

SEX-BASED DIFFERENTIATION OF MENTAL REPRESENTATIONS OF STUDENTS'

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Abstract: Every individual's knowledge is based on a semantic network that connects individual concepts into branching mental concepts. The submitted study deals with mental representation of curriculum content in students through conceptual mapping in teaching. Visualisation of students' internal systems of knowledge supports learning with comprehension and prevents mechanical teaching. The variable researched here was how students' sex influenced the resulting mental representation illustrated through their conceptual map...

Keywords: conceptual map, mental representation of curriculum content, semantic network, operationalization parameter.

1 Introduction

There is still only an insufficient number of experts examining the mental representations of students. This area either is subject to rather sporadic research or is analysed as part of other research activities. We believe that the current didactics and its specialised areas must be enriched using psycho-didactic, constructivist, cognitive, neurocognitive and neuropsychological disciplines. Such approaches allow us, as students create their mental maps and their interpretations, to observe not only how they structure acquired knowledge but also what their processes are for understanding curriculum content. In the current constantly changing world students must be able to individually construct and modify their knowledge structure.

1.1 Learning

Learning consists of creating knowledge structures capable of receiving and storing new information. This process is activated when potentially meaningful material enters the field of cognition. It is then incorporated through a subsequent interaction into a higher-level conceptual system. When knowledge is placed into suitable cognitive structures at an adequate level, it is stored and usable in the future. If its placement is not suitable, new knowledge will be forgotten. Individuals with well-organized cognitive structures tend to store the information for long periods of time.

Every teacher should primarily focus on identifying how his/her students learn, remember information, plan their learning and retrieve information from their memory, make decisions, think and use individual cognitive processes. Leslie O. Wilson (2005) recommends considering several principles if we want to increase the effectiveness of students' learning. In particular, learning requires sufficient time, involvement of both cerebral hemispheres, suitable environment, adequate structure of information, respecting students' different learning styles, group work and practical activities in class.

Teachers cannot understand how students think, learn, and remember things if they merely stand in front of the class and explain the teaching material for 45 minutes. If we teach students how to understand information, think critically, contemplate and analyse subjects in broader contexts, we can help them throughout their lives.

1.2 Preconcepts

Each student seeks meaning in things or facts through understanding. Gavora (2012) claims that understanding is based on knowledge about the world, skills and cognitive competencies. Reading with comprehension has gradually become one of the main means of collecting information since

students, consciously or often even unconsciously, interrelate different materials.

Comprehension stems from the knowledge acquired by a child throughout his/her life about the world, based on his/her previous experience. Knowledge represents a certain semantic network, where every piece of information has its own place and system. If learning is not based merely on repetition but is meaningful, then each new piece of knowledge will be incorporated into a child's existing knowledge structure. A piece of information is incorporated into the system once it is received. However, in many cases it is adopted inaccurately.

Hejný and Kuřina (2015) point to the fact that often information is only received but not grasped and included into one's knowledge structure. It is not easy to differentiate between these terms since there is a very thin line between storing and grasping. The structure of mental imaginations has been studied by Kosslyn (1994), Glasgow and Papadias (1992) Wong, Lu and Rioux (1989) and others.

Thagard (2001) offers an explanation of how we learn and understand concepts. He holds that concepts are a type of mental representation; however they cannot be seen as sets of typical features, but rather as an attempt at finding coherence between them and the world. This may, potentially, explain why certain students are not able to recall the logical sequence of the material. What if in their thinking they find a different coherence between concepts and the world? In such cases students' concepts will not overlap with the teacher's, and the material may not be understood, or potentially there may be misconceptions.

1.3 Mental maps

Visual systems have been used in learning processes to capture and display knowledge from ancient times. Since 1972, one such system has been used as an instrument for examining significant changes. In the European geopolitical space, mental maps were first mentioned in 1965 by the German educator Richter, who examined structuring of teaching material.

Recently, experts have attempted to find a common term for the diverse approaches to structuring curriculum material. Terms such as cognitive maps, semantic maps, spiderwebs, and mind maps have been gradually replaced by the term of concept map for the output and concept mapping for the activity. Some authors, including Fisher (2004), Buzan (2011), Veteška (2009), prefer the term mental map.

The most significant contribution of social constructivism, as represented by L.S. Vygotsky, was to explain the relationship between mental structure and the socio-cultural environment. In didactics, cognitivism gave rise to concepts of developmental learning and scaffolding (Zankova, L.V., El'konina, D. B. and Davydova, V.V.), concepts of meaningful learning (Ausubel, D. P., 1967), inquiry-based instruction and discovery learning (Bruner, J., 1965), and prior knowledge assessment theory (Dochy, F. J., 1992, 1996).

Concept mapping was presented by Novak and Gowin in 1980. It is based on a theory of propositions that posits that all teaching material is constructed of hierarchically ordered propositions. A proposition is a knowledge unit presenting a connection between two concepts. Additionally, the text in the curriculum material is structured in a unified hierarchical scheme, where the most general concepts are in the upper part of the map and those at lower levels have a more specific character. Newer and increasingly elaborated concepts of mapping continue to be developed.

Teachers in a modern school should present their students the broadest array of possibilities that can assist them in their learning. For example, they can use concept mapping in

instruction. It is generally known that specific knowledge presented in isolation, without logical connections, that cannot be associated with other elements in the curriculum material, is the most difficult to remember.

The school environment primarily draws on the left cerebral hemisphere that dominates analysis, words, numbers, linear sequence and various types of progression. Our educational system continues to rely heavily on arranging chairs in rows; the notes primarily consist of words; exercise books routinely use lined paper, and students usually make their notes in bullet points and lists, and learn them by heart. All these processes rely more on the left hemisphere, which impoverishes the brain's potential. Working with mental maps is a necessary exercise since it helps one to assign new pieces of information to all information already stored in the brain more easily. The concept map helps to sort both new and old information naturally; moreover when creating a mental map one engages both hemispheres – the left for logical sequencing, words, concepts and numbers; the right for imagination and visualisation. It is precisely the activation and use of both cerebral hemispheres in one's brain that contributes to simpler remembering and more effective learning. Novak (1990) claims that the map serves to capture the meaning of certain concepts through a graphic representation of their mutual relations. It also must be noted that mental maps are a dynamic rather than static structure.

2 Differences between boys and girls in the educational system

Male and female brains demonstrate small but observable differences, which are often overrated or misinterpreted since the scientific research of differences between males and females is almost always accompanied by heated discussions. There are two major lines of interpretation of this issue. One group of experts explains the differences in male/female behaviour and intelligence mainly through cultural influence and the socialization process. The second group attributes those differences mainly to biological factors and chromosomes.

Male and female brains demonstrate subtle differences that probably emerge in the pre-natal period as a result of sex hormones that lead to an individual brain's masculinisation or feminisation.

However, many studies hold that the differences in behavioural and cognitive functions in men and women are barely identifiable. Stereotyped thinking claims that men are usually more aggressive and are better in mastering tasks involving spatial skills; women tend to be more empathetic and outscore men in more demanding verbal memory and language skills tasks.

Women often point to a number of both social and educational barriers that continue to exist even in the 21st century, preventing them from establishing themselves in technical areas dominated mostly by men.

Tindall and Hamil (2003) have identified main reasons why women tend to choose to study humanities rather than technical subjects. This choice is mainly influenced by social factors, stereotypes, traditional gender roles, and a relatively higher level of empathy and sensitivity. Those determinants tend to be mentioned in the context of women's choice to stay away from predominantly male disciplines. This work follows up on Heffler's conclusions (2001) on existing differences in the way men and women learn. The author claims it is evident that traditional education does not support diverse learning styles of students depending on their sex.

Research in education focused on students' learning styles primarily concentrate on identifying the relation between a student's learning style and the material, or between the learning style of a student and instruction style of a teacher.

So far, little research has examined the impact of brain development on one's learning style and his/her preferred learning strategies.

Severiens and Dam (1997) used ILS questionnaires (Inventory of Learning Styles) to examine the level of identification of a student's learning style with his/her biological sex. Androgynous individuals, typified by their high level of femininity as well as masculinity, were characterized by a high level of effort to understand the meaning of the curriculum material. Their learning strategy was to immerse themselves in the curriculum material; they were independent, and interested in the subject. Masculine individuals acted more self-confidently and ambitiously, and mostly with internal motivation. Feminine types had a tendency to double-check knowledge while learning, perform more thorough analysis during the learning process, and rely on external regulation. Both those extreme types expect to be pushed into learning by external factors, i.e. external motivation was significantly predominant.

Lorenzo et al. (2006) describes seven basic teaching strategies that will allow the teacher to help his/her pupils to balance out the differences between boys and girls in instruction. Those mainly include integrating everyday life experiences and student interests (of both sexes) into instruction; using basic knowledge and working with students' existing pre-concepts; an interactive environment enhanced through cooperation and communication; activities aimed at enhancement of students' understanding; activities developing key competencies in both sexes; alternatives in discussions among groups resulting from differences between sexes; and structuring of material and accepting diversity in the frequency of responses of both sexes.

3 Research

The research was carried out between October and November 2017 at a secondary grammar school in Nitra ("gymnasium"). During the research period, we analysed students' mental representations through concept mapping. The sample consisted of 115 students (four classes of the second year at a four-year secondary grammar school), of whom 49 were boys (43%) and 66 girls (57%).

Research methods and measurement of research data

The research instrument was a test of concept mapping. We examined five parameters of operationalization: number of key concepts in the map – PKP, frequency of concepts – FP, number of hierarchies – PH, quality of hierarchies – KH, and consistency – KONZ; the higher the score in any category, the better the results. The students had to develop their concept map on a thematic area of history (humanities).

The differences in outputs of concept maps made by boys and by girls were assessed using profile analysis. Profile analysis is a multi-dimensional statistical method, equivalent to a multivariate analysis of variance (MANOVA) for repeated measurements. The prerequisites for profile analysis is a multidimensional normal distribution of the vector of variables in the considered groups (boys, girls); homogeneity of variance – co-variant matrices between groups; and linear dependency between the variables.

Canonical correlation analysis was used to examine correlation relevance among variables from the LSI questionnaire and variables resulting from concept maps. Calculations were made in the R programme (www.R-project.org), using profileR, CCA, ggplot2, MVN, and corrgram programme packages.

Profile analysis

The research goal was to verify if there are statistically significant differences between boys and girls when it comes to successful mastering of a text with concept maps. The first step was to verify whether profile analysis was an appropriate research method.

Equality of variance-covariance matrices in boys and girls was verified through Box's M-test. Results of this test do not reject the hypothesis on equal variance-covariance matrices ($F(15;42796,37)=0,72;p=0,766$). Bartlett's test of sphericity was used to test the hypothesis on the variables' unit correlation matrix. The latter results lead us to reject this hypothesis ($X^2(10)=370,06; p<0,001$ due to sufficiently strong linear correlations between the variables).

The correlogram in Figure 1 shows correlations among five variables. We can see that all the correlations are positive, statistically important and relatively high.

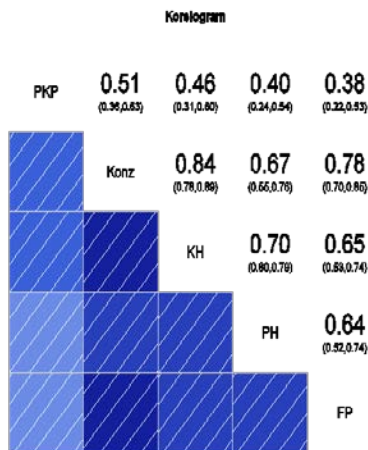


Figure 1: Correlogram

The profile analysis results of lead us to reject the hypothesis on the linearity of profiles $F(4;110)=3,19; P=0,019$. The hypothesis on linearity of mean values of variables for boys and girls is, however, not rejected ($F(1;113)=1,89;p=0,172$), since the differences between boys and girls are not statistically significant. The third hypothesis on the flatness of the profiles ($F(4;111)=396,79;p<0,001$) is rejected.

Table 1: Descriptive statistics of variables in test of concept mapping by sex.

Sex	Concept maps	Average	SD	Median	Min	Max
Men (n = 49)	PKP	2.6	1.3	3	0	5
	FP	33.1	20.1	27	6	84
	PH	5.1	2.8	5	0	10
	KH	2.7	1.3	3	0	5
	KONZ	4.8	2.6	4	1	10
Women (n = 66)	PKP	3.0	1.2	3	0	5
	FP	36.2	18.2	31	9	87
	PH	5.6	2.6	6	0	13
	KH	3.5	1.2	4	0	5
	KONZ	6.3	2.3	6.5	1	10

(SD – significant deviation), FP (frequency of concepts), PH (number of hierarchies), KH (quality of hierarchies), KONZ (consistency)

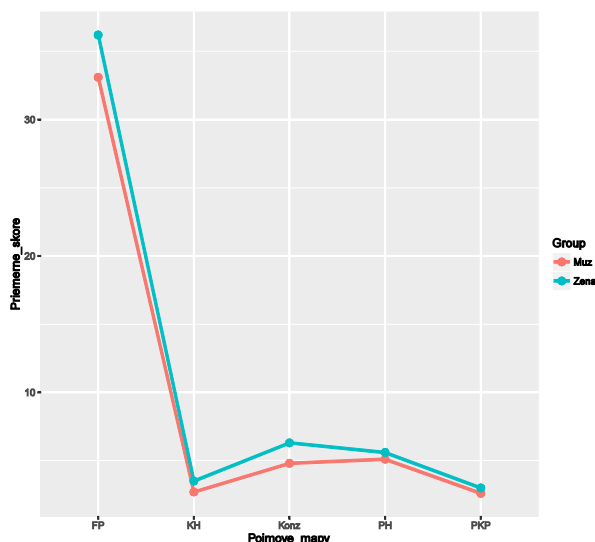


Figure 2: Profile graph for boys and girls

The above graph in Figure 2 Profile graph for boys and girls illustrates that the differences between boys and girls in making concept maps are not statistically significant. However, from the pedagogical perspective there are several important deviations that need to be considered carefully.

Development of common concepts is a relatively lengthy process with an emotional background, occurring under the impact of individual experience. On the other hand, development of scientific concepts starts with their verbal definition and subsequent operations with the given concept, ultimately resulting in understanding a logical relation among concepts adopted. The most significant differences we observed related to the parameter of operationalization of concept frequency (FP) where it is observable that the girls incorporated more concepts into the concept map than boys. This item included the absolute number of concepts in students' mental representation (related to the given teaching material – including inter-disciplinary concepts or those directly related to the curricula but not mentioned during instruction). This may, in our opinion, be explicable by the girls' more robust vocabulary. Any student, in order to define the material's main concepts, must penetrate into the content of the text through profound analytical activity. He/she should, first of all, understand the links among individual pieces of information and integrate them from different parts of the text.

Concept definition does not facilitate sufficient comprehension of reality. Correct definition of concepts does not necessarily mean that the student has understood the curriculum material. All students' answers must be analysed in more detail – in this case, subjected to further parameters – such as placing concepts into hierarchy and their consistency.

There was no significant difference in number of hierarchies (PH) between the two genders. For structuring concepts into hierarchies, we assessed the level of links/relations, i.e. the type of link between lower and upper (mutually related) concepts. The students may use hierarchy to express links between individual pieces of information within one topic that is the subject of a concept map.

Interestingly, boys were able to sort a lower number of concepts into approximately the same number of hierarchies as girls; the girls had a much higher number of concepts to structure and systematize. However, the lower number of concepts listed by the boys had a negative impact on other operationalization parameters. When making hierarchies, one must realize individual concepts and identify links between them. Practically, he or she must find the concepts, and compare and connect them.

Such text interpretation requires a higher level of independent consideration of a student, and therefore he/she must use information from the given material but also from other sources.

The conclusion may be that although the girls managed to list more concepts, their sorting into hierarchies was more challenging. This could be the result of a lower level of understanding of the links among concepts, or of not understanding the meaning and content of individual concepts. For a student to be able to create a hierarchy and identify the most important links, he/she needs to have the highest operational level of knowledge: evaluation and synthesis.

Further, the mutually related parameters - quality of hierarchies (KH) and consistency (KONZ) were examined. The quality of hierarchy, in our context, represents the level at which the concepts are connected into a hierarchy: their mutual links and connections, as well as connections with key concepts. Consistency represents the quality of a concept map created by a student. In both parameters of operationalization the girls scored higher, i.e. their assessment was better.

The mental representations of the girls as captured through concept maps represented the curriculum material in a comprehensive way, while the maps of the boys more often only captured elementary information about the material. The girls' concept maps summarized not only the current teaching material, but also material from the previous thematic areas. Therefore, the overall quality of concept maps created by the girls (considering individual criteria of a given parameter) was at higher level.

New knowledge is meaningful for a student only when it is incorporated into previously existing knowledge structures. The depth and scope of adoption of a concept is an important factor. This process was more prevalent in girls in our research.

Students differentiate based not only on the quantity, character of the knowledge and information they bring to school, but also on how they receive the new knowledge and incorporate it into the knowledge structures. Equally, it is important to consider the uniqueness of understanding the teaching material. From the teacher's perspective it implies a need to diagnose what creates the basis of a student's knowledge. Also, the teacher should respect student's independent perspective on the curriculum material. The material itself plays a significant role in the process: the content and stimulation of the text, and its scope and complexity from the student's perspective.

If the teacher accepts the individual differences among students that can manifest themselves through their learning style and use of strategies for material comprehension, and respects and knows the level of students' preconceptions, it can be said that such a teacher positively supports the perception of students' skills. Our research did not find statistically significant differences between the two sexes, however the teacher should strive to encourage the thinking of each student, confrontation of different interpretations, and the drawing of conclusions.

4 Conclusion

This research aimed at analysing and reviewing the ability of students to capture mental representations of content in certain curriculum material through concept mapping with respect to their gender. The research offers interesting findings for pedagogical practice, since concept maps seem to be a suitable method for identifying the level of knowledge in students. Therefore, they can be used as a reflective tool for a teacher or a self-reflective tool for students.

Students must be taught how to independently create their own mental representation of a certain thematic area, or of information, that has a stable place in their knowledge structure. Each person is unique, with an individual learning style and unique way of processing information. The teacher as organizer

of instruction should take those factors into consideration regardless of whether students are boys or girls.

We believe it is important to enable students to use their own ways of explaining, interpreting and collecting facts, to work with different types of information of their choice, compare and analyze acquired knowledge, and encourage them to reflect critically on their own activities.

It is important that each student understand a given subject, is able to link it with acquired knowledge from other study areas, work with it, and apply it in everyday life. If a teacher demonstrates to the students how to structure their knowledge simply, it will have a positive impact not only on the quality of the knowledge, but also on their attitude towards learning.

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