

The effects of applying concept mapping on students' achievement

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Abstract: Students are exposed to a great deal of information in everyday life which they have to comprehend and process. Information processing can be fostered by various learning strategies. One such strategy is visualization. Among visual techniques, concept mapping has various applications in learning situations. Based on this technique, we initiated an intervention programme series in Hungarian grammar for 4-8 graders. We aimed to explore changes in the performance of low achieving students and also to analyse the construction of students' concept maps. Two different groups were involved in the study. The experimental group participated in a training program, whereas the control group was only administered the pre- and posttests. According to our analysis, in numerous cases poorly achieving students performed higher in the pretest than in the posttest. Regarding the exercises of the intervention material, we assumed that students tend to achieve higher in those tasks where the structure is given in advance and they only have to provide the content, as opposed to those tasks in which they have to construct maps entirely by themselves. This hypothesis was confirmed by our results. A possible further direction for research is to apply concept maps to different learning situations, e. g. for exploring prior knowledge.

Keywords: learning techniques, visualization, information processing, concept maps, content based intervention

1 INTRODUCTION

The basic idea of the need for a knowledge- and hence learning-based society has become increasingly widespread in the 21st century. The success of a country, region or city is determined by the ability of its inhabitants to acquire and develop new knowledge. Yet, the definition of useful knowledge and the need for certain kinds of knowledge are constantly changing along the lines of scientific and technical development. However, with the acquisition of some key competences, skills and knowledge elements, the constant renewal of knowledge becomes more manageable. Hence, their acquisition and their enhancement should already start in public education in order for the students to be able to adapt to the changing environments in their future workplaces when entering the labour market. Cooperation, ICT skills, logical reasoning, composition of own ideas, communication and learning to learn are all essential for coping with the difficulties which learners face after leaving school. For the purposes of the present study the key competence of learning to learn is highlighted here. The possibilities of enhancing learning skills in school are discussed in detail. A developmental study of implementing the

technique of concept mapping at elementary school is presented. Furthermore, the study focuses on the impact of the developmental work in the lowest achieving subsample, investigating the question whether development efforts have contributed to any significant results.

2 THE FOUNDATIONS OF TEACHING TO LEARN

The development of learning skills has traditions at the University of Szeged as numerous theoretical and empirical studies have been produced in this field (e. g. [1, 2, 3]). Moreover, certain teaching strategies have also been proposed that can contribute to enhancing students' learning potential, such as the theory and practice of mastery learning. The findings of Csapó [4] indicate that students' achievement can be successfully developed even in traditional classroom settings if the learning content is organized into appropriate units with adequate feedback and additional work of correction, if deemed necessary. Oroszlány constructed some guidebooks to learning methods (e. g. [5]) that provide an aid to teachers as well as to students in their learning processes. In addition, he developed a programme of teaching to learn that directs teachers thoroughly how to use student tasks in their teaching. It includes domains such as the inner conditions of learning, the development of memory, dynamic reading or the culture of thinking. Furthermore, the developmental work of Robert Fisher [6], which has been published in Hungarian as well, provides useful information to teachers about learning, and helps parents to understand the learning processes of their children.

In the section dealing with developing key competences, The Hungarian National Core Curriculum (NCC, [7]) highlights the importance of effective learning, and places it among the fundamental goals of school education. It is essential in learning that prior knowledge be activated at the beginning of the process, new information be acquired and new knowledge be constructed as a result of the former two steps. As for the quality of knowledge, such knowledge is needed which can be transferred through actual situations and applied in everyday life. NCC also emphasises teaching to learn among its key developmental tasks. Beyond the role of knowledge acquisition, attention and memory, the document emphasizes the importance of external factors inducing stable psychical change as well. In other words, every cognitive skill and factor of

personality development affecting learning is involved. Undoubtedly, teachers also play a significant role in developing students' skills and equipping them with learning techniques, thus enabling them to plan and execute their learning processes appropriately. Hence, if teachers know the learning strategies, styles and habits of their students, they can adjust their teaching methods to their needs for the sake of more effective development.

3 LEARNING TECHNIQUES

Students encounter a great deal with information in their everyday life as well as in their school studies. In order to be able to process this amount of information they need to know learning techniques that contribute to the effective organization of the knowledge to be acquired. There are a number of techniques which are suitable for processing and organizing information and foster understanding. The most commonly used one is perhaps note-taking, and mind map and concept-map in the field of the visual representations.

Staub [8] points out that even mere note-taking in itself fosters memorization. It is assumed that information processing taking place in the application of this technique is beneficial for the memorization of information, since it requires more effort in concentrating on the content to be processed. Consequently, the more detailed the notes are, the wider the possibilities are for creating associative connections between knowledge elements and inducing deeper understanding. Further advantages of note-taking include that the notes are taken with a well-defined goal in mind and that one also has the chance of learning when revisiting them. However, note-taking in class has to cope with the difficulties of quick and parallel information-flow. It is easier to face these challenges if students are aware of the goals and main points of the lesson. Note-taking is further supported by the use of individually created abbreviations, highlighting and the use of colours.

As for visual techniques, the mind map developed by Tony Buzan [9] is the one most widely used in practice. Structurally, one concept is in the centre and all the additional concepts and ideas are linked to it. The figure itself is suitable for displaying major and minor branches, highlighting the main points using colours or various sorts of designations. Buzan and Buzan [9] define four logical foundations of constructing a mind map. In terms of stress, they call attention to the importance of pictorials and point out that the size of inscriptions, lines and pictures may vary. In the application of associations, they mention that arrows are suited for expressing relationships between branches. In addition, they consider the use of colours and codes also important. Unanimity is represented in the use of different formal elements, for instance, underlining adjusted to word length or thicker central lines. It is further considered important to elaborate an individual style when constructing mind maps.

Concept map, however, is a tool applicable to more diverse learning situations. It is suitable, for instance, for assessing prior knowledge, visualizing textual relationships or outlining a process e.g. an experiment. According to Novak and Gowin [10] concept maps are constituted of nodes and linking words. The inscriptions can be mere concepts or even ideas which can be connected by crosslinks which can be used for referring to relationships across levels. The maps are hierarchical in structure and they either go from general to specific or from specific to general issues.

4 USING CONCEPT MAPS IN SCHOOL

As it has been mentioned above, school education should provide students with learning strategies fostering information processing and should also enable them to master these strategies. Furthermore, it is expected that schools should provide guidance in terms of learning methods allowing students to enhance the effectiveness of their learning. Subject teachers have a crucial role in this, since they are the ones who can provide the appropriate development in each learning domain. A starting point of this process is reading comprehension, which cannot be mastered solely in Hungarian grammar and literature classes. It is essential that students learn to comprehend different text types, figures or tables in various subject domains. Undoubtedly, schools should place more emphasis on the teaching of reading and not only in the initial phase of schooling. The institutional development of reading skills should not be finished in grade 4. Further efforts are needed to make the students master reading strategies that enable them to comprehend what they read to a greater extent. The optimal acquisition of reading techniques requires an even longer process of learning. It would be reasonable to go on with their teaching even to tertiary level and practice the directed processing of professional literature in higher education in order for students to fully acquire the techniques needed for comprehending specialized texts. Such initiatives can be encountered for instance in the USA [11].

5 DESCRIPTION OF THE TRAINING PROGRAMME

The training programme started with introducing students in grades 4-8 to the use of concept maps. The construction of concept maps was based on Novak et al. [12, 10]. Concept maps consisted of nodes containing main ideas and linking words signalling the relationship between them. According to the previous research, concept maps are suitable tools for improving text comprehension and interpretation [16]. In terms of the structure of our programme, the intervention programme of Nagy Lászlóné [3], furthermore, of Csapó, [13], Csíkos [14], Pap-Szigeti, Zentai and Józsa [15] provided us guidance.

The major goal of the programme was to teach the ways one could visually display the definitions learnt in the subject of Hungarian grammar. Students often encounter definitions in textbooks which they have to understand and memorize. I provide one example from the textbook. This definition was part of the research. *It is possible that we cannot or do not intend to specify the establishment of the predicate. The means to express the indefinite subject are indefinite pronouns and verbs in 3rd person plural. (Indefinite subject)*

This programme was meant to provide an aid for this process. The training focused on the activities of selecting the keywords and representing their relationships. The development of the programme began with synthesizing the theories of meaningful learning and concept mapping which was followed by reviewing the requirements of the subject, the tasks of development, the Frame Curriculum, the National Core Curriculum and the course syllabi. After defining the goals, the actual items of concept mapping assessment (in the form of pre- and posttests) were developed. The items and the complete tests were adjusted to the subject matter content corresponding to the given grade. This stage was followed by the actual execution of the training programme. Two different groups were involved in the study; a control group, which was only administered the pre- and posttests, and an experimental group, which was the actual sample of the developmental work of the training itself.

At first, both groups took the pretest, which was followed by the developmental work of providing concept mapping training to the experimental group. The training consisted of approximately 30 tasks. The students received a booklet prepared in advance with the definitions they had to learn and directions for solving the task of constructing concept maps. Two basic task-types were used: completing a map by filling in the nodes and constructing a map. The tasks used initially in the training belonged to the former task-type and the proportion of the more complex map construction tasks gradually increased throughout the programme.

The programme was designed to provide instant feedback to the students in order for them to be able to monitor their own achievement and learn from their mistakes. As a final step of the programme, a posttest was administered to both the experimental and the control groups. The rating of the tests and concept maps was carried out by expert raters.

Hypotheses

1. It was hypothesized that the results of poorly achieving students would be significantly higher in the posttest.
2. It was further assumed that students tend to achieve higher in those tasks where the structure is given and they only have to provide the content, as opposed to those maps they had to construct entirely by themselves.

6 SAMPLE AND DATA-COLLECTION

The study investigated the processing of a short text with the help of concept maps in grades 4-8. Grade 4 was selected because this age group (10-year-olds) was assumed to be capable of individual text processing and had already overcome major reading difficulties. Involving further grades made it possible to examine the effect of age in short text processing. Since grade 8 is the final grade of primary education in Hungary, the research could provide an overview of the achievement of the last 5 grades of elementary education. As for the type of the settlement, institutions incorporated in the sample were selected from towns and villages as well. The pretest was completed by 61 students in the experimental group and 62 in the control group of grade 4, and further 69 students in the experimental group and 55 in the control group of grade 7. In addition, a larger-scale assessment was also carried out. Its sample was as follows: the experimental groups included 61 students in grade 5, 55 students in grade 6, 53 students in grade 7 and 64 students in grade 8, while in the control group there were 65 students in grades 4 and 5, 47 students in grade 6, 68 students in grade 7 and 84 students in grade 8.

The selected poorly achieving subsample constituted of the lowest third of the pretest sample. Yet, in case of grade 7 and 8 participating in the second larger data collection, no students were found in the lowest achievement category, thus the second lowest was selected. This resulted in a much smaller subsample from the second sample. Fortunately, however, small samples are quite usual in concept map studies [15]. Hence, the number of participants was as follows: from the first sample 8 poorly achieving students were selected into the experimental group in grade 4, and 7 students into the control group, while in grade 7, 6 students constituted the experimental group and 3 the control group. In case of the second pretest, the experimental groups consisted of 7 students in grade 5, 9 in grade 6, 9 in grade 7 and 19 in grade 8, whereas the control groups contained 21 students in grade 5, 2 in grade 6, 16 in grade 7 and 25 in grade 8. The experiment lasted from October 2006 to February 2007 in the pilot study and from March to June 2008 in the second stage. The programme was gradually developed.

7 RESULTS

The investigations sought to answer the question, whether or not the concept mapping training programme significantly contributed to the students' achievement. The results are displayed in Table 1.

Tab. 1. Students' achievements in the pre- and posttests

Grades	Pretest/ Post-test Experi- ment mean	Pretest/ Post-test Experi- ment sd	Pretest/ Post-test Control mean	Pretest/ Post-test Control sd
Grade 4 (1 st data collection)	28,1/59,0	3,7/17,0	26,6/29,8	6,7/11,7
Grade 7 (1 st data collection)	25,3/36,0	7,8/10,9	10,5/11,8	4,8/7,0
Grade 5	18,3/21,0	10,4/10,3	22,2/29,4	8,6/15,1
Grade 6	27,5/35,7	4,5/13,8	29,6/29,6	0,9/14,0
Grade 7	52,9/45,6	9,8/21,2	53,4/37,1	7,6/11,3
Grade 8	52,6/62,6	11,1/16,8	55,7/52,2	8,5/16,4

The first posttest revealed significant increase in student achievement both in grade 4 and grade 7, hence confirming the first hypothesis. In case of the second posttest, grade 5 experimental group students did not show significant difference from the pretest, however, the students in the control group achieved significantly higher, though the standard deviation in this group increased as well. Experimental group students in grade 6 achieved scores higher by 8.2% compared to the pretest, yet this increase was not found to be statistically significant. The control group in this grade did not display any changes. In grade 7, no significant change was found in case of the experimental group, but the control group showed a drop in achievement as compared to the posttest, which – considering that all the other factors were unchanged – might be due to their lack of participation in the training. The experimental group in grade 8 outperformed the control group in the posttest, which confirmed the prior hypothesis.

It was also hypothesized that students would be more successful in those tasks of the assessment where the structures of the maps are given, opposed to the ones where they had to construct the entire concept map themselves. This hypothesis was supported by the findings in each subsample. The individual construction of the concept maps, the understanding and organization of information, and the deduction of the relationships between the categories were found to be more challenging to students.

In order to investigate the effect of the intervention and of the individual tasks incorporated in it, deeper analysis was conducted involving the complete sample. The additional influencing factors of the two task-types were explored. This exploratory analysis was complemented by the examination of additional data about students' learning habits collected alongside the tests. In the case of the first assessment, grammar posttest explained a great deal of the variance in concept mapping. Besides this effect, the influence of activity during learning was also found to be significant in grade 4. In the second investigation, inductive reasoning was also assessed besides learning strategies and learning habits. The majority of effects on completing a map by filling in the nodes was attributable to grammar pre- and posttest, whereas the effects on constructing a map were

mostly due to inductive reasoning, the use of memorization as a learning strategy, impulsive and silent learning styles. Yet these effects varied between the grades.

8 CONCLUSION

For the effectiveness of learning, students need to be able to process the information they encounter and to recognize the relationships between these pieces of information. In other words, they should be equipped with the techniques of effective information processing. Several such techniques exist, which help the students not to get lost in the information flow even in their adult years. The students can decide which one to use according to the situation. Therefore, it is important for them to master these techniques and be able to select the appropriate ones for the given situation. This study examined the use of the technique of concept mapping as a basis of a training programme. The findings of the programme indicate that a significant increase can be generated in the achievement of poorly achieving students by using this technique. However, the students in the sample were more successful in those tasks which operated with a pre-prepared structure and the students only had to fill it in with the relevant nodes or arrows. Unfortunately, the task-type that required the students to construct an entire concept map by themselves based on a given definition, proved to be too difficult for them. The selection and organization of information, the construction of a hierarchical system was not an easy task for students. Teachers need such methodological guides that would introduce them to the theoretical foundations of this technique, but at the same time provide practical examples. This way it could be possible to incorporate concept mapping into the subject matter and students could master its usage in domain-specific situations as well.

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