GRAPHIC VISUALIZATION OF LEARNERS´ MENTAL REPREZENTATION

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Abstract: The presented paper compares the influence of nonlinear structuring of the curriculum on the graphical visualization of the curriculum of a selected thematic unit in the mental representations of learners. The method of an experiment and the method of a test of conceptual mapping were applied in the research. The consistency of concept maps was assessed by the relational method of evaluation through an ordinal variable: graphical visualization of a concept map. By the analysis of the results it has been discovered that through the use of nonlinear structuring of the curriculum the learners' results have improved in experimental groups within the investigated parameter of operationalization.

Keywords: concept map, mental representation of a curriculum, meaningfulness, parameter, structuring of the curriculum, strategy.

1 Introduction

In recent decades we have seen a growing negative response to the quality of didactic procedures applied in school. Despite the critical response towards school and school education there is no doubt about the importance of education for human life. Today we know that teaching only scientific knowledge is not enough and that part of effective teaching is the development of skills linked to critical thinking such as: the ability to identify key ideas in texts and arguments, to recognize connections, to search for relationships between information, to correctly interpret data, to draw logical conclusions. All of the mentioned connections regardless of the specificity to the subject in schools give teachers a specific task: to psycho-didactically process the curriculum and include such teaching methods that stimulate critical thinking skills.

2 Psycho-didactic Competencies of a Teacher

Following international efforts to support the development of critical thinking of learners in the teaching process it is desirable to identify in our provenance educational strategies that have the potential to stimulate critical thinking in educational practice. Within the preparation process of future teachers we consider the identification of strategies for the development of critical thinking as a basic prerequisite for quantitative and qualitative change in their training for the 21st century. The requirement for the determination of strategies of critical thinking development is to define the construction level of critical thinking and the evidence that the skills to think critically can be directly influenced within the educational process (Halpern, 2014; Abrami, et all, 2008; Heyman, 2008).

The basic pillar of the school and formal education as a whole is the teacher which logically implies a requirement to change the preparation of future teachers. We believe that the goal should be to equip teachers with psycho-didactic competencies so that they are able to provide cognitive-oriented learning experiences and implement adaptive teaching strategies for the development of learners' critical thinking. We define teacher's psycho-didactic competencies as the abilities and skills of a teacher to psycho-didactically process the curriculum and manage education with the intention of developing learners' cognitive and metacognitive processes and their application in practice, implementing teaching strategies and assessment activities that have the potential to significantly contribute to the development of all personality and cognitive characteristics of a learner.

Authors who have attempted for operationalization and who tried to define strategies for the development of critical thinking

overlap in several constructs therefore critical thinking is defined primarily through the naming of cognitive abilities. According to Kneedler (1985) the development of critical thinking requires the development of competences:

- identify, define and specify the problem (identify the main starting points, controversial issues, determine the main idea of the text, compare the similarities and differences between two subjects, determine which information is important and which is irrelevant, formulate appropriate questions leading to a deeper understanding of the situation)
- assess information related to the problem (distinguish facts and opinions, apply criteria for quality assessment, check the consistency of statements, recognize value systems, recognize emotional factors, various ideologies)
- draw conclusions (determine the suitability and adequacy of the data for the conclusion, predict the likely consequences of the solution adopted).

3 Constructivism in Educational Practice

It appears to us that little attention is paid in educational practice to what teaching strategies are aimed at developing the competence of effective learning and the development of critical thinking. It is necessary to constantly ask ourselves what a successful but especially a functional model of learning should look like. Although each situation provides learners with the same information, they cannot perceive them all at once, so when they perceive, they spontaneously choose the ones they evaluate as easier to accept, although they are not aware of the degree of necessity. It is evident that each learner receives different information from the same situation. The degree of information selection among learners depends on their experience, so the more experience learners have with selecting information, the better they can set their filter.

It is necessary that in educational practice we analyze information that is key to understanding the presented curriculum (knowledge of which is essential) and select information that is complementary and learners can acquire them later. The imperative of a contemporary education system should be not only to lead learners to acquire knowledge but also to organize basic information so that it forms a supportive system for their internal knowledge structure. Constructivist requirements and their application in educational practice represent primarily an emphasis on the individual interpretation scheme of the learner, as a learner with his/her active construction of cognition develops his/her learning mechanisms. We perceive constructivism in the teaching process as a reflected educational activity, construction and reconstruction of learners' internal knowledge system, focusing attention on supporting learner's active understanding and stimulating higher cognitive functions. Constructivist education is not the transfer and subsequent acquisition of "finished" knowledge but the construction of one's own meanings of individual knowledge and their subsequent systematization into the internal knowledge structure.

We understand the constructivist approach in educational practice mainly by updating previous knowledge, the active role of the learner, focusing attention on activities that induce thought operations, problem situations that support the development of critical thinking, the emphasis on social and cultural context when acquiring new information, construction of schemes and models of acquired knowledge, modification of internal knowledge structures based on experience.

We believe that the mechanism of information processing as well as the quality of perception are key determinants for the formation possibly modification of specific learning strategies because stated factors also significantly affect the symbolization, coding, organization of information into functional units and

work with mental representations of learners. A learner's learning strategies should always be assessed especially in the context of his/her cognitive preconditions, thinking, ways of processing verbal and non-verbal information, memory. Modification of learning strategies is very challenging for learners as learning is very often connected with a number of different habits and automated activities.

Ertmer, Newby (2013) include the following among learning and teaching strategies that develop learners' critical thinking: structuring of the curriculum, instructional explanation, conceptual mapping, summaries, syntheses, mnemonics, information organization, analogies, demonstrations, organizing and classifying of information to encourage optimal information processing.

4 Strategies of Curriculum Structuring

When learning or teaching it is necessary to convey to learners not only individual concepts but also the relationships between them. Many times in an effort to understand the relationship between concepts learners are unable to identify the basic structure of the curriculum in the presented text - they either create an incomplete structure or include insignificant relationships in it. Therefore we consider as important that teachers lead their learners during the educational process to be able to independently assemble a structure of the curriculum and then create the entire conceptual-relationship network.

In our understanding we perceive structuring of the curriculum as a basic identification and detection of syntactic structures in mutual relations from the aspect of transfer to the mental space of learners.

Resnick (1996) characterizes three basic indicators that influence the structuring of the curriculum: the manner of teaching (teaching methods, lesson organization), age of learners (adequacy of mediated content to learners), range of curriculum (perfect mastery of main concepts of the curriculum and relationships between them).

The teacher's main principle should be to explain the curriculum to the learners as plastically as possible so that the created "real image" can be transformed into a language that learners understand. In our school system it is as if we have forgotten the technique by which we could significantly simplify learning for learners. We talk about optimal structuring of the curriculum that prevents the mechanical learning of the selected content but supports the processing of the curriculum in its own - understandable way. The problem with current educational practice is that learners often know how to name the facts, data, concepts, the main ideas of the curriculum but they are not able to understand the text, notice and interpret the relationships between the concepts of the so-called concept – relation network. Therefore we came to a conclusion that teaching should be implemented in order to lead learners toward understanding the meaning of the presented curriculum in a comprehensive context. The semantic structure and the broad-spectrum variability of the semantic perception of the curriculum fundamentally influence its subsequent interpretation.

As follows from the above statements the correct structuring of the curriculum is important for better and easier remembering by learners (as there is a better construction of meanings). Through structuring we can consciously create connections between pre-acquired and new knowledge, structuring can be perceived as an active process in which learners create and seek meaning. Among other things students' learning is through structuring more contextual (isolated facts and theories are not learned in abstract form, as they are transcoded into an easier-to-remember form).

4.1 Conceptual Mapping

By the analysis of relevant literary sources we characterize conceptual mapping as the creation of comprehensive schemes of structural relationships. It is about the organization of the logical structure of certain cognition, the creation of causal, mutual or possibly final relational levels between the whole and its main parts within cognition (ideas, concepts, hypotheses, principles). We consider the concept map as a design of the mind to be the ultimate function of thinking. The map is stored in memory as a structure in which auditory and visual data about specific information are accumulated together with models of effective action.

Conceptual mapping as opposed to linear (in professional literature called 'traditional') structuring of information represents a system that supports the way the human brain works, which is supported by numerous studies of meta-analysis of cognitive benefits of mapping (Nesbit, Adesope, 2006).

Conceptual mapping is a natural technique (the rooted equipment of the human thinking model) for organizing information and visualizing a complex of data as well as their mutual interactions. Through the given technique we can look at the curriculum holistically but also analytically. It brings an innovative view to the subject matter of curriculum and its structure or systematization.

Understanding and interpreting the conceptual map is a demanding and active process that has a relational character as the learner identifies his/her own knowledge structure and key elements of the curriculum. By connecting information with previously created and functional networks of knowledge we gradually mature towards new forms of understanding. We consider conceptual mapping to be a useful technique that facilitates effective learning, the development of critical thinking and the organization of received information into logical relationships (between concepts, ideas, connections, associations).

5 Empirical Considerations

The research was focused on finding connections between the presentation of the curriculum by the teacher and the resulting learner's mental representation of the curriculum - shown through a concept map. Remembering a set of facts or knowledge from the curriculum is not enough. Emphasis is placed on whether the learners have understood the discussed curriculum, whether they can work with it and interconnect related knowledge (included in their internal knowledge structure).

The main goal of our research was to *analyze the conceptual level of structuring the curriculum and its relationship to the creation of mental representations among learners in upper secondary education.*

In the research area we analyzed how the selected type of curriculum structuring applied in mediating the content of the subject history influences the conceptualization of learners' knowledge reflected in their mental representations - represented by a concept map.

H: We assume that learners to whom the subject content was presented by nonlinear structuring achieve a statistically significantly higher level of graphical visualization of the map than learners to whom the subject content has been presented by linear structuring.

5.1 Selection of Research Sample

The professional public considers developmental psychology to be one of the most important aspects in the selection as well as in the organization of the curriculum, specifically the age assumptions and learners' ability to master the curriculum. When we were considering the target group the high school environment appeared to be optimal. It is in high school that learners gradually move to the stage of cognitive development, in which they are able to abstract, work with hypothetical judgments, think in general terms and generalizations. It is about

formal-abstract way of thinking which is the basis for the development of critical thinking.

Based on the above statements we deliberately chose a grammar school in Nitra. In addition to the age aspect we also took into account a specific subject within the selection criteria, the intentionality of the selection was given mainly by the topics of the content of education and the relevant year.

The total research sample consisted of 96 pupils, four first-year classes of a four-year grammar school. Due to the nature of the research and the formulated hypotheses it was necessary to divide the research sample into two large parts which represented the control and experimental groups.

Table 1: *Number of Learners*

Group	Number of Learners
Control Group A	26
Control Group B	23
Experimental Group A	23
Experimental Group B	24

5.2 Research Methodology

We used the method of *experiment* to verify the effectiveness of our chosen change in the way of teaching through conceptual mapping. The realized experiment took place in natural conditions at the grammar school in Nitra. In the research we focused on the experimental verification of how the selected type of structuring of the curriculum affects the mental representation of learners (expressed through concept maps). The teaching lasted 5 months - September to February (the period of time to go over the necessary thematic unit) and it included the subject of history in each of the above classes.

In the control groups we proceeded by explaining the new curriculum (thematic unit) through a linear structuring of the curriculum. The procedure was based on traditional teaching methods - spoken interpretation. We also worked with information and communication technologies during the lessons; we also searched for information together with learners and work with additional teaching texts.

In experimental groups we proceeded with nonlinear structuring of the curriculum when explaining the new topics from the history course (thematic unit). For this purpose we constructed a concept map for each lesson - and each new subject topic of the given thematic unit, through which the subject matter was passed on to the learners. All additional teaching materials chosen by us were processed by nonlinear structuring.

Through the *concept mapping test* we analyzed the mental representations of learners from a selected thematic unit - if the concept map is constructed by learners we talk about a graphic scheme of their knowledge. Within the frame of evaluation it was the so-called *Relational method of concept map evaluation*, specifically we analyzed the main parameter of operationalization: graphical visualization (the resulting effect and the quality of the created map). We mean the partial use of paper, the colour of the map, the clarity and a graphically represented overall view of the learner regarding the thematic unit, as well as the individual parts of the curriculum.

We assessed the quality of conceptual maps using the IRT theory. Specifically we used the *model of correlated latent features* (Rijmen&De Broeck, 2005). We further compared the obtained scores of conceptual maps with respect to the affiliation of learners to the groups (control and experimental group) with a nonparametric alternative of one-factor multivariate analysis of variance (Bathke, Harrar, 2008). To verify the assumption of local independence we used test statistics M_2 (Maydeu-Olivares & Joe, 2006) which has a chi-square distribution.

Table 1: *Graphic Visualization of the Map - Evaluation Criteria*

5	The concept map is shown clearly as a non-linear complex hierarchical structure which demonstrates a high degree of understanding of
	individual parts but also the entire thematic unit. The mental representation is marked in colour or possibly the essential parts are graphically highlighted.
4	The concept map is recorded as a nonlinear structure with several elements of the hierarchy. It shows a relatively high degree of understanding of the thematic unit. There are several coloured or graphically represented parts on the map. We consider the map to be clear.
3	The map is shown as a nonlinear structure in which errors are found. We cannot talk about integrity in looking at the thematic unit. The colouring of the map and the graphical representation of the individual elements is relatively small. The map is not clearly depicted.
2	The visual side of the concept map shows signs of misunderstanding of the thematic unit. In the organization of the map we find only a partial insight into the curriculum. Partial use of the paper is incorrectly organized, we consider the map confusing.
1	We do not consider the constructed structure of the map to be correct, it rather points to a misunderstanding of the thematic unit or its parts. The map is not clear, the colour is absent. We consider the resulting effect to be erroneous and incomplete.

As can be seen in the picture learners of the experimental group achieve better evaluation in the investigated parameter of operationalization.
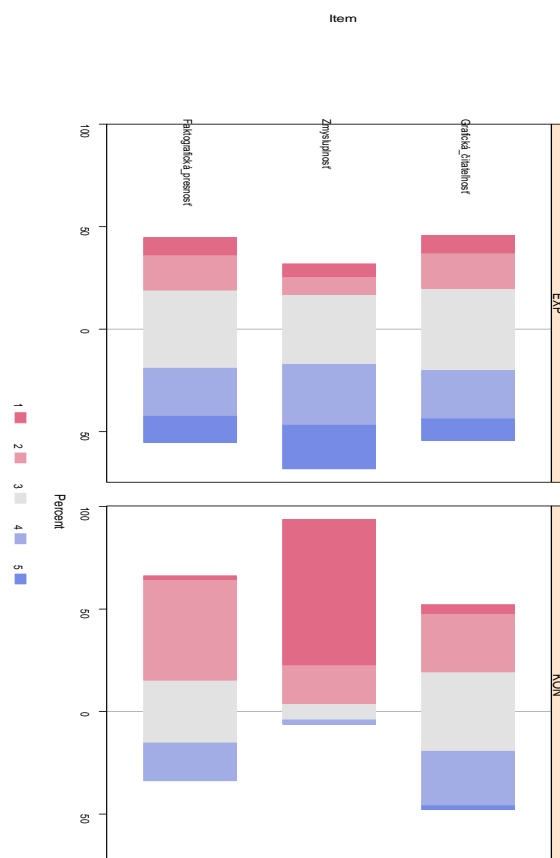

Figure 1: *Success in Solving Items in the Control and Experimental Groups*

In the majority of cases students learn the subject matter of history mechanically in order to memorize all the facts and

information but they do not learn meaningfully. We think that if learners' understanding of the content of the subject of history is to be improved it is necessary to assess and compare different teaching strategies. The range of our analysis lies in the comparison of the application of nonlinear and linear structuring of the curriculum to mental representations of learners recorded through conceptual mapping. The results of the experiment show that nonlinear structuring of the curriculum is a more appropriate strategy than linear structuring which presently is predominantly used during the teaching of history classes.

In the research survey we assumed that students who were presented with the study material by nonlinear structuring would achieve a significantly higher level statistically of graphical visualization of the map than the students who were presented with the study material by linear structuring. We state that the hypothesis has been confirmed. Within the hypothesis we focused on the final quality and effect of the concept map. We paid attention to the clarity of the recorded statements, the colour of the map, the partial use of the paper and the overall overview of the thematic unit by the student. From the results we conclude that the students of the experimental groups achieved better evaluations. An interesting finding lies in the awareness of the fact that students of the control and experimental groups were evaluated (in the analyzed item) at all levels on a scale of 1-5.

In the concept maps of the students of the control groups we recorded several cases of misunderstanding of the thematic unit, possibly a partial insight into the curriculum. Pointing out the above during the analysis of the concept maps of the control group students we found that they often placed the key concept on the edge of the paper so they were subsequently unable to develop the rest of the concepts in all directions. In many cases the information on the map was not partially correctly recorded therefore the concept maps of the pupils of the control groups cannot be considered clear. It can be seen in the Figure that the students of the experimental groups had the graphic visualization of the maps processed better. Their depictions were non-linearly complex, clear and showed a high degree of understanding of the given thematic unit. In addition we can speak about a holistic view of the thematic unit as all the essential parts of the curriculum have been graphically highlighted. It is interesting and it pointed to the fact that although we worked with students using mostly one type of concept map (although all types and methods of mapping were introduced in the instruction), the outputs of students in the experimental groups were diverse. We believe that the students themselves chose the method of mapping that suited them best and were able to record their mental representations in as much detail as possible.

6 Conclusion

Knowledge as such can only be considered as "dead capital" if one lacks the ability to use it adequately and effectively in everyday life. Unfortunately too much emphasis is placed on knowledge in our schools and insufficient attention is paid to how to make optimal use of it. Modern understanding of teaching is not about conveying finished knowledge to students. The current goal of the educational process is to educate a critical-thinking person with an open mind, naturally curious, flexible, looking for new information, looking for further perspectives and arguments for formulating final decisions. This is only achievable if the teacher is able to choose such teaching methods as directly stimulate the development of given skills.

We believe that it is necessary for conceptual mapping to be used in educational practice as a common learning strategy. The concept map represents an individual construction of knowledge with regard to the specific level of cognitive competence of individual students - it is about respecting the individual construction mechanisms of the brain, creating and modifying preconcepts in specific subject matter.

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