Evaluating a Concept Mapping Training Programme by 10 and 13 year-old students

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Abstract

The PISA 2000 study found large differences between countries in terms of quality of learning. In some countries, students prefer rote learning to meaningful learning. However, such memorisation of the material does not lead to recallable and usable knowledge in the long run. Ausubel's (1968) well-known theory serves as a basis for several techniques of meaningful learning, including concept mapping, which emphasises the visual organization of comprehended information. The present study reports the results of an experiment using concept mapping for deepening students' understanding of teaching materials. It focuses on definitions frequently used in science and Hungarian grammar lessons. Results indicate that concept mapping training programmes can improve participants' achievement. Experiences show that the technique of concept mapping is frequently unfamiliar to students. More time would be needed for practising and using it in different learning situations.

Keywords: Meaningful Learning; Concept Maps; Training Programme

Introduction

In the process of teaching, two important questions arise. The first is how much fact and information students should learn. The second is in what way and in what textual form they should be presented. Successful learning is a widely researched topic (Csapó, 2007; Waeytens, Lens & Vandenberghe, 2002). Techniques and strategies that improve student achievement were investigated within the framework of these studies. When these learning methods are compared, the method of concept mapping is unique among visual learning techniques (Novak, 1990; 1998; Novak & Gowin, 1984). Concept mapping is widely used and has a variety of applications. Among others, it is used to explore prior knowledge (Gurlitt, Renkl, Faulhaber & Fischer, 2007), to visually represent texts (Hardy & Stadehofer, 2006), and to reveal problems (Barroso & Crespillo, 2008) and misconceptions (Berionni & Baldoni, 2004,

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Himangshu, Iuli & Venn, 2008). In general, it is a tool that is used to facilitate meaningful learning and help students to represent their knowledge in a visual form.

In Hungarian schools, grammar is one of the most problematic subjects. One reason for this is that schools place an artificial burden on students by an early introduction of grammatical definitions and rules in mother tongue education. The PISA 2000 results show that Hungarian students are relatively weak in using meaningful learning strategies that aid their conceptual understanding (Artelt, Baumert, Julius-McElvany & Peschar, 2003, 40). These results indicate that students have a preference for using memorizing strategies. However, in the long run, rote learning does not lead to recallable knowledge. Although rote learning can be useful for some learning purposes, the range of its possible applications is fairly limited. The problem arises when students use rote learning too frequently, and memorize information without seeking to establish connections between concepts. Therefore, rote learning should be replaced by meaningful learning, which helps foster a deeper understanding of things. This underlying assumption of the need for meaningful learning serves as the basis for our developmental programme. The goals of our programme are to be accomplished via the use of concept mapping.

There are numerous ways to visually construct concept maps. Below, I provide an example by Novak & Canas (2003, Figure 1.).

Figure 1. A concept map based on Canas & Novak (2008, 27) that shows the key features of concept maps in line with our definition.

Concept maps represent organized knowledge. They are composed of concepts that are connected by linking words. Two concepts and the interconnecting words make up propositions, which comprise units of meaning. In the cognitive structure, knowledge itself is built up of propositions which can be connected to each other. The proposition of concepts in the hierarchical structure depends on our creativity and prior knowledge. Concepts are stored in the form of objects and events, and they are labelled as symbols or words, which

may be connected by lines or arrows. In order to express the interrelationships between different levels we may use crosslinks. This kind of knowledge organization helps the process of teaching and learning to be more effective. In addition, concept maps help to answer focus questions that are context dependent.

Concept maps in practise

Concept maps have a wide range of uses. They are used in various areas, from kindergarten to higher education. Now we will focus on various ways of applying concept maps. For instance, Mancianelli et al. (2004) used concept maps to teach scientific language to 4-5 year old children. Children were provided with samples related to everyday topics like pumpkins and nests. The process of learning started with the activation of prior knowledge, when students carried out experiments with the objects at their disposal. After discussing the subject's properties, they drew a concept map. This early developmental technique attempted to acquaint children with concept mapping. Similarly, Berionni and Baldoni (2004) also applied concept mapping in early childhood. Berionni's and Baldoni's concept maps were part of everyday school life and were drawn either individually or within the frame of a group activity. Concept maps drawn by students informed teachers about students' misconceptions and the dynamic processes of their thinking.

Poveda and Oneca (2006) used the technique of concept mapping in elementary schools. Their goal was to study the development of the concept mapping technique. In the long run, they set out to gather information on student learning techniques with the help of concept mapping. They intended to explore the efficiency of concept mapping as a learning technique, and its effectiveness as an assessment tool. By comparing concept maps drawn at the beginning and at the end of the learning process, Poveda and Oneca (2006) concluded that students created more correct propositions and more detailed concept maps by the end of the study. In Ahlberg and Vuokko's (2004) study, concept maps were drawn by 20 elementary school students during two periods, each lasting three years. They set out to find out the teachers' experiences during the study, the reliability of the concept mapping technique in the long term, its effect on learning, and how concept maps and gender differences can affect preschool performance. The two three-year periods encompassed 23 projects. The results revealed that students were able to create significantly more correct propositions by the end of the programme in both learning periods. In the first part of the study, the students' preschool performance did not affect their achievement in making concept maps. In contrast, the results of the second part of the study showed that preschool achievement had a significant effect on concept mapping. The explanation the researchers provided was that the most important goal of their programme was simply that students learned, used and developed their learning skills. Although it had a dramatic effect in each class, no significant differences could be detected concerning gender.

Halimi (2006) used concept maps to investigate novice translators' text processing skills. Translation is a complex process as it requires many skills, such as understanding written texts, finding the main ideas, expressing content in the second language, problem solving, decision making in various situations and recalling information. Halimi (2006) investigated whether concept maps help students comprehend texts, and whether they could easily notice and recall the main ideas and grasp text cohesion. Students were divided into two groups. The experimental group was introduced to concept maps as tools of text analysis. Then, participants had the possibility to practise following instructions such as 'select the main ideas from the text', 'connect these ideas to others'. In the meantime, the other group analysed texts using traditional text analysis techniques. In the second part of the study the roles of the two groups were transposed. At the end of the study the students in the

experimental group were requested to do free recalling on the texts, write down what they could remember and then answer open-ended questions. According to the results, concept maps facilitated the work of students. In conclusion, the group which was first introduced to the concept mapping achieved better results. Halimi (2006) drew our attention to the role of practice; 20 hours of practice sessions per month proved to be too short a time for students to become familiar with the technique of concept mapping.

Vakilifard and Armand (2006) combined the activation of text comprehension and prior knowledge in their study. They introduced concept maps to foreign language students. 18 students took part in the study, 9 students were placed the experimental group and 9 in the control group. The students in the experimental group took part in a four-session training course. At the beginning the group got a concept map in which nodes and linking phrases from a given list were to be completed. This exercise sought to activate prior knowledge. Later, students were provided with a text. After having read it, students had the possibility of studying the given map and making changes based on their own opinions. During the study more and more parts of the concept maps, which were required to be reconstructed, were modified by the students. Before reading the text, the control group was given a multiple-choice test to fill out. This activity was followed by reading the given text, and on the basis of this students could correct their previous answers based on prior knowledge. At the end of the study, the results of text comprehension were analysed in both groups. In one of the exercises it was expected that students would find the answer in the text, while in the other exercise, connections and relationships between concepts within the text had to be found and understood. The students' performance in the experimental group turned out to be better than that in the control group. The experimental group was given questions at the end of the study to find out whether concept mapping had been helpful for them. Almost all the participants reported that they found concept maps useful for exploring the text structure, finding the key ideas and establishing the relationship between them and organizing information.

Recently, IT solutions in concept map research have gained growing popularity besides paper-pencil tests. More concept map software packages are available commercially[1]. Reader and Hammond (1994) requested students to create concept maps on PCs. The students' working process and the alterations they made in a new window were recorded during the practical sessions. The organization of concepts, the place of concepts, the system of grouping and the working process were all analysed. Students who connected all the concepts achieved the lowest scores. In this case, the students tried to summarize the ideas in a single figure regardless of their meaning. At the end of the programme, the researchers found that concept maps help students to organize their knowledge and to integrate new information in a meaningful way. They concluded that the learning of a text with a computer is more beneficial if students draw concept maps as opposed to taking standard notes.

Applying concept maps frequently plays a central role in collaborative learning. Immonen-Orpana and Ahlberg (2010) used this technique with physiotherapy students. Nine out of 22 potential participants were selected to participate in their study. Thus, the training group was composed of only nine students, out of which 3 students were high achieving, 3 students belonged to average achieving students and 3 students were low achieving students. A potential reason for the small size of sample might have been that researchers aimed at a more detailed analysis of thinking processes. Besides heuristics, concept mapping was used for evaluating the learning process. The main focus was placed on the analysis of reflective metacognitive competence development. The study analysed concept maps

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1   e.g. http://vue.uit.tufts.edu/, http://inspiration.com, http://cmap.ihmc.us/

constructed during individual and collaborative work and examined the collaborative processes occurring during learning. The results showed that in the first two cases the differences between the individually created concept maps were very small, whereas considerable improvements were registered following shared collaborative learning. It was also observed that the atmosphere was very supportive and students communicated more compared to learning situations relying on traditional methods.

Concept maps also appeared in teacher training colleges. Zanting, Verloop and Vermut (2003) asked students to use this technique to analyse and assess the practical knowledge of the mentor teachers. The researchers interpreted practical knowledge as complex knowledge that is related to teaching experience, integrates content knowledge and is related to students and the teaching situation. Zanting, Verloop and Vermut (2003) provided a reason for studying practical knowledge from the viewpoint of mentor teachers. By observing them, teachers can profit from their own responses and explanations of their teaching. Describing our own ideas and knowing how to formulate assumptions gives an opportunity to reflect on our own activities. For future teachers, this is helpful because this way they can gain access to undocumented knowledge. Zanting, Verloop and Vermut (2003) showed how students could relate practice to theory and form their own opinions about teaching. The researchers were also interested in the students' opinions regarding concept mapping. They used data gathered in interviews to assess the practical knowledge of mentor teachers. They found that over 70% of the students considered concept maps useful to a greater or lesser degree. One benefit they mentioned was that concept mapping helped them to study different opinions and ideas. Furthermore, it helped teachers to reconsider their own views. Some of the problems participants faced were that concept mapping did not reveal any new information and it was too artificial and abstract for them. In contrast, concept mapping was useful for mentor teachers because it helped them to clarify their ideas and gave them the opportunity to analyse their own behaviour. The construction of concept maps occurred spontaneously and helped them to analyse new experiences. On the whole, concept maps were more analytical and descriptive than the interviews. In the following section, we present the results of our study related to concept mapping, based on text comprehension and the understanding of definitions.

Aims and research questions

Ausubel's theory (1968) served as the theoretical background for this study. In addition, the technique proposed by Novak (1990, 1998) and Novak and Gowin (1984) was applied in the construction of a concept mapping intervention programme. Here we seek to improve the students' comprehension of rules by means of concept mapping. The main aims are that students should learn to find the main concepts in a text, discover the relationships within the text, and ultimately, learn to draw concept maps unaided. We set out to discover the effect of the concept mapping training programme in Hungarian grammar and examine whether there are significant differences between the results of the experimental and control group.

Our hypotheses were the following:

a) We expected to find significant differences between the performance of the experimental and the control group and we predicted that the experimental group would perform better at the posttest.

b) As far as the types of concept mapping exercises are concerned, we expected to find significantly higher scores in the posttest when we compared the performance of the experimental group both on the pretest and posttest.

c) We expected that students would perform significantly better in completing exercises. We presumed that these types of exercises required only a superficial understanding and more instructions.

d) We expected that the variables of the chosen background tests would explain the tasks of concept mapping to a great extent. We hypothesized that the technique of concept mapping would have a positive influence on learning strategies, learning styles, attitude and school marks in different subjects.

Methods

Samples

The present study was carried out from October to February 2007 and was part of a large-scale project on concept mapping with more than 200 participants. The random sample consisted of 10 and 13-year-old students. 10-year-old students are 4th graders and 13-year-old students are 7th graders in Hungary. The participant classes were selected from partner schools of the Research Group on the Development of Competencies from the University of Szeged, which took part in a large-scale project (other studies involved were e. g. Antal, 2009; Molnár, 2009). The classes chosen included more low-achieving and disadvantaged students. The participants were divided into an experimental group and a control group. In the study 61 10-year-old and 69 13-year-old students were included in the experimental group and 62 10-year-old and 55 13-year-old students formed the control group. The research design was complex since teachers used different course books and workbooks in different schools. There are three versions of learning materials in use in these schools by three different editors, each of which has a different content and structure.

Instruments and procedures

While the pretest was based on students' prior knowledge, the posttest included the topics of the concept mapping exercises. The subjects used for the intervention material were included in the National Curriculum. The learning material was developed for 4th and 7th grade students. Our study consisted of 25 sessions by 10-year-old students and 31 sessions by 13-year-old students. In the study, each exercise was constructed by the teachers of the given subject. The research procedure was constructed to serve the aims of the developmental programme by promoting meaningful learning.
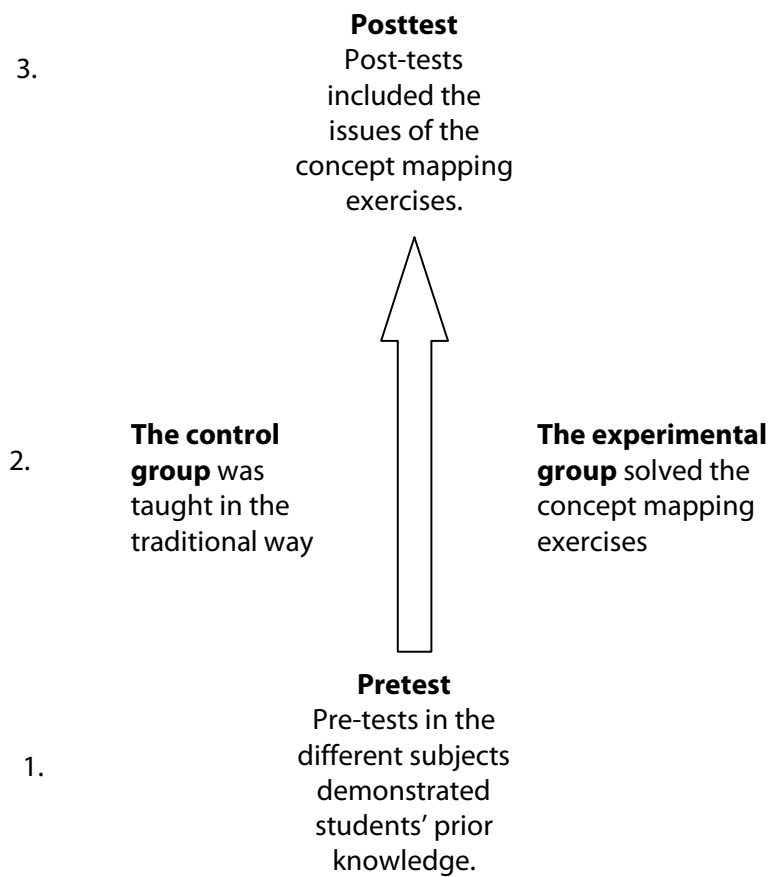
3.

Posttest
Post-tests
included the
issues of the
concept mapping
exercises.

2. **The control group** was taught in the traditional way

The experimental group solved the concept mapping exercises

1.

Pretest
Pre-tests in the
different subjects
demonstrated
students' prior
knowledge.

Figure 2. Research design.

The students worked on the given exercises, one per lesson, during the lessons. For the completion of each exercise, a time of five to ten minutes was allotted. Each student was provided with a workbook containing the exercises. First, the students each had to read the text of the given exercise, then they had to follow instructions of the prompts in the workbook, and after they drew their own concept maps. After students had finished the exercise, they received feedback. The task types included: (1) completing a map by filling in the nodes and defining the linking words, and (2) constructing a map from scratch. Below, I provide two examples from the Hungarian grammar programme (Figure 3. and 4.).

Indefinite subject

It is used when we cannot or do not wish to specify what the predicate modifies. Indefinite pronouns and verbs in 3rd person plural can occur in this position.
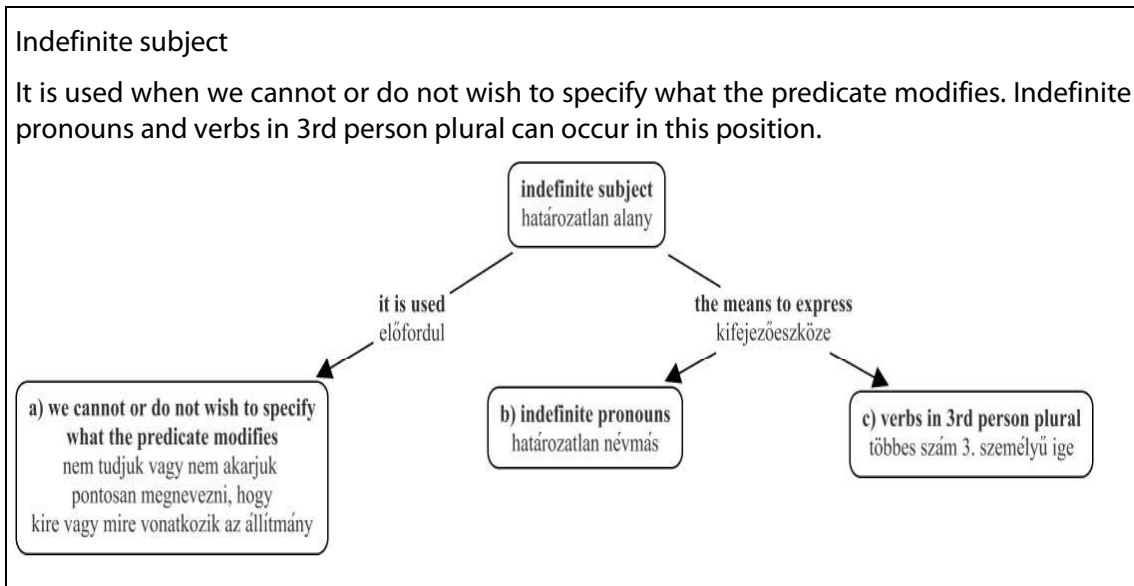
Figure 3. Sample task for 7th graders: Completing a map by filling in the nodes.

The object

The suffix "-t" is the formal marker of the object in the sentence. As regards word class, object position is generally occupied by a noun or a member of other word classes which can act as nouns like the question words "whom" and "what"
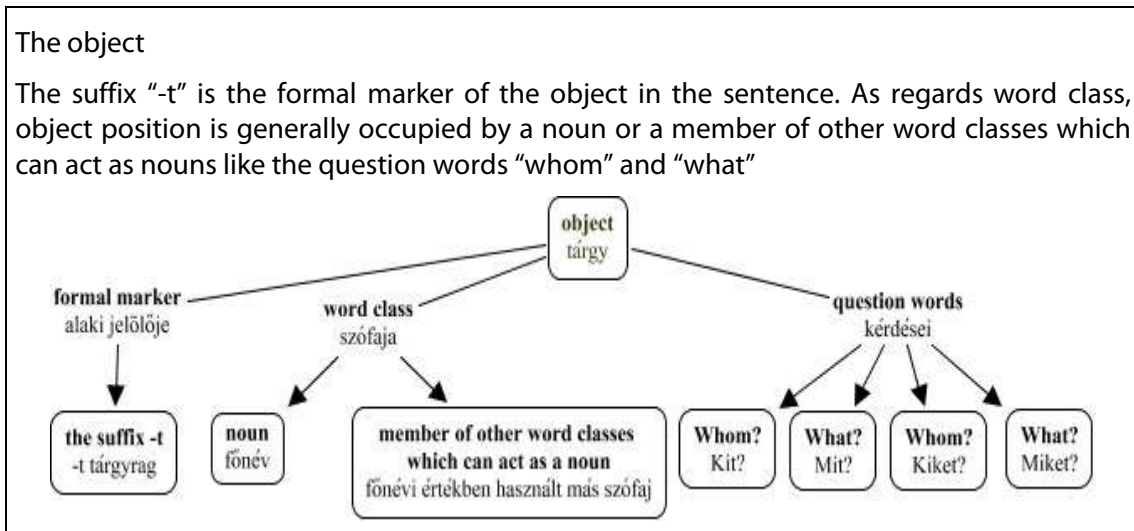
Figure 4. Sample task for 7th graders: Constructing a map.

The pretest was based on the students' prior knowledge in the different subjects, in line with the National Core Curriculum requirements. After completing the pretest, the experimental group was requested to participate in a series of concept mapping tasks, while the control group was taught in the traditional way. The posttest sought to examine the new knowledge acquired after the pretest. Pre- and posttests were constructed by teachers who were experts in their field. Both tests and concept mapping exercises were each corrected by one teacher.

4.3. Feedback for the students

First, the teachers were given a workbook that also included the completed maps, serving as sample maps and unified starting-points. The students were presented with the solution of the given map after having completed their own. After examining the workbooks, both teachers and students were given the possibility to raise relevant questions. Second, the students received their own workbooks without a key. These workbooks were used throughout the concept-mapping programme. Written instructions were provided in the workbook, which fostered individual work. After each exercise, feedback was given in

different forms. (1) The teacher and the students discussed the solutions of the mapping task; the students could also consult their own maps. (2) The teacher and the students discussed the solution without the help of the exercise books. (3) There was no feedback – the teacher did not give help until the exercise was completed. Having solved their tasks, the students could discuss them with the teacher.

Results

Tests

Students' knowledge was assessed at two different times. Their degree of knowledge was measured using a knowledge test at the beginning and the end of the programme. Cronbach's alpha was in most cases very high: 4th graders pretest: 0.95, posttest: 0.95; 7th grader pretest: 0.94, posttest: 0.95.

The tests contained different types of exercises. Recall, converting and recognition were assessed in the pretest of Hungarian grammar by 10-year-old students, while in the posttest recall and converting were assessed. As regards the tests of 13-year-old students, in the pretest recognition, implementation, recall, converting and interpretation were measured, while in the posttest recalling, recognition, implementation, and interpretation were in the focus.

Constructing the tests was quite a demanding task since teachers in the selected schools use different course books and workbooks. We had to take into account the potential differences in the learning material presented to various classes at a given time. Consequently, pretests in every subject were based on students' prior knowledge, which was common for every student. Posttests analysed the learning material presented with concept maps. This was necessary in order to be able to study the results of the experimental group and compare the results the two groups. During the construction of the posttest we also ensured that the learning material was familiar to both of groups. School teachers provided help in the process of the construction of these tests.

Results of the survey

Our study was carried out in the subject of Hungarian grammar. As stated in the first hypothesis, we assumed that we would find significant differences in the posttest and we presumed that the experimental group would achieve better results. Furthermore, we predicted that the experimental group would perform better when we compared the pre- and posttest results.
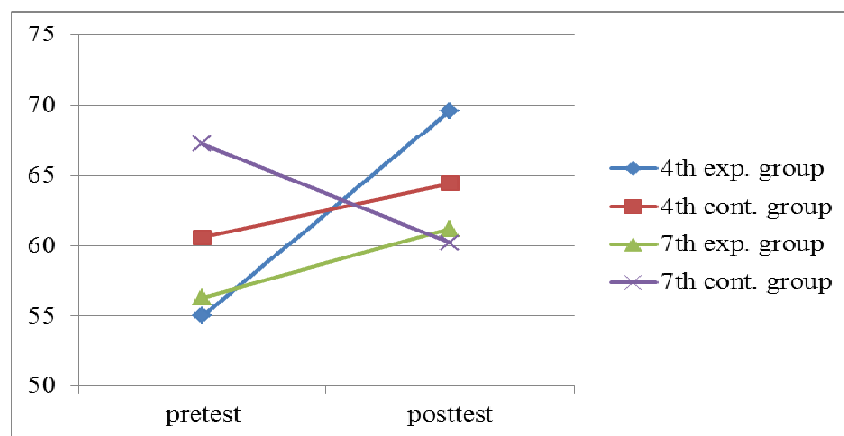

Figure 5. The results of the pre- and posttest (%p).

We did not discover significant differences between the experimental and control group in the 4th grade classes after comparing the pretest and posttest results. However, we found significant differences between the results of the two groups in the posttest, where the experimental group achieved better in the recall exercises (Mexp.gr.=77.5%p, Mcont.gr.=70.1%p; *p* <0.05). In addition, a significant difference was found in the performance of the experimental group for the pre- and posttest. Thus, our hypothesis that the experimental group would perform significantly better in the posttest was confirmed (Mexp.gr.=55.0%p, SDexp.gr.=18.2; Mcont.gr.=69.6%p, SDexp.gr.=16.7; p=0.001). The performance of the control group changed significantly as compared to the pre- and posttest results as well. They achievement also showed increase (3.8%p, t=3.304, *p*=0.001).

Regarding the results of 7th graders significant differences were found between the experimental and control group on the pretest. Here the experimental group performed less successfully in comparison with the control group (Mexp.gr.=56.3%p, SDexp.gr.=13.9; Mcont.gr.=67.2%p, SDexp.gr.=21.1). However, we did not find any significant differences after comparing the posttest results (Mexp.gr.= 61.2%p, SDexp.gr.= 14,6; Mcont.gr.= 60.2%p, SDexp.gr.= 23.3). It appears that the experimental group made up for their disadvantage. We investigated the differences between the pre- and posttest results of the two groups. On the one hand, a significant increase was found for the experimental group (t=-4.950, *p*=0.001), on the other hand we also observed a significant decrease in the achievement of the control group (t=4.135, *p*=0.001). Overall, the experimental group performed better in the posttest, which supports our first hypothesis.

Students in the experimental and control group were placed into groups of three according to their results. The first group contained low-achieving students, the second group contained average ability students, while the third group included high-achieving students (Table 1.).

*Table 1. The number of the groups.*

	4th grade experimental	4th grade control	7th grade experimental	7th grade control
group 1 (low-achieving)	8	7	6	3
group 2 (average)	36	29	46	18
group 3 (high-achieving)	17	26	17	34

One beneficial effect of the programme was that low-achieving students in the experimental group obtained significantly higher results in the posttest and we even observed a general improvement among them. In contrast, no changes could be detected in the achievement of the control group for group 1. However, group 3 showed a significant increase for 4th graders and a significant decrease for 7th graders. Our results suggested that the increase in the students' performance could be attributed to the programme. In most cases we found evidence that the low-achieving students in the experimental group performed better on the posttest, but at the same time we saw no significant change or decrease in the control group. Furthermore, we registered a significant increase for high-achieving students from the control group.

4th graders
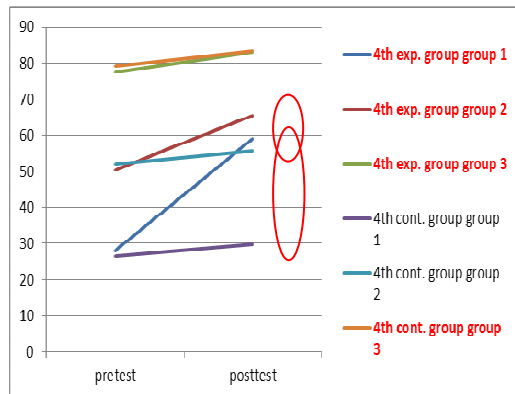
7th graders
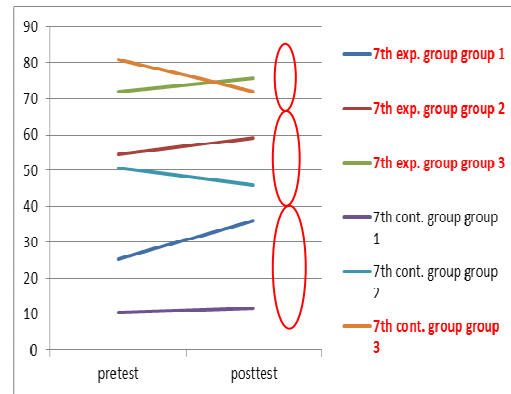
Figures 6-7. The results of the groups (%p) (significant differences are highlighted in bold and red p≤0.05).

By comparing results of the different groups in grade 4, we noticed a significant improvement in the posttest in two cases. Concerning the achievement of 7th graders, the low- and medium achievers showed a significant change in the posttest, furthermore, high-achieving students reduced their disadvantage and the differences were levelled (Figures 6-7.).

We analysed the effect of the programme and got extremely promising results (d4thgrade=0.63; d7thgrade=0.66), which encouraged us to further test the effectiveness of the concept map technique in other school subjects.

As stated in the third hypothesis, the two types of concept mapping exercises displayed significant differences. The 'completing a map by filling in the nodes and defining the linking words' type of exercises produced significantly higher results (M4thgraders=83.1%p; M7thgraders=76.1%p) in comparison with constructing a map (M4thgraders=64.2%p; M7thgraders=68.1%p). One possible explanation for this might be that these types of exercises only require a superficial understanding, while the creation of concept maps from scratch demands a deeper understanding and needs more organization. Gap filling exercises proved to be more successful, which may be partly due to the fact that more texts provided more input for students. It appears that it was easier for students to look for pieces of information in the text than to draw a concept map on their own. In order to draw a concept map from scratch, the ability to gather information and high level organization skills were required. Understanding was assessed on the basis of the layout and complexity of the concept map, which reflected their degree of comprehension of the given reading material.

Connections with other variables

We carried out a regression analysis using the two types of concept maps in each given subject as dependent variables and results from pre- and posttests, inductive thinking test, learning methods and learning strategies questionnaire, Hungarian grammar marks and attitudes as independent variables. In grade 4 we found that grammar pretest (34.5%) and learning activity (6.8%) explained almost than half of the completing exercises as dependent variable. One effect of constructing exercises as dependent variable could be seen in the grammar posttest (20.6%), while the other variables did not show any effect. Overall, we may reasonably conclude that applying the concept map technique in the classroom had a positive effect for this age group. In grade 7, the effect of the type of concept mapping exercise was more considerable in both cases, as with completing exercises as dependent

variables the type of exercise accounted for 38,2% of the results, and with constructing exercises as dependent variables it accounted for 52.2% of the results. A weaker effect of the grammar posttest (27.2%) could be seen among the independent variables in the completing exercises. The completing exercises had the largest effect and accounted for the results of construction exercises.

In summary, it may be concluded that based on our preliminary expectations, different types of concept map exercises had a clearly measurable effect on each other. Moreover, we also noticed a beneficial effect in the knowledge tests.

Conclusions

Visual organizational tools can be applied in different ways in schools. They provide numerous opportunities to draw attention to various connections. They are mostly used for acquiring content knowledge. However, following the stage of acquisition of knowledge, self-regulated learning plays an important role in organizing newly acquired knowledge.

In the concept-mapping programme, alongside with being asked to complete the exercises, students were introduced to a new learning strategy. They were more successful with 'completing the maps by filling in the nodes' exercises associated with a superficial understanding than they were with 'constructing a map' exercises. These exercises enabled students to work independently and organize information by themselves.

The aim of our programme was to provide students with skills that would allow them to map a text and understand it thoroughly. We had favourable results among the students, consequently we claim that low-achieving students also profited from the programme. The concept mapping technique can definitely have a beneficial effect in the classroom and on student achievement. However, its effect depends on the student's abilities. In the present study, it had a positive effect on low-achieving students in Hungarian grammar. The results suggest that success in the use of concept maps could be increased by tailoring the use of concept maps to students' individual needs. Unfortunately, acquiring and applying the technique of concept mapping in different fields is rather time-consuming. Consequently, this technique should be applied on a longer time-scale and within a wider range of subjects in order to make the differences more apparent. Further studies are currently being carried out based on these experiences from the first stage. In addition, research is extended to new areas for example science subjects. The PISA 2000 study found that Hungarian students apply rote-learning strategies far too often. Unfortunately, a long-term plan is required to change these habits. Not only students, but also teachers will need additional support, learning material and practical demonstrations to use new techniques. However, as this study shows, the benefits of applying concept maps in the classroom are evident.

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References

Ahlberg, M., & Vuokko, A. (2004). Six years of design experiments using concept mapping - at the beginning and at the end of each of 23 learning projects. In A. J. Canas, J. D. Novak, & F. M. González (Eds.) *Theory, Methodology, Technology*, Proceedings of the First International Conference on Concept Mapping. Pamplona: Spain.

http://cmc.ihmc.us/papers/cmc2004-220.pdf, 2008. 12. 29.

Antal, E. (2009): The improvement of analogical reasoning of 7 8-years-olds. *Paper presented* at the *13th Biennial Conference for Research on Learning and Instruction*, Amsterdam, the Netherlands,

August 25 29. 2009. In: G. Rijlaarsdam (Eds.): *Fostering Communities of Learners. 13th Biennial Conference for Research on Learning and Instruction. Programme* (p. 85). Amsterdam: Graduate School of Teachinng and Learning, UvA.

Artelt, C., Baumert, J., Julius-McElvany, N., & Peschar, J. (2003). *Learners for life, student approaches to learning: Results from PISA 2000*. OECD.

Ausubel, D. P. (1968). *Educational psychology: A cognitive view*. Holt, Rinehart and Winston, Inc.

Barroso, C., & Crespillo, R. (2008). Concept maps: Tools for understanding complex problems. In A. J. Canas, P. Reiska, M. K. Ahlberg, & J. D. Novak (Eds.) *Concept Mapping –Connecting Educators*, Proceedings of the 3rd International Conference on Concept Mapping (pp. 129-132). Vol 3. Tallinn: IHMC, Tallinn University, University of Helsinki.

Berionni, A., & Baldoni, M. O. (2004). The words of science: the construction of science knowledge using concept maps in Italian primary school. In A. J. Canas, J. D. Novak, & F. M. González (Eds.) *Theory, Methodology, Technology*, Proceedings of the First International Conference on Concept Mapping. Pamplona: Spain.

http://cmc.ihmc.us/papers/cmc2004-067.pdf, 2008. 12. 29.

Canas, A., & Novak, J. (2008). Facilitating the Adoption of Concept Mapping Using CmapTools to enhence Meaningful Learning. In Okada, A., Buckingham Shum, S. J., & Sherborne, T. (Eds.) Knowledge Cartography, Software Tools and Mapping Techniques (pp. 25-46). London: Springer.

Csapó, B. (2007). Research into learning to learn through the assessment of quality and organization of learning outcomes. *The Curriculum Journal*, 18(2), 195-210.

Gurlitt, J., Renkl, A., Faulhaber, L., & Fischer, F. (2007). Interactions of expertise and prior-knowledge activation with low-coherent and high-coherent concept mapping tasks. In D. S. McNamara & G. Trafton (Eds.), *Proceedings of the 29th Annual Conference of the Cognitive Science Society* (pp. 1055-1060). Austin, TX: Cognitive Science Society.

Halimi, S. (2006). The concept map as a cognitive tool for specialized information recall. In A. J. Canas, & J. D. Novak (Eds.) *Concept Maps: Theory, Methodology, Technology*, Proceedings of the Second International Conference on Concept Mapping. San José: Costa Rica. http://cmc.ihmc.us/cmc2006Papers/cmc2006-p81.pdf, 2008. 12. 29.

Hardy, I., & Stadehofer, B. (2006). Concept maps wirkungsvoll als Strukturierungshilfen einsetzen: welche Rolle spielt die Selbstkonstruktion? *Zeitschrift für Pädagogische Psychologie, 3*, 175-187.

Himangshu, S., Iuli, R. J., & Venn, M. (2008). Impact concept mapping has on pre-service teachers understanding of sciene content knowledge and development of their science pedagogy. In A. J. Canas, P. Reiska, M. K. Ahlberg, & J. D. Novak (Eds.) *Concept Mapping–Connecting Educators*, Proceedings of the 3rd International Conference on Concept Mapping Vol. 2. Part two, (pp. 438-444).

Immonen-Orpama, P., & Ahlbert, M. (2010): Collaborative Learning by Developing (LbD) Using Concept Maps and Vee Diagrams. In P. L. Torres, & R. C. V. Marriott (Eds.) *Handbook of Research on Collaborative Learning Using Concept Mapping* (pp. 215-237). Hershey, New York: Information Science Reference.

Mancinelli, C., Gentili, M., Prioiri, G., & Valitutti, G. (2004). Concept maps in kindergarten. In A. J. Canas, J. D. Novak, & F. M. Gonzáles (Eds.) *Theory, Methodology, Technology*, Proceedings of the First International Conference on Concept Mapping. Pampolona: Spain. http://cmc.ihmc.us/papers/cmc2004-195.pdf, 2008. 12. 29.

Molnár, Gy. (2009): Inductive reasoning in the first grade: a training program and its longitudinal effect. Paper presented at the 13th European Conference for the Research on Learning and Instruction. Amsterdam, the Netherlands, August 25–29, 2009. In G. Rijlaarsdam (Eds.): *Fostering Communities of Learners. 13th Biennial Conference for Research on Learning and Instruction. Programme* (p. 166). Amsterdam: Graduate School of Teachinng and Learning, UvA.

Novak, D. J., & Gowin, D. G. (1984). *Learning how to learn*. New York: Cambridge University.

Novak, J. D. (1990). Concept maps and Vee diagrams: two metacognitive tools to facilitate meaningful learning. *Instructional Science*. *19*(1), 29-52.

Novak, J. D. (1998). *Learning, creating and using knowledge*. New Jersey: Lawrence Erlbaum Associates.

Poveda, M. R. F., & Oneca M. J. T. (2006). A study of links in concept maps constructed by primary school learners. In A. J. Canas, & J. D. Novak (Eds.) *Theory, Methodology, Technology*, Proceedings of the Second International Conference on Concept Mapping. San José: Costa Rica. http://cmc.ihmc.us/cmc2006Papers/cmc2006-p27.pdf

Reader, W., & Hammond, N. (1994). Computer-based tools to support learning from hypertext: concept mapping tools and beyond. *Computers Education, 22*(1-2), 99-106.

Vakilifard, A., & Armand, F. (2006). The effects of 'concept mapping' on second language learners' comprehension of informative text. In A. J. Canas, & J. D. Novak (Eds.) *Theory, Methodology, Technology*, Proceedings of the Second International Conference on Concept Mapping. San José: Costa Rica.

http://cmc.ihmc.us/cmc2006Papers/cmc2006-p79.pdf , 2008. 12. 29.

Waeytens, K., Lens, W., & Vandenberghe, R. (2002), 'Learning to learn': teachers' conceptions of their supporting role. *Learning and Instruction, 12*(4), 305–322.

Zantig, A., Verlop, N., & Vermut, J. D. (2003). Using interviews and concept maps to access mentor teachers' practical knowledge. *Higher Education, 46*, 195-214.