of the sixth grade (63%) and 40 were students of two divisions of the seventh grade (37%). The sample was collected from all sixth and seventh grade classes at this school. According to gender, the sample consisted of 55 boys (51%) and 53 girls (49%).

Data Analysis

Microsoft Excel 2016 was used to organize the obtained data. For statistical processing of the organized data, the SPSS 22.00 software package was used. Data was processed and presented at the level of descriptive and inferential statistics. At the level of descriptive statistics, frequency distributions (f, f %), mean value measures, variation measures, correlation measures and the Kolmogorov-Smirnov test for testing normality, were used. Some of the ordinal variables (multilevel scales) were considered as interval, with the assumption that the differences between the values were the same. This way of dealing with variables referred only to the calculation process, and not to the interpretation of the results obtained.

Research Results

Regarding the analysis of text comprehension, the study presents the results of reading comprehension, with regard to expository texts from the field of engineering and technology and manufacturing instructions for the EG: before and after the implementation of the metacognitive model for developing *technology and engineering* functional literacy (McM_T&E).

The expository text comprehension results show that only 3.7% of the students have achieved results which classify them as 'bad readers' (18.5% of students in the pre-test), and 18.5% of the students have achieved the results which classify them as 'slow readers' (53.7% of students in the pre-test). The number of science and engineering functionally literate students grew remarkably, viz.: 14.8% in the pre-test, and 53.7% in the post-test. These are students, who reached the level of 60% to 75% of correct answers. Also, the number of students who reached the highest level of reading comprehension grew: from 13.00% in the pre-test to 24.1% according to the post-test.

The results of reading comprehension in the CG classify 31.5% of the students as 'bad readers'. These students have all made progress – in the post-test, there were no bad readers in this group. The results for average readers show a different picture: the group of average readers hardly changed (44.4% in the pre-test, and 46.3% in the post-test). The number of functionally literate students in the field of engineering and technology grew: 14.80% in the pre-test, in comparison to 51.9% in the post-test. The number of very good readers grew: 9.3% were classified as 'very good readers' in the pre-test, and 24.1% in the post-test. The results concerning the reading comprehension of manufacturing instructions draw a similar picture and confirm the effectiveness of the metacognitive model for developing *technology and engineering* functional literacy (McM_T&E).

Conclusions

Functional literacies in individual subject areas can only be the result of cross-curricular co-operation between a mother-tongue teacher and a subject teacher, or teachers, with the share of responsibility leaning towards the latter as the level of education progresses. It needs to be clear, of course, that only properly qualified teachers will be able to competently perform their role in this process. Therefore, they need to be trained in at least two areas, namely, in the field of functional literacy, in particular STE functional literacy, and in collaborative work. If this is to be achieved, methods of working with teachers must change, and in turn, teachers must also adapt their ways of working with students and begin applying different teaching and learning methods, such as the proposed metacognitive model McM_T&E for training students in science, technology and engineering literacy.

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