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Applying concept maps to facilitate meaningful learning

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Introduction

The rapid development of the modern global economy has resulted in changes in the job market to which both employers and employees have to adjust. Without education, further training and retraining it is impossible to keep up with the ever-changing circumstances. Unlike in earlier times, at the beginning of the 21st century it is no longer true that studying comes to an end after the secondary school leaving exam or after getting a degree and it does not continue in your working life. As a consequence, the role of knowledge in the school has changed; the value of knowledge that follows the changes in the social and scientific life has become more appreciated. With this knowledge students are able to continue with lifelong learning. Students are not only in need of encouragement to learn but they also need to do it in a meaningful way. A different quality of knowledge is transmitted to Hungarian students in schools that they will need later on (*Csapó*, 2002); schoolbooks contain a lot of knowledge and facts that students have to learn but their knowledge still falls behind the standards on the international scale based on international surveys (the PISA study, IEA studies). Learning skills, strategies and techniques are expected which help students to learn and acquire knowledge in and outside school; in other words, they learn in order to learn (*Habók*, 2008d). Meaningful learning and the concept mapping technique offer such a possibility. The present theses is based on these notions.

This dissertation consists of two main parts. The first part introduces the theoretical approach to the subject starting from the topic of 'learning to learn', through discussing meaningful learning and memorisation to defining concept mapping. The second part of the theses deals with an empirical study on the technique of concept mapping and a discussion of the results. It describes a comprehensive developmental training programme that focuses on Hungarian grammar and the natural sciences. The testing of the programme was carried out among 4th graders (10 year-olds) and 7th graders (13 year-olds), then it was followed by a wider sample taken from among the same age groups. In the framework of the third experiment we extended the study to 5th, 6th and 8th graders (11, 12, 14 year-olds). In addition, the study included the testing of science-related subjects. These tests were specially designed for 4th and 7th graders. Our goal was to develop a training programme for students that would help enable them to process the learning materials more efficiently. The core of the programme consisted in selecting key words, highlighting main ideas and establishing the logical connections within the text that the students were required to represent in the form of concept maps. We tried to get them apply the strategy of meaningful learning instead of rote learning. Our programme sought to facilitate a learning technique that students could apply in other subjects and various situations later on in life.

The theoretical sources and framework of the dissertation

Meaningful learning

A question which often arises in school education is how much material students should memorise and what kind of knowledge they need to acquire in order to progress successfully. Recently, numerous international (*Artelt* at al., 2003; *B. Németh* and *Habók*, 2006) and national (*B. Németh*, 2002; *Csapó* and *B. Németh*, 1995; *Molnár*, 2001) studies have dealt with aspects concerning the results attained by students on applying the knowledge learnt in school and the quantity of school material they are attempting to acquire. In addition, studies have examined how transmitted knowledge corresponds to the criteria of usable knowledge. The PISA study revealed (*Artelt* at al., 2003) that Hungarian students try to acquire as much knowledge as they can; they often use memorisation as a learning strategy, but of course, there are differences between students and cultures. The key question arises of whether learning equals memorisation of the learning material on a word for word basis, what learning strategies students use and how their knowledge becomes meaningful through information acquisition (*Habók*, 2007d; 2008c). However, meaningful learning presupposes not only the learning of transmitted knowledge and its insertion into the cognitive structure but also that students can apply the methods, rules, formulas and definitions they learn during school lessons. Meaningful learning means a discovery process through which students can apply the things that they learnt during school lessons.

Measuring and assessing students' prior knowledge is essential in school education. However, these may be overlooked by teachers if the student learns the school material verbatim. Often it may appear that students understand what they render since they can retell what they have learnt even without any real comprehension (*Novak*, 1998). Reciting definitions and shorter texts does not mean that students have an overview of the school material and can establish links to their knowledge system. Meaningful learning demands a lot of effort from students and this occurs at a deeper level because understanding knowledge and the exploration of connections are time-consuming while rote learning can occur faster, and it does not require any additional study. The student simply takes in knowledge and learns it, but the material learnt does not become an active part of his or her cognitive structure.

Ausubel's theory (1968) laid down the basis of meaningful learning. Based on his ideas we shall look at rote learning and meaningful learning, as well as reception and discovery, in more detail. We will place rote learning and meaningful learning along one axis and reception learning and learning by discovery along another axis (*Ausubel*, 1968; *Bubolz*, 1990; *Driscoll*, 1994; *Weinert*, 1976). We speak of rote learning when no connection is made between prior and new knowledge and the knowledge remains isolated. One condition of meaningful learning is that students use advanced organisers for meaningful learning in a learning task. At the same time the learning material should be meaningful in itself. Namely, students should not be passive recipients but active participants who are able to form and organise their learning. Reception learning can be observed in most schools; the content of the transmitted school material is in focus and it is presented in a final form that does not require additional processing skills from the students. The essence of learning by discovery is to offer possibilities of experimentation and exploration. This method is especially successful in teaching science subjects. But the claim that reception learning is just mechanical and only learning by discovery is meaningful is too simplistic. Both suppositions address the old assumption that the knowledge we acquire, have comprehended, and own is the one we have discovered. However, in reality, depending on the method of distinction, completely autonomous learning dimensions are created. This distinction not only differentiates rote learning from meaningful learning, but also reception learning from meaningful learning. Stemming from this, depending on the conditions of learning, reception learning and learning by discovery can both be rote and meaningful (*Ausubel*, 1968).

Rote reception learning incorporates any disconnected knowledge we memorise, while meaningful reception learning represents a higher level where the comprehension of knowledge and its integration into the cognitive structure takes place but the active pursuit of knowledge still causes a difficulty. Students do not understand the results based on experiments and make mistakes in the case of rote discovery learning. They have problems when applying, or identifying the connections and establishing the cause-effect relationship.

Novak (1998) cites studies carried out in the US in the late 50s, which revealed that students often learn the course material word for word, and that they use memorisation strategies. In consequence, to aid learning by discovery, more and more programmes were developed which required the students to employ discovery techniques. However, most of the students were unable to self-explore the complex principles that scientists and researchers had already formulated. Over the years learning by discovery was pushed into the background. This also explains why the emphasis nowadays is not so much on discovery, but rather on independent problem solving, on the understanding of knowledge and on its integration into the cognitive structure, as well as on the building of meaningful knowledge. Learning by discovery in itself is not enough. Experiments are carried out in vain during a lesson if students do not recognize the rules and scientific principles (*Novak*, 1998). The highest level of learning is meaningful discovery learning by which students can solve problems on their own. With this method they process and comprehend the rules and integrate new knowledge into their cognitive structure.

The successors of *Ausubel*'s baseline theory added new components to the original concept, enriching the basis of the associated concept mapping studies. One such researcher was Mayer (2002), who, for instance, drew attention to the importance of the advanced organisers or *Tarouco*, *Geller* and *Medina* (2006), who, drew attention to the importance of the active, constructive, intentional, authentic and cooperative activities. According to *Ausubel*'s successors, social processes come into play and conversation group experiences are also considered important. This fundamental idea will play a key role in understanding concept mapping. Without a doubt, *Novak*'s personal work (*Novak*, 1990, 1998; *Novak* and *Canas*, 2006; *Novak* and *Gowin*, 1984) represents the starting point in researching and developing the notion of concept mapping. His seminal theory has had an influence on contemporary research and still shapes concept-mapping research.

Concept maps

Novak et al. started doing research on concept mapping at Cornell University in 1972. Initially, they intended to study the way children understood different scientific concepts through visualisation. *Novak* carried out his work with *Canas* and his colleges at the West Florida University and in 1986 they founded an institute called the Institute for Human and Machine Cognition. Since then they have been cooperating with numerous institutes and the concept mapping community has broadened as a result of their contribution.

Novak (1990) observed that students frequently use rote learning in the school but in his opinion they can be motivated to learn in a meaningful way by applying the method of concept mapping. Moreover, based on previous studies he concluded that concept maps are effective tools both from the cognitive and affective points of view. *Novak* (1990) considers concept maps as metacognitive tools. They are the kind of graphic tools that aid knowledge representation, which make the communication of their knowledge possible and highlight the small differences between the meanings of notions, thus revealing slight differences in meaning (*Canas et al*., 2004; *Novak* and *Canas*, 2006). *Novak* and *Gowin* (1984) collected the attributes and characteristics of concept maps that create the basis of concept maps. According to this theory, concept maps consist of concept labels while the expression of the connection between concepts is possible through linking phrases. Two nodes and the relation between them constitute a proposition that we store in our cognitive structure, together with the perceived rules which we learn in a meaningful way. Concept maps are structured hierarchically, from the general to the specific. The connections of the concept maps, which appear in the form of arrows, are modified depending on the subject.

In brief, we worked out our concept maps according to the following rules. We built up our diagrams from propositions which consist of nodes and linking lines. Linking phrases are visible on the lines which refer to the connections between nodes. Nodes and links may be built up from a concept or they may appear in the form of main ideas depending on the given topic. As regards their construction, concept maps are built up in a hierarchical way. We follow the direction from the general to the specific or from the specific to the most general. We started out from the general level in our research. We expressed the direction of connections via arrows that start from the first member of the proposition to the other members related to it.

The advantage of concept maps is that we can represent knowledge in the form of connections. We relate the information associated with a certain concept and the multi-thread connection will make us less likely to forget it. *Novak* (1998) stressed that we do not store all pieces of information we learn in our memory. He based his theory on the results of laboratory experiments, according to which people memorised syllables or pairs of words less successfully than those that were in a meaningful relation. This is also the case with school material. According to *Ausubel* (1965, 1968), recall is dependent on the material to be memorised. Rote-learned syllables and word pairs cannot be related to the main elements of the cognitive structure, thus a minimal number of connections is established which favours the forgetting mechanism. Even if we repeat rote-learned knowledge and we over-learn it, we still cannot recall knowledge more precisely after a few hours or days. In contrast, the knowledge that we learn meaningfully and integrate into our cognitive structure may be recalled for weeks or months after (*Novak*, 1998).

Concept maps in practice

The application of concept maps is widespread. It is used from kindergarten to adult education. *Mancianelli et al*. (2004) used concept maps to teach scientific language to children aged 4-5. A concept-mapping programme was developed by *Giombini* (2004), intended for the transmission of narration and writing for students. *Berionni* and *Baldoni* (2004) applied concept mapping in primary schools where it appeared in everyday situations. It served as a tool for acquiring knowledge. It also aided the recognition of concepts and their interconnections as well as the synthesis and organisation of knowledge. *Poveda* and *Oneca* (2006) also worked with primary school pupils. Their goal was to observe the process in the development of the concept mapping technique. They sought to collect information about a pupil's learning process based on the increase in the numbers of links and complexity of connections. They attempted to establish the effectiveness of the concept map as a tool of evaluation.

Since school learning is related to text processing, *Rionda* (1996) commenced his studies after noticing that students could not summarise a text. They merely copied out fragments from the original text, they did not understand the connections, they considered less relevant details important and they could not produce a coherent text. In the experiments besides reading and summarising texts, there were also filling-in and drawing concept map tasks. *Gurlitt et al*. carried out a study among secondary school students and university students. They studied the organisation of concepts with a critical review of their own work. *Vakilifard* and *Armand* (2006) combined the activating of text comprehension and prior knowledge. They applied concept maps among foreign language students. *Halimi*'s (2006) study is also concerned with text processing and foreign language learning. He used concept maps in assessing text processing by students in translation classes. *Halimi* (2006) was interested in finding out whether the use of concept maps helps in establishing the main ideas and highlights the cohesion of a text. *Hauser, Nückles* and *Renkl*'s (2006) study of concept mapping also focused on text processing. They based their assumptions on *Ausubel*'s assimilation theory (1968) as well as on *Novak*'s and *Gowin*'s findings (1984). They sought to answer how effective the tools that support concept mapping are and what kind of maps make students produce the best results during text comprehension. *Hilbert* and *Renkl* (2005) also worked with texts among university students. They examined whether the use of concept maps produces a positive effect on learning, whether it influences the results of learning and whether cognitive processes determine the results of learning during concept mapping. *Hardy* and *Stadelhofer* (2006) reported on concept maps structured in various ways that were applied to science texts for 21-43 year-old participants. Here they examined the issue of knowledge organisation. They based their assumptions on the notion that the use of concept maps helps one see the connections between relevant concepts and helps one structure acquired knowledge.

According to some researchers, concept maps are suitable tools for studying skills other than text comprehension. For instance, *Wheeler* and *Collins* (2003) placed critical thinking in the focal point of their research by which they could identify how nursing students approach a problem, how they performed in care-providing situations, and how effective the application of concept maps was when applied to the critical thinking process.

Acquiring and practising the technique of concept mapping is time-consuming, and it is often related to concept-based developmental programmes. *Hinck et al*. (2006) reported on such a developmental programme. The goal of their research was to survey the effectiveness of concept maps in care work. This technique was acquired by nursing students on mental health courses in vocational education. They sought to explore the various concept maps drawn by students at the beginning and at the end of the course, along with how students assessed their own learning, to what extent they were satisfied with using concept maps and how they were able to establish connections instead of applying linear thinking. *Zantig*, *Verloop* and *Vermut* (2003) used concept maps and interviews in teacher-training education. The goal of their survey was to observe how students analyse and access the practical knowledge of mentor teachers. They studied how students evaluate concept maps and interviews as necessary tools to acquire the practical knowledge of mentor teachers, and they also attempted to examine the nature of practical knowledge.

In addition to paper-pencil figures, computer-generated figures have also made their way into the concept mapping procedure. They have become evermore widespread and future research in this field is computer-related. There is now a wide variety of software available for visualising concept maps (programs available on the Internet include http://vue.uit.tufts.edu/, http://inspiration.com, http://cmap.coginst.uwf.edu). *Chiu*, *Wu* and *Huang* (2000) also used a computer for concept mapping, as did *Reader* and *Hammond* (1994) in their study.

In summary, the use of concept maps spans the whole education system through different age groups. Our study focuses on Hungarian primary and secondary school students, with the participation of 10-14 year-old students.

Hypotheses

- Since our programme was related to a concrete school subject in each case, we hypothesised that we would find significant differences between the experimental and the control group. We supposed that the experimental group would perform better at the post-test and also by comparing the performance of the group on the pre-test and post-test we expected that the performance of the experimental group would markedly improve. (*Habók*, 2007a, 2007b, 2007c, 2008a, 2008b, 2008e)

- We hypothesised that low-achieving students would show a significant increase in their achievement by the post-test with the help of this technique. We gave them the opportunity to practise throughout the programme. We tried to get students accustomed to this technique by practising it during each lesson so that they could apply concept mapping themselves and realise how useful this learning technique is. (*Habók,* 2007a, 2007b, 2007c, 2008a, 2008b, 2008e)

- We hypothesised for the types of concept mapping exercises that students would achieve significantly better results in the 'fill-in-the-node' exercises. This is based on the notion that exercises which had to be started from scratch required a deeper understanding and the students got fewer instructions. (*Habók*, 2007a, 2007b, 2007c, 2008a, 2008b, 2008e)

- Considering the concept map types, we suppose that the task structure has a decisive role. Depending on the architecture of the tasks, we presume that the 4th-7th grade students will draw the ‘fill-in-the-node’ spoke exercises most successfully in Hungarian grammar, while the 4th graders will experience success with the same type of exercises, in natural science. It is very likely that the lowest results will be registered in the case of tree ‘constructing’ type exercises. The 8th graders would be most successful, presumably, in ‘fill-in-the-node’ chain exercises, while least successful in drawing tree shapes, similarly to the students taking part in the chemistry programme; but this time we expected the advantage of the ‘fill-in-the-node’ tree type exercises. In physics, we expected, beside the higher results in case of the ‘fill-in-the-node’ spoke exercises, the lowest results to be shown in the case of net 'constructing' exercises. (*Habók*, 2007a, 2007b, 2007c, 2008a, 2008b, 2008e)

- Let us suppose that the variables of the chosen background tests explain the tasks of concept mapping to a great extent. It is expected then that the technique will manifest its influence on the learning strategies, and styles, on the attitude towards different subjects, on inductive thinking, on text comprehension. (*Habók*, 2008b, 2008e)

The methods and instruments of the study

The evaluation of our concept mapping programme is related to the school subject called Hungarian grammar. The programme was carried out in three stages. First, it was carried out from October 2006 to February 2007; second, from March 2007 to June 2007; third, from March 2008 to June 2008. During the first and second stages we worked with 4th and 7th graders, while in the third one we also involved 5th, 6th, 7th and 8th graders in our survey. In the third study we also tried out our science programmes among 4th and 7th graders, and among 7th graders in physics, chemistry and biology.

With each grade the study began by solving some concept mapping exercises. During this time, the control group learned in the traditional way. After completing the programme, each group had to do a knowledge test. We assessed the students using additional background tests, and we also collected background data via questionnaires. Inductive thinking and a learning strategy questionnaire were used in the first study, while inductive thinking, learning habits and text comprehension were considered in the second study. In the third study we used a learning-style questionnaire along with inductive thinking test and the study-strategies section of the study-habits questionnaire.

The results of the empirical study

The first study

As stated in the key hypothesis, because our programme was related to the contents of concrete school subjects in each case, we assumed that we would find significant differences in the post-tests that favoured the experimental groups. In addition, when comparing the results of the pre-test and post-test, a significant increase in performance was expected in the experimental group. In the following we will summarise our findings of the differences between age groups.

We did not find any significant differences after comparing the pre-test and post-test between the experimental and control group in the 4th grade. Our hypothesis was not supported here - the advantage of the students in the experimental group could not be detected. However, there was a difference between the results of the pre-test and post-test in the experimental and control group. Students performed better on the post-test. The results in the pre-test showed significant differences between the experimental and control group among the 7th graders. But no significant difference was found in the post-test, which means our hypothesis about an expected increase in performance in the post-test was not supported. The results of the groups reveal a different picture based on their pre-test and post-test results. The experimental group showed a significant increase in performance. We also found a change in the control group where we observed a decrease in performance.

The results of the low-achievers changed significantly in the post-test among 4th and 7th graders. Our hypothesis found positive support in the experimental group among the 4th and 7th graders, where we noticed some improvement among low-achievers in the post-test.

The second study

Here significant differences were found between the experimental and control groups in the post-test among the 4th graders; the experimental group did significantly worse. In the results of the pre-test and post-test we found significant differences in the 4th grade experimental group, but their performance declined in the post-test. There was also a significant difference between the results of the 4th grade control group in their pre-test and post-test. In this case we also observed a decline among the experimental group as well. Our hypothesis that the experimental group would have a distinct advantage over the other groups was not confirmed in practice. We could not find any significant difference between the experimental and control groups in the pre-test among the 7th graders. However, a significant difference was found between the experimental and control groups in the post-test. Here the experimental group performed better, as expected. A significant difference was found in the performance of the experimental group for the pre-test and post-test. Since students did better in the pre-test, this result ran counter to our expectation that students would perform better in the post-test. The results of the control group in the post-test also showed a significant change in the post-test compared to the pre-test; there was a noticeable decline.

The results of the 4th grade low-achievers showed a significant change; namely, we observed a definite decrease in performance. The performance of the low-achievers in the control group did not change significantly compared to the pre-test, much like that for the low-achievers in the 7th grade control group. Thus, our expectation that the programme would lead to an increase in achievement for low-achievers was not confirmed among the 4th grade students. We did, however, observe a significant increase in performance among the 1st group in the 7th grade classes. Hence, our hypothesis was supported here as we expected them to improve. The students who did worse in the pre-test did better in the post-test.

The results of the third study for Hungarian grammar and science tests

Continuing our examination of the results of the third study in Hungarian grammar, there was a significant difference between the two groups in the pre-test, where the experimental group performed better. We also found a significant difference in the post-test, where the experimental group performed better. In the post-test the performance of the experimental group did not show any significant difference, while the performance of the control group showed a significant decline.

With the 5th graders, the experimental group performed significantly better in the pre-test and this advantage was manifested in the post-test as well. These results accord with our hypothesis that the experimental group would do better in the post-test compared to the control group. In the post-test, however, the experimental group did not do so well. We could not discover any significant difference in the control group among the groups when we compared the two tests. In this case our hypothesis about the advantage of the experimental group, after comparing the pre-test and post-test, was not confirmed in practice. We assumed that we could not detect any increase after comparing the pre-test and post-test because the pre-test was based on prior knowledge, while the post-test was based on newly learnt material. No significant difference was found between the results of the pre-test and post-test of the low-achieving 5th graders of the experimental group. The low-achievers in the pre-test from the control group did better in the post-test. Hence, our hypothesis was not confirmed because we expected those students in the experimental group who did badly in the pre-test would do better in the post-test.

We found a significant difference in the pre-test among 6th graders. The control group performed better. Yet, we did not observe any significant differences between the two groups whose results do not support our hypothesis about an increase in academic performance. As regards the pre-test and post-test, we found a significant change in the post-test. The results accord with our hypothesis that we expected an increase in performance in the post-test. We did not find any significant change in the control group. Neither did we find any significant differences in the pre-test among the low-achievers in the experimental and control 6th grade groups, when we compared the pre-test and post-test results. Hence our hypothesis about a significant increase in the results of low achievers found negative support.

We investigated whether by comparing the results of the pre- and post-tests there might be any significant difference between the results of the 7th grade groups in the pre-test. There was a significant difference in the post-test; the experimental group performed better and the results support our hypothesis about an expected increase in academic performance. In the post-test the experimental group showed a significant decrease compared to the pre-test. This result does not support our hypothesis as we expected an improvement in the post-test. There was also a significant difference between the results of the tests in the control group. We could not group any of the low-achievers in the 7th grade experimental group; hence no comparison was possible. There was no significant difference between the medium-achievers in the experimental group, but we did find a significant decrease in performance in the control group. In this case we could not demonstrate that the low-achievers had shown a significant improvement in their performance.

An analysis of the results of the 8th graders was very important since most anchor exercises that were built into the pre-test and post-test appeared in both tests. We found, by comparing their pre- and post-test results, that there was no significant difference between them. Our hypothesis was not confirmed, as we had expected a marked improvement in the post-test. We only noticed a decrease in performance among the control group. We could not group any low-achievers in the 8th grade control group; hence we could not make any comparison among the groups. A difference was observed in the performance of the medium-achievers in the experimental group, and we did not observe any significant change in the performance of the control group. Hence, we could formulate our hypothesis based on the results of the medium-achievers; namely, since we saw that the experimental group had an advantage, our hypothesis was supported because we found that there was an increase in the performance of the low-achievers in the post-test.

Science subjects

We also compared the results of the pre- and post-tests in science among 4th graders. According to the results, the experimental group did significantly better in the pre-test than the control group. We also saw that the experimental group had an advantage in the post-test. These results justify our hypothesis that the expected advantage of the experimental group would be revealed by the post-test. Comparing the pre- and post-tests, the experimental group showed a significant increase in performance, just as we expected. We did not find any significant changes in the performance of the control group in the post-test. We could not group any students in the low-achieving group in the 4th grade experimental and control group in science; hence no comparison was possible among the groups. We noticed a significant improvement among the medium-achievers in the post-test, which supports our hypothesis that low-achievers would do better compared to the control group. Here we did not find any significant changes in the performance of the control group.

A significant difference was observed between the results of the two groups in the physics pre-test, which persisted in the post-test as well. This result justifies our hypothesis as we expected significant differences in the post-test that would favour the experimental group. The test results of the experimental group were significantly better in the post-test. We also observed this tendency in the control group, where we also noticed an increase in performance. In the results for the low-achievers we found a significant increase in performance among the experimental group in physics. The results of the students in the control group also showed a marked increase. Thus in brief, a significant increase in performance could not necessarily be attributed to the programme.

There was no significant difference between the pre-test results of the two groups in chemistry. In the post-test there was a significant difference; namely, the experimental group had a definite advantage, which supports our hypothesis as we expected that the advantage of the experimental group would be noticeable by the post-test. The results of the experimental group were significantly weaker, so our hypothesis was not supported here as we expected that the experimental group would show a significant increase by the post-test. We also observed this tendency among the control group; we noticed a decline in performance as well. In chemistry we examined the results of the medium-achievers because of the small sample size. The performance of both the experimental and control groups showed a significant decrease. In this school subject we find support for our hypothesis that the low-achievers in the experimental group would do better by the post-test.

The experimental group did not show any significant improvement in the pre-test in biology, and the situation did not change in the post-test; we did not observe any significant difference between the two groups. These results did not agree with our hypothesis about an expected increase in results for the post-test. Comparing the pre- and post-tests, the performance of the experimental group showed a significant decrease; thus our hypothesis was not supported here either. We observed this tendency in the control group; we found a significant decline as well. The reason may be that while the pre-test concentrates on exploring prior knowledge, the post-test surveys the newly learned knowledge which students did not practise. There was no significant difference among the experimental and control groups when the results of the pre- and post-tests in biology were compared; once again our hypothesis was not supported as we expected students to do better by the post-test.

In the first study we did not find any significant effect size through our programme. In the second study we found different effects: with the 4th graders there was a medium effect size, while for the 7th graders there was a small effect size. In the third study in Hungarian grammar the effect size was average for 5th graders, and negligible for the 6th and 8th graders. For the 7th graders we observed a marked effect size. In the science subjects we found a marked effect size in physics for the 4th and 7th graders, and an insignificant effect size in chemistry and biology. However the results show that within the second measurement, for the 4th graders, within the third measurement, for the 6th graders in grammar, and for the 7th graders in physics, the control groups have attained the higher results. That is the effect shown is not a result of the programme.

The results support our hypothesis that we should expect to find better results in the label completion exercises compared to other types of exercises. The students actually did better in this type of exercise, as these exercises demanded less organising from them.

With regard to the concept map structure, our hypothesis was confirmed in the following cases, where we expected the spoke 'fill-in-the-node' type exercises to present an advantage while the 'construction' tree and net type ones to be at a disadvantage. Within the first measurement, at 7th grade level, the second measurement, at 4th and 7th grade level, within the third measurement, at 4th, 5th and 7th grade level in grammar, chemistry and biology we experienced the advantage of the 'fill-in-the-node' type exercises, while a lesser level of attainment was manifested during the first measurement, at 4th and 7th grade level, during the second measurement, at 4th grade level, during the third measurement, at 5th and 6th grade level in grammar, and at 7th grade level in chemistry and biology with the tree 'construction' type exercises.

Connections with other variables

The first study

We analysed the effect of concept maps on other variables. Our analysis consisted of an examination of the Hungarian grammar pre- and post-tests, inductive thinking tests, the parts of the learning strategies test, the students' grammar mark, their attitude to Hungarian school subject, along with the two types of the concept map exercises - the filling-in/label completion and concept map drawing tasks. First, we chose as a dependant variable the 'filling-in' concept map in the first study in the 4th grade. Doing so, we could account for a relatively high proportion of the 'filling-in' concept maps with the given variables. The influence of the grammar pre-test was the biggest, and we also observed the effect of learning during the activity, but it had a relatively low impact. The drawing type mapping revealed an effect in the grammar post-tests. Other variables were not present. In the first study in the 7th grade classes, the drawing exercises had a bigger effect among the explanatory effects. The post-test effect proved equally high. More than 50% of the variance of the dependent variables could be explained by the two independent variables. The effect of concept map use appeared to be biggest for this grade.

The second study

We carried out a regression analysis using the two types of concept maps as dependent variables in both grades. We included in the analysis the Hungarian grammar pre- and post-tests, inductive thinking tests, text comprehension test, parts of the learning strategies test, the grammar mark, Hungarian grammar attitudes, along with the two types of concept maps, namely the 'filling-in' and 'constructing' exercises.

In the second study our analysis of the filling-in' exercises led us to conclude that the 'constructing' exercises played a key role. This indicator had a higher effect: almost half of the effects belonged to it. From among the other independent variables the effect of the Hungarian grammar test was present to a lower degree, and to an even lower degree in the text comprehension test. This accounted for less than half of the 'filling-in' exercises. The grammar post-test as independent variable appears in this case with a negative value. With it we were able to account for 20.6% of the effects in the first study. In general, the independent variables of the given concept map represent most of the effect of the chosen variables in the 7th grade. The weak effect of the grammar post-test was manifested in the 'filling-in' exercises, while the small effect of the grammar mark was observed for the 'constructing' exercises.

The third study on Hungarian grammar

The two types of the concept maps, namely the 'filling-in' and 'constructing' exercises, played a part in our analysis of the dependent variables in the third study on Hungarian grammar. Here the Hungarian grammar pre- and post-tests, inductive thinking tests, the learning strategies and styles test, the grammar mark and Hungarian attitudes were treated as independent variables, and the two types of concept maps (the 'filling-in' and 'constructing' exercises) were included in the study. From our analysis of the results of the 4th grade experimental group, we found the effect of only one very low variable in the 'filling-in' exercises. In another analysis of the results we also looked at the inductive thinking test broken down into sections. From it, we could account for 38.6% of the variance of the dependent variables by means of tree-independent variables. In this case we can attribute the larger effect to the grammar pre-test and a smaller effect to the oral analogies. The grammar post-test also appeared as an independent variable but it displayed a smaller effect compared to the other variables. A regression analysis involving the 'constructing' concept map among 4th graders showed that we could ascribe 65.2% of the effect to the 'constructing' exercises. More than half of the effects could be attributed to the inductive test. In addition to this the effect of the Hungarian grammar post-test was also present, though to a lower degree.

The two types of concept maps (the 'filling-in' and 'constructing' exercises) were used in the analysis of the dependent variables. We chose to analyse the Hungarian grammar knowledge pre- and post-tests, inductive thinking tests, the learning strategy and parts of the learning strategies test, the grammar mark, attitudes to Hungarian grammar, along with the two types of concept maps for the 5th-8th graders.

According to the results of the 5th graders, the accounted-for variance was high for the 'filling-in' exercises, and higher still for the 'constructing' exercises. We were able to account for the variance of the 'filling-in' exercises with the grammar pre-test to a higher degree. This was followed by the 'constructing' exercises and it is interesting to note that the effect of the memorisation strategies can also be seen. The 'filling-in' exercises were the most dominant among the significant effects shown by independent variables in the 'constructing' exercises. They accounted for more than 50% of the variance. In addition to the type of 'filling-in' exercises, we could even detect the effect of the elaboration strategies related to the processing of the learning material. While the nodes and links had to be found via the 'filling-in' exercises, the self-organising part of the connections had to be decided in the 'constructing' exercises that favoured the use of elaboration strategies.

We were able to interpret the greater part of the variance in the 'filling-in' exercises among 6th graders. The greater part of the known effects may be expressed by tree variables. These were the grammar pre-test and the inductive thinking test, which proved to be the second determining factor. It is interesting to note the presence of the impulsive learning style, but other styles could not be found among the variables. The observed effect could be ascribed to one variable in the 'constructing' exercises as a dependant variable, which accounted for almost half of the explained variance. To sum up, the knowledge tests played a greater role in this grade compared to other variables.

A similar tendency to the previous studies was noticed among the 7th graders. In both cases the effect of the types of the concept mapping exercises was bigger. The weaker effect of the grammar post-test could be seen among the tests in the 'filling-in' exercises as dependent variables. The effect of the silent learning style was slightly smaller. The grammar post-test was the most dominant with the 'constructing' exercises as dependent variables. By comparison the effect of the silent learning style was very low, while the effect of the grammar pre-test was negative.

It was also possible to formulate similar conclusions about the 8th graders. We could account for the majority of the dependent variables via the types of the concept mapping exercises. The ’constructing a map’ exercises and the grammar post-test had a significant effect. The 'filling-in' exercises yielded the highest effect, higher than that for the 'constructing' type of exercises, accounting for 47.3% of the explained variance.

Science subjects

We analysed the science subjects in a similar way to that for the science pre- and post-tests, the learning styles and learning strategies questionnaire, the science mark and attitudes, along with the two types of concept maps, the filling-in' and 'constructing' exercises. However, we left out the science mark in the 4th grade because of missing data. With the science subjects we were able to account for 82.1% of the observed effect by the 'filling-in' exercises among these classes. The greater part of the variance of the dependent variables could be ascribed to the four given independent variables. The effect of the 'constructing' exercises was the highest; the effect of the inductive thinking was also large. However the effect of the pre-test was present, along with the effect of the mechanical learning styles. The effect of two independent variables played a significant role in the 'constructing' exercises: the science post-test showed a bigger effect and the inductive thinking part displayed a slightly lower effect. The effect of inductive thinking was relatively large for both dependent variables, indicating that inductive thinking had played a critical role in the problem-solving exercises among these age groups and subjects.

We could ascribe 73.0% of the observed effects to the 'constructing' exercises and the post-test in physics by treating the 'filling-in' exercises as dependent variables. In the case of 'constructing' exercises, we got the best results when we treated the 'filling-in' exercises as independent variables. Besides these, the role of the control strategies was decisive among the learning strategies. It involved the checking and monitoring of one’s own work. The memorisation strategies displayed a negative effect and played a weaker role in the organising of knowledge and capacity for deeper thinking.

The 'constructing' exercises and the chemistry mark appeared as variables which revealed a significant effect relative to the 'filling-in' exercises taken as a dependent variable in chemistry. The two variables accounted for 56% of the dependent variables. The 'filling-in' exercises had the larger effect in the 'constructing' exercises as dependent variable. Similarly, the chemistry post-test had a big effect too. The silent learning type was present as well, but to a lower degree.

We may infer that there was a dominance of both types of concept maps in both types of exercises in biology. However, the effect of the biology post-test also played a role and so did the filling-in' exercises in the case of the 'constructing' exercises.

Summarising, we can infer that the concept maps had a big effect on each other, and we can also state that there was a marked effect in the knowledge tests. Inductive thinking was instrumental in several cases in revealing the known effects. The visual, silent, impulsive and mechanical learning styles played a role among the learning styles, but to a lower extent compared to the earlier variables. The learning activity was highlighted among the learning strategies in the first study. In the third study, all three strategies (elaboration, memorisation and checking) played a role. The effect of text comprehension also appeared among 4th graders, manifesting itself in reading and text comprehension.

The students' opinion about the programme

We asked the students to give their opinions about the programme in the third study on Hungarian grammar and science. They had to decide on a five-degree scale if they had drawn the figures with pleasure, whether drawing the figures had caused a problem, whether they intended to draw figures about the reading text, and whether they could recall the lesson more successfully after they had drawn it.

Based on the replies of 4th graders in grammar, these showed the highest mean, revealing that the construction of the figures did not cause any problem. The highest mean was found in all the other grades by the questions about whether they had drawn the figures with pleasure. We got a lower mean similar to the previous case when students reported their intentions of drawing figures in the future. Students displayed the highest mean on the question in science, physics, chemistry and biology. They said that they could recall the learning material more successfully when they had drawn a figure of it. The lowest mean was found for the question that asked whether students would draw figures in the future. The replies of the students that gave the highest mean in physics indicated that students had drawn figures with pleasure. Once again the lowest results were obtained for the question about whether they would draw figures in the future.

Summary

The quality of the knowledge to be acquired has changed, largely because of economic and social changes. The type of knowledge and skills which help us to adjust to the new conditions now has a greater value. It is not enough to acquire a mass of knowledge; one should also be capable of applying it in practice. We can foster the acquisition and application of knowledge by disseminating useful learning techniques. We presented such a learning technique within the programme dealing with the concept-mapping notion.

We began with the theme of learning to learn in the theoretical part of the dissertation, and then we outlined the connection between learning and memorisation, and also that between learning and understanding. We went on to the theory of meaningful learning and outlined several approaches. Afterwards, we reviewed the basis of concept mapping and related studies.

In the empirical part, a description of the developmental programme related to concept mapping applied to school material followed. The results showed a multifaceted picture. The low achieving students' results registered both on the tests and on the pre-test showed a varied picture. On the basis of the group results, we found that the 'fill-in-the-node' type to be at an advantage over the 'constructing' type exercises. As for the structure of the exercises, the highest results and the lowest ones were not shown in all expected cases of 'fill-in-the-node' and 'construction' type tasks. We analysed the size of the effect and we found that the degree of knowledge was influenced by the developmental programme incorporated in a school subject, and an effect size was found; however, there were differences among age groups.

We demonstrated that, for the test results and other variables, the success of the concept mapping exercises was markedly determined by the effect of the other types of exercises. In addition, we found that the knowledge test was also dominant. The effect of inductive thinking was also important. However, the learning styles and strategies only influenced the concept mapping exercises to a small degree.

During the studies we could not stop the students from using their memorisation skills. There were no significant differences among the groups. One task for the future will be to apply the technique of concept maps and incorporate them into the school curriculum, and also make use of them in more school subjects in the long term. Of course, the teachers involved will need to get additional teaching support and practical demonstrations where they can learn more about its theoretical basis and practical applications.

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