WORD ASSOCIATION TEST FOR STUDYING CONCEPTUAL STRUCTURES OF TEACHERS AND STUDENTS

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Abstract. The paper presents the use of a free word association test for revealing the scientific conceptual structures of teachers and students, concerning two stimulus words – living cell and biodiversity. The stimulus words retrieve a cluster of associations most of which are based on science education and are studied as connected. Associations with the stimulus words are analyzed and classified according to predetermined criteria. The stimulus word 'living cell' was quantitatively assessed in order to find out the balance between the associations with its components and to make inferences about curricula and textbooks. The stimulus word 'biodiversity' was comparatively assessed using four target groups and the results analyzed in order to find out the effect of biology education on the development of attitudes to this global environmental problem. The data is used to make inferences about the word association test combined with concept map construction as an assessment technique and to make some recommendations for teaching and for improvements of curricula and textbooks.

Keywords: association, word association test, conceptual structure, conceptual associations, living cell, concept map, biodiversity

Introduction

The ability of the brain to make associations and facilitate learning and intellectual development has been studied and elucidated by many scientists. Some studied the nature of associations and the mechanisms of their building by the brain (James, 1890; Bain, 1894; Bradley, 1922; Pavlov, 1927). Others directed their investigations to associative memory (Hinton & Anderson, 1989; Willshaw, 1989; Maki, 2007), associability (Suret & McLaren, 2005), associative learning (Locke, 2000; Levine, 2000; Novak & Govin, 1984; Wills, 2005). Still others were attracted by word association technique (Galton, 1880; Colgan & McGuinness, 1998; Dollinger et al., 1991), cluster analysis and concept or mind map construction in teaching (Deese, 1966; Mervis & Rosh, 1981; Smith & Heise, 1992; Halford, 1993; Dicarlo, 2006), association of emotions and thinking (Zajonic, 1990; Field, 2005).

The human conceptual system is characterized by two main concepts – category and schema.[1)] The visual representations of these concepts are concept maps (Novak & Gowin, 1984), mind maps (Buzan & Buzan, 1996), intellectual maps (Kostova 1998, 2000). Psychologists, like geneticists, who map the genes, map the connections among words, learned as a result of everyday experience.[2)] Maps, especially concept maps, aid learning in all subjects (DiCarlo, 2008; Smith & Heise, 1992). In science teaching students are asked to study scientific terms and then recall or recognize them when given words as test cues (Novak & Govin, 1984). In this activity several mental processes are involved: comparison, analysis, comprehension, model construction, elaboration, retrieval, etc.[3)] (Bruner, 1960). Conceptual mapping organizes learning at the level of conceptualization in the sense of the theory of constructivism, the foundations of which were laid by J. Piaget.

Most neo-Piagetian theorists of cognitive development incorporate the concept of relational mapping (Case, 1985, 1992; Halford, 1993; Pascual-Leone, 1987). Case integrated important aspects of the Piagetian stage theory and cognitive information-processing theory and draw out implications for the design of instruction. However, Halford is the only neo-Piagetian who has formally proposed that analogy plays a central role in the development of logical reasoning, and who has linked analogycal processes to performance in traditional Piagetian tasks. In his structure-mapping theory of cognitive development Halford proposed that most logical reasoning was analogycal.

Word association is a powerful research technique, introduced by Galton (1880) and subsequently developed by Carl Gustav Jung for studying human conceptual systems. Galton looked for a link between a person's I.Q.

(intelligence quotient) and word associations and did not find convincing data. Carl Jung theorized that people connect ideas, feelings, experiences and information by way of associations. According to him, ideas and experiences are linked, or grouped, in the unconscious in such a manner as to exert influence over the individual's behavior. These groupings he named 'complexes'.

Word association, also known as associative experiment (Davidov, 1983) is a test, consisting of a list of words, administered to the respondent, who has to answer to each word by means of the first word coming to his or her mind. This research technique has a long history and has been in use for more than a century. It can be of several types according to its structure, mode of application, aims etc. In controlled word association test the informant's response is constrained in terms of category, word class or concept for response selection. Free association test requires responses that are not restricted to any specific category or class of words. In discrete word association test each participant is asked to produce only a single associate to each word (Dollinger et al., 1991), while in continued association test the same stimulus word is presented several times at certain intervals for giving associative responses. When the stimulus word or the list of stimulus words is presented to the respondents only once and they are asked to give as many associations as they can in a pre-specified period of time, the test is called continuous. If the whole list of stimuli is presented several times, the test is called successive.

For solving a number of practical problems word association technique proved to be very valuable. It is applicable in public opinion research about the use of science in the field of inquiry to collect necessary information about public likes and dislikes and use it in advertising and attracting the customers. It provides the possibilities to compare the first and the last word of associations, repetition of words and pathways of associations, treatment of people with some psychological problems, visualization of concept associations, using concept density maps,[4)] proper message by market researchers, level of anxiety of students in different classroom activities, conceptual knowledge organization (Colgan & McGuinness, 1998), effect of multimodal stimuli on associative learning, thesaurus construction (Spiteri, 2002), preverbal numerical competence (Jordan, 2008), etc.

Word association technique applies different types of questionnaires: a table with two columns (first column – list of stimulus words, second column – associated words), sentence completion (a list of sentences to be finished with more than one example for each sentence, list of stimulus words with spaces to fill in the associated words at a given time under a given situation.

Category learning can be accomplished by means of multiple cognitive forms that depend on different brain systems: analogical reasoning (Goswami, 2001), concept clustering[3)], concept hierarchies, connectionism. Taxonomies of concept hierarchies are crucial for knowledge-based systems, including natural sciences[3)]. Connectionism is a paradigm in cognitive science that is used in the fields of artificial intelligence and cognitive psychology, neuroscience (Knowlton, 1999) and philosophy of mind. It models mental and behavioral phenomena as networks, each composed of a large number of simple units (Colgan & McGuinness, 1998). The material basis of these networks is given by the achievements of neurophysiology in studying nerve synapses. This link of connectionism to neuroscience is called biological realism and is criticized as reductionism. Nevertheless the brain has a built in capacities for connecting the studied information with that already processed, organized and stored. As early as the embryonic period of human development the long axons of neurons "travel" through the brain looking for corresponding receiving stations in order to make communication connections. This process continues after birth and experience shapes the brain throughout life. Synaptic connections and modifications are involved in the learning process (Levine, 2000). Their understanding helps to use successfully association technique and concept mapping for improvement of learning.

The analysis of the mentioned studies supports the assumption that development and use of a word association test is a scientific technique for obtaining valuable and reliable results, whose interpretations can help to make some insights in understanding and assessing learners' conceptual systems. So far results from word association tests have not been used for concept maps construction.

The concept (intellectual) map is a "nonlinear diagrammatic representation of meaningful relationships between concepts" (DiCarlo, 2006), a mental model, a schematic representation, which is a hierarchical structure from interconnected words, ideas, problems, solutions, arranged around a key word in radial circles (Buzan & Buzan, 1996). It can represent a structure of concepts, derived from a textbook by means of content analysis or retrieved from the memory by means of association test or brain storming (Novak & Govin, 1984; Kostova, 1998, 2008). Concept maps are used to enhance meaningful learning (DiCarlo, 2008) by providing "fixture", support, construction of interconnected scientific words.

Constructing concept (intellectual) maps is a useful teaching and a learning method for systematizing and organizing not only the concepts under study, but also the already learned concepts. It is used to create a context for incorporation of new knowledge, for reconstruction of already acquired cog-

nitive experience (Bruner, 1960), or for building a new system of meanings of our external world after Vygotsky. It is radial, spatial, with increasing concentric circles from groups of words, coming out from a central key word or words as a structure by means of subordination. Basic rules were developed for its successful construction, incorporating the use of the two hemispheres – logical thinking and imagination (Buzan & Buzan, 1991). Different graphical organizers are used in visual construction of concept maps. The results of word association test depend to a great extend on the information (knowledge) and the predisposition of the respondents (Zaller, 1992).

Combining the word association test and concept construction, using concept (mind, intellectual) maps of the obtained data could be of great help in revealing the conceptual structure that is on top of people's minds in a given situation. Such maps can then be used to enhance discussion and concept clarification, which is the intention of this study.

Aim. To investigate the conceptual associations of teachers and students in Bulgaria using free association test and build conceptual structures (mind maps and schemas) for assessing respondents' knowledge, biology curricula and textbooks (Table 1).

Table 1. Aims and Participants in the Word Association Test

Words	Aims and Participants
Living cell	To investigate the *conceptual associations* of 80 biology teachers in order to make decisions about the conceptual structure of the term cell as part of their biological culture, the relevance of the biological curricula and textbooks.
Biodiversity	To investigate the *conceptual associations* of 40 biology teachers, 15 supervisors, 40 students of 7th grade and 52 students of 10th grade to biodiversity as a priority concept in nature conservation and sustainable development, in order to make decisions about the conceptual structures of the target groups, school curricula and text-books.

Methodology

The method used in the investigation of teachers' and students' conceptual associations was a *continuous free word association test.* This is a reliable technique used as a procedure for measuring number, direction and

strengths of connections[2)]. Two stimulus words were chosen for the investigation – a living cell and biodiversity. The cell is a key biological concept, which forms the basis for sound biological knowledge as life can exist only within cellular structure. The concept is included in all textbooks in Bulgaria and develops gradually in the successive grades from 5th to 12th. In the fifth grade students get a generalized picture of the cell, study the prokaryotic, eukaryotic, plant, fungal and animal cells. The 6th grade develops the notions of cell division, cell specialization (tissues), reproductive cells, importance of cells in growth, development, transport, movement and irritability. The 7th grade enlarges the pictures of the different types and kinds of cells in studying the kingdoms Monera, Protoktista, Fungi, Plants and Invertebrates'(from kingdom Animals). Eight grade textbooks deal with vertebrates and human biology, 9th grade is concerned with ecology, cytology and biochemistry, 10th grade with genetics, ontogeny and evolution, 11th grade with cytology, genetics and biochemistry and 12th grade with ecology, nature conservation and evolution. Health education and biodiversity are included in all textbooks for all grades. Therefore the cell and the biodiversity are both key concept of biology education in the secondary school. This means that all biology teachers should have contemporary conceptual structures of these two concepts as they organize and create the intellectual climate of the classroom.

The sample of investigation of associations with the term 'cell' included only teachers having university education in biology. They had school practice from five to twenty years and were enrolled in post-graduate qualification courses on innovative biology teaching strategies, preparing them to introduce just published before the investigation new biology textbooks, written according to a revised school program. The sample of investigation of biodiversity associations included teachers with university biology education, enrolled in postgraduate courses on biology teaching, supervisors with university education in pedagogy, enrolled in postgraduate courses on value development, students from middle school and students from high school. The comparative studies of the associations of the four groups could give some insights in the influence of biology teaching on environmental culture, concerning a global environmental problem. The data from the investigation could give some information and hints about the use of a free word association test and concept maps in reinforcing successful learning in biology.

The investigation continued for four years from 2005 to 2008 in courses, organized with teachers at the University of Sofia and other towns (Rousse, Montana) and with students from schools in Sofia.

Data collecting was done with a question requiring writing associations with a given word. Each respondent was given a sheet of paper and a pencil and was instructed to be ready to write the words, phrases, ideas, that came to his or her mind in the same succession as they appeared, when hearing a given word. The respondents could write the words or draw pictures as visual memories, coming on top of their minds driven by the stimuli. Then they were told the word 'living cell' and started to write. They had to finish in three minutes time and hand over the papers. The same procedure was repeated with the word 'biodiversity' but with other respondents. The papers were collected, analyzed and maps were constructed using the connected words for each group of the respondents. The concept maps were discussed with teachers and educators in order to improve the maps and to draw inferences about knowledge, curricular and textbooks. The maps were then improved using content analysis of the corresponding chapters from the new biology textbooks. Thus the results of the word association test and the concept mapping were used for learning associations in a conscious, intentional and effortful way (Wills, 2005).

Results and Interpretations

I. Associations with the word living cell

The stimulus word 'cell' evoked lots of connections to other words. The total number of them was 948 and the average number of associations per a teacher was 11.9 (Table 2, Fig. 1). All teachers responded to the test according to their individual flexibility of remembering, knowledge and type of memory. Some teachers started to write at once, others were delayed with the response, "sort of block in self-expression". The delay may be due to "too many possible answers rushing to the surface and creating a sort of log-jam or to the feeling of being uncomfortable with the response of the responder", called "resistance to answer – repression" in Freud explanation. This argument cannot be accepted as teachers had to write the connections in the way they appeared in their minds but not to sort them out and choose the appropriate. Probably the reason was in the memory. Those, who were delayed in answer had not taught cytology for enough long time and had to strain themselves to remember the facts. Teachers, who responded at once, had recently been teaching the lessons on cell structure and functions. This fact shows that every teacher spends time and effort to organize his or her knowledge and teaching strategies for the coming lesson and cannot enter the classroom unprepared.

Table 2. Number of teachers (NT) per number of associations (NA)

Variables	Associations												Total
NA	7	8	9	10	11	12	13	14	15	16	17	18	948/80=11.9
NT	4	5	6	12	14	9	8	7	5	5	3	2	80
Total NA	28	40	54	120	154	108	104	98	75	80	51	36	948

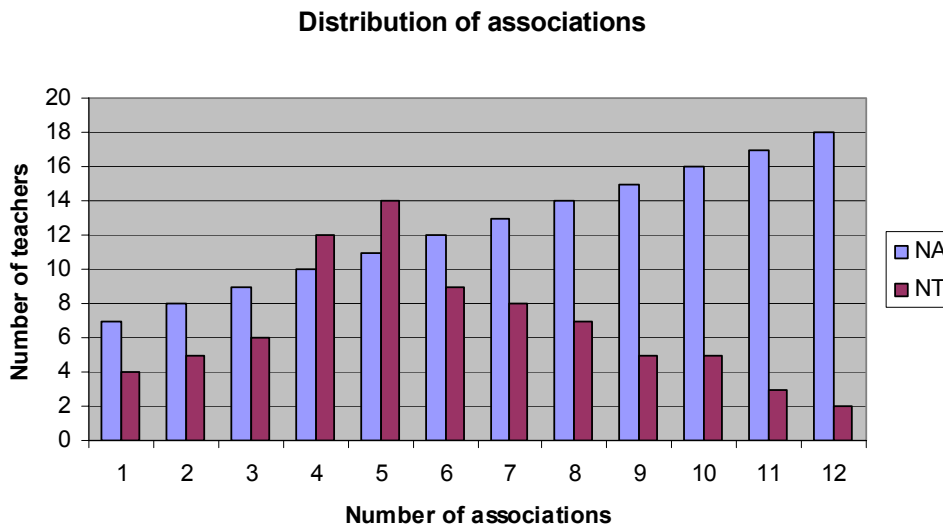

Fig. 1. Distribution of numbers of associations per numbers of teachers

The concept map of the cell, constructed on the basis of associations has 14 rays, coming from the central concept, the stimulus word (Table 3, criteria, Fig. 2). Each number was a core for concrete associations (details in Table 3).

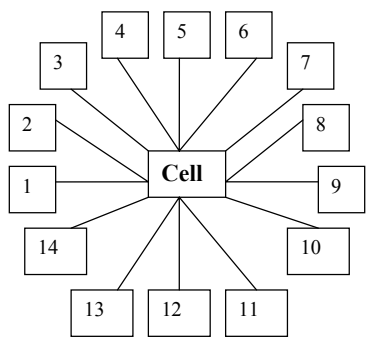

Fig. 2. Simplified model of the concept map of teachers' associations

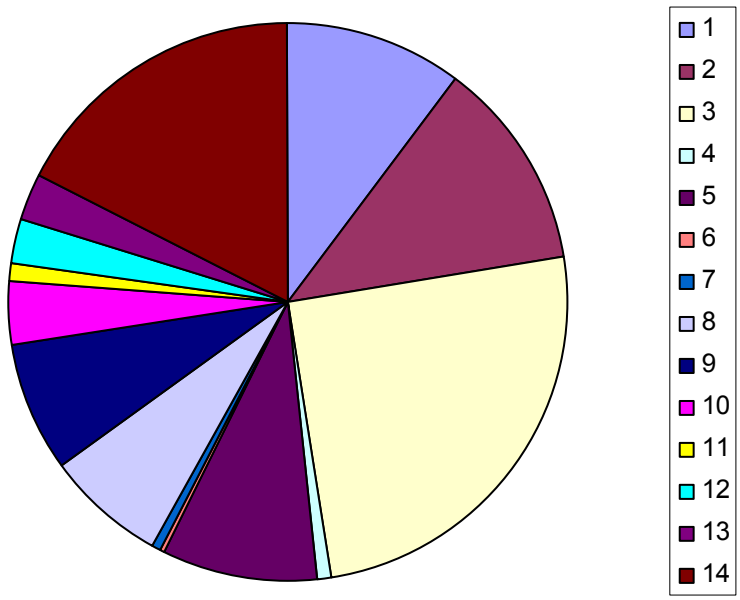

Fig. 3. Percentage distribution among the different criteria

The first ray (analogies and description) is based on teachers' visual memory and analogies (Goswani, 2001) or on their way of metaphorical expression. Probably those teachers worked with younger students in middle schools and used such kinds of expression to make themselves understood by them.

Some of the teachers tried to define the cell as a biological concept. Definitions (criterion 2, Table 3) are not complete but underline the basic characteristic of a generalized cell. Most of the teachers associate the cell with its structural components, which means that they predominate in the textbooks and due attention is given to them in the process of teaching (criterion 3). Composition of the cell was not on top of their minds (criterion 4), probably because they did not link cytology with biochemistry. DNA, from all chemical composition of the cell, occupies the first place, may be due to its role in cell activities.

Functions of the cell (criterion 5) are much less remembered than structures, but the given generalizations represent them properly on the whole. The connection between the cell and its surroundings, the transport through the cell membrane and its selective permeability are missing in the associations.

The associations with the role of the cell in the body (criterion 6) and its relative independence (criterion 7) are not significant. They are covered by other criteria (definition, hierarchy) and probably should not

be given a separate place in the classification. Understanding of the hierarchy (criterion 8) is very essential as it shows connections and order. It is due to the good representation of the biological systems and the theory of biological organization in the textbooks. In the previous several successive educational reforms (1972, 1981, 1989, 1995, 2001) the system approach gradually became a priority. Cell types (criterion 10) and cell kinds (criterion 8) are very well represented in the textbooks, starting from 5th grade and teachers paid due attention to them in teaching. As it has already been pointed out[5] "the way we describe something, can affect the way we perceive it and the way we perceive it can affect the way we use it". This also shows the role of association in teaching and learning and that it takes place both voluntary and involuntary.

The state of the cell (criterion 11) does not occupy a significant place in teachers' associations, but it plays a very important role in health education. Therefore the neglect of it should find its solution in syllabi and textbooks. The diseases of the body are diseases of the cells.

Criterion 12 shows the practical approach to teaching and learning and the use of different strategies. It also directs our attention to the significance of the methods used in studying cells. Lack of experiments for revealing the chemical composition and the life processes of the cell is inexplicable. It can be due to the deterioration of biology laboratories in schools due to lack of financial resources as well as to the invasion of classrooms by information technologies. This is a warning to educators that direction of biology teaching is not on the right lines. Experiments and observations are the core of biological sciences.

Table 3. Classification of biology teachers' associations with the stimulus word cell

Criteria	%	Examples
1. Analogies & description	10.4	Enclosed space (3%), box (3%), Cosmos (3%), cube (3%), house (3%), brick (3%), beginning (3%), pulsating unity (3%), living unity (3%), basic unity (21%), particle of an organism (52%).
2. Definition	12	Microscopic size (10%), basic living particle (27%), structural and functional unit of organisms (17%), smallest particle of the body performing all living processes (42%), living unity (4%)

3. Anatomical & morphological Structure	25	Living system (1%), complex system (1%), vacuoles (3%), cytocentre (1%), Golgi apparatus (4%), plastids (7%), ribosomes (5%), mitochondria (6%), endoplasmic reticulum (3%), nucleus (16%), cytoplasm (11%), cell membrane (9%), cell wall (8%), lysosomes (2%), organels (7%), dimensions (5%), diversity (3%), volume (1%), oval (2), different shape (5%),
4. Composition	0.8	Atom (33%), molecule (33%), DNA (34%)
5. Functions	9	Division (24%), new cells (24%), biochemical laboratory (4%), catalyzed reactions (4%), living processes (4%), life (4%), energy (4%), variation (4%), heredity (4%), metabolism (12%), functions (12%).
6. Role	0.3	Building (50%), structural (30%), functional (20%)
7. Independence	0.6	Independent existence, independent working
8. Hierarchy	6.9	Part of multicellular organism (22%), part of hierarchy (9%), unicellular (18%), multicellular (18%), plasmodesms (5%), tissues (13%), organs (13%), organism (2%)
9. Kinds	7.5	Plant cells (41%), animal cells (37%), fungal cells (22%)
10. Types	3.5	Prokaryotic (45%), eukaryotic (37%), bacteria (9%), blue green algae (9%).
11. State	1.2	Living (50%), cancer (25%), dead (25%).
12. Studying	2.6	Microscope (12%), textbook (11%), illustrations (11%), making a model (22%), drawing a picture (22%), comparison (11%), word description (11%)
13. Generalizations	2.8	Diversity of type and unity of pattern (34%), structure and order (24%), complexity (22%), common origin of life (12%), every new cell comes from a preexisting cell (8%).
14. Visualization	17.4	Description (25%), drawing (33%), schematic presentation (20%), concept map (10%), unicellular organism – euglena, paramecium (12%)

Some of teachers' associations (criterion 13) are generalizations from the facts of cytology and are very essential in developing a scientific attitude to the living world. They show the level of conceptualization of the scientific term cell. They are all precisely stated and given due attention. It is a teaching practice at the end of studying a new lesson to make generalizations from the facts and in this way to make a distinction between them, although that is not always easy.

Many teachers in the three minutes response tried to express themselves by means of visual representations (criterion 14). Labeled drawings predominated, which prompted that this had been the main teachers' method of visualization. Obviously concept maps, though very useful, new and interactive, had insignificant place. Teachers need training in concept mapping and in their didactic use. It is not easy to construct a useful and correct concept map. This justifies the use of the concept map on teachers' cell associations for improving it and for training in its application as a teaching tool (Wright, 1987). That was done by organizing a discussion on the concept map by means of the following questions: 1. what are the shortcomings of the model (the concept map); 2. how can the structure of the model be improved; 3. what connections between the concepts can be established; 4. how can the conceptual associations map be evaluated, as individual and as collective work; 5. has the method cognitive significance; 6. what conclusions can be drawn from the conceptual associations map; 7. is the method suitable for use in school.

Table 4. Questions (Q) and responses in the discussion

Q	Responses
1	It takes a lot of space (1m/1.5 m cardboard) for presentation. The criteria are too many and could be improved and reduced. The test was unexpected and we were not prepared. May be in another situation we would give different associates. Definitions are not complete and well worded. Illustrations are not precise.
2	Some associations refer to more than one criterion, which requires the use of symbols. Different criteria can be separated by writing them in different colours. Connections between structures and functions are not shown on the map.
3	The map enhances the establishment of new connections between: structure and evolution, structure and types, functions and types, etc. Each criterion is connected with the others.
4	If it is a result of a group of people, it should be evaluated as group work. In this case it is interactive and participants should be evaluated according to their personal contribution and ability to communicate. Individual evaluation is possible if each participant makes his or her own concept map.
5	The method has a high cognitive value as it presents a whole picture of the situation, summarizes the information from many topics in cytology, provokes establishment of new associations, aids remembering and construction of concepts, gives order in the knowledge, reduces the chaos, helps in warming up for new studies on the key concept, distinguishes hierarchical relationships of concepts, etc.

6	The association map can serve as a basis for making generalizations concerning all unifying themes in biology, besides those given in criterion 13, such as: unity of the cell and its environment, material bases of living processes, evolution of life, etc.
7	Students can make a concept map on each lesson and then use all the concept maps for making a generalized concept map on the chapter of cytology. The map provokes questioning and discussion. It provokes ideas for improving the syllabi and textbooks. For example structure and functions of the cell should be studied together. Chemical composition should not be discussed as something outside the living cell, etc. The conceptual structure cannot be the result of a single lesson. It could be improved if it is the result of solving a generalized problem. Associations and concept mapping should be subdued to a problem solving approach.

II. Associations with the word biodiversity

The stimulus word 'biodiversity' did not evoke so many connections with other words as the word cell, though the number of respondents was much greater and the sample included different target people. May be the reason was half the number of biology teachers in the target group, expected to be best acquainted with the problem. The mean value of the number of associations is still highest for biology teachers (Table 5, Fig 4). Supervisors' and high school students' responses are nearly equal in mean value of the number of associations but differ in contents (Table 6). Biology teachers have a scientific knowledge of the problem as that is connected with their profession and with their responsibility for developing a responsible attitude in students, while the supervisors' knowledge and perceptions are due to the influence of mass media. Students from the middle school had studied aspects of biodiversity in the course of three years (from 5th to 7th grade) only on organism level and the term biodiversity was not included in the textbooks, but species classification and characteristics of concrete species were covered. Students in the tenth grade (high school) studied biodiversity on organism level in all grades from 5th to 8th. In the 9th grade of one of the textbooks[6)] the concept of biodiversity is discussed in the chapter of ecology, entitled "Biosphere". It is connected with the term sustainable development and the three levels of biodiversity are explained – genetic, species and ecosystem. The information is not obligatory and teachers usually omit it. This explains the missing of the term sustainable development in the associations of the four groups. The information is also missing in the school programmes, made by the Ministry of Education and Science (Bulgaria).

Table 5. Numbers of associations, corresponding to numbers of participants. Total and mean values. (Meaning of symbols: NA – number of associations, BT – biology teachers, S – supervisors, S_1 – students in the middle school, S_2 – students in the high school, TNA_{BT} – total number of association of biology teachers, TNA_S – of supervisors, TNA_{S1} – of middle school students, TNA_{S2} – of high school students, T NA – total of 1, 2, 3 and 4).

Variables	Number of associations												Total/mean
NA	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	
BT – 40	1	1	3	3	4	10	9	3	2	2	1	1	
1. TNA_{BT}	6	7	24	27	40	110	108	39	28	30	16	17	452 / 11.3
NA	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	
S – 15	1	1	2	3	3	2	1	1	1				
2. TNA_S	0	1	4	9	12	10	6	7	8				57 / 3.8
S_1 – 40		5	8	9	9	4	3	1	1				
3. TNA_{S1}	0	5	16	27	36	20	18	7	8				137 / 3.43
S_2 – 52	3	7	6	7	7	11	7	2	1	1			
4. TNA_{S2}	0	7	12	21	28	55	42	14	8	9			196 / 3.76
T NA	6	20	56	84	116	195	174	67	52	39	16	17	842 / 5.73

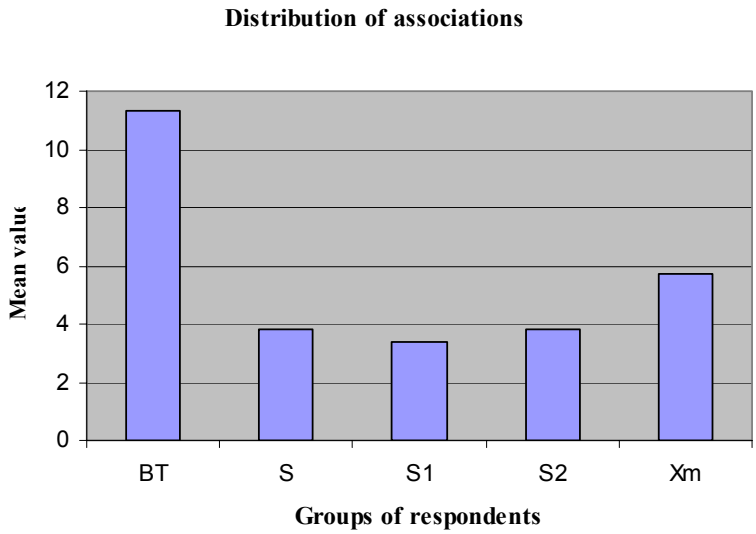

Fig. 4. Mean value of numbers of associations per groups (Xm – mean of the four groups)

The four target groups have different conceptual structures, connected with biodiversity, which is due to the level and type of education, personal experiences and interests.

Biology teachers' associations cover all the levels and aspects of biodiversity. Criteria for species classification are not considered by them as pertaining to biodiversity, which makes the concept map different from concept maps intended for teaching (Biodiversity concept map), but they are present in the syllabi and textbooks for the tenth grade. The information about biodiversity is not well structured in the textbooks, which is probably the cause for the chaotic character of the associations and the big number of criteria in order to classify them.

Supervisors have not studied biology and nature conservation at the university, but they have a fairly good orientation in the problem and can help students in the development of proper attitudes. They are better acquainted with the social aspect of biodiversity.

Seven grade students perceive biodiversity from its emotional side, which is suitable for their age and personal experience. The influence of biology and health education has modified their associations and understanding. The results coincide with other investigations (Kostova & Atasoy, 2008; Kostova, 1998, 2000).

Tenth grade students have better presentations in ecology and genetics. They also point out to the resources for learning about biodiversity, which gives impression about the teaching strategies (Table 6, criterion 1). The word gun, which is associated by supervisors and students with humans, is probably a sign of human technical equipment for species destruction.

Table 6. Classification of associations with the stimulus word biodiversity and their presentations in the target groups (figures in brackets show the repetitions of the words)

Criteria	Target groups			
	Biology teachers	Supervisors	7th grade	10th grade
			students	
1. General interpretations & perceptions	Diversity in living nature (5), harmony, many faces, colors, quality, quantity, uniqueness (3), *beauty* (6)	Life & social diversity, uniqueness, *life styles*, *beauty*, *love, care* (3)	Diversity, *liberty, odor,* harmony, *beauty*, *happiness, scenery, feelings, carpet, peace of mind*	*Model, school, textbook, pen, textbook, desk, student, classroom*, social diversity
2. Plants	Plants (12), protected (15), flora (8), varieties (6)	Plants (4)	Plants, species, oak, birch trees, herbs, flowers, greenness, species, pine-scrub, etc.	Plants (3), ecological groups, grass, shrubs, trees, biome diversity
3. Animals	Fauna (20), invertebrates (4), vertebrates (11), protected (13), breeds (2)	Animals (2)	Animals, species, breeds, insects, reptiles, carnivores, birds, mammals, butterflies, bears	Animals in forests (3), ecological groups, diversity in biomes, water land and flying animals (7)
4. Humanity	Human races, human beings, behavior, responsibility, individuality, foods	Humans, guns, mode, environment, campaigns	Guns, humans, important for us, needs protection	Human beings, guns, interference in environment
5. Organism level	Unicellular (3), multicellular (4), colonial (2), sizes, shapes, individual diversity (11), species diversity (15), taxons, classification (8), populations (2), rare & endemic species (3), prokaryotes, eukaryotes	Preservation of species, important in medicine (4)	Species diversity, names of concrete species (9)	Species diversity (5), similarities, differences, classification (6), populations (4), number, size, viruses, bacteria,

6. Environment and adaptations	Behavior (5), ethology, xerophytes, diurnal, nocturnal, biotope, living, non-living, nature protection (7), environmental problems (3)	Destruction, ozone holes, dangerous existence, technologies, protection, school, community	Living conditions, animal and plant protection, reservations (3), parks (7), meadows, natural resources	Living conditions, ecological factors, biological resources, herbs, flowers, biotope
7. Life processes	Metabolism (5), nutrition, respiration, aerobes, anaerobes, reproduction, fertilization, movement (3), biorhythms, oxidation-reduction	Metabolism, nutrition respiration, reproduction, movement, diversity in living processes (2)		Contraction, relaxation, parasites, autotrophs, heterotrophs
8. Structural diversity	Roots, root systems, tissues, organs, systems, chemical diversity (6), carbohydrates, lipids, proteins, biomass			
9. Genetic level	Mutations (14), crossing over (13), fertilization (9), diversity of biochemical processes, proteins, molecules, chromosomes, DNA (10)	Genetic engineering, laboratories, experiments, cloning, biotechnologies		Genetic diversity, DNA, molecules, nucleic acids, proteins (6), biopolymers, chromosomes, replication, genes (7), information, complementarity, biochemistry
10. Evolution	Mutation, heredity, variation (21), natural selection (14), speciation (18), origin of life, palaeonthology,	Mutations, natural selection		Origin of life, evolution
11, Supra-organism levels	Populations (6), biocoenosis, ecosystems (9), biosphere, landscapes (19), biomes (7), Earth, Universe, cycle of matter, food chains (22), food webs, community structure, succession, productivity, ecological equilibrium, biotic & abiotic factors	Ecosystems, biosphere, rivers, seas, meadows	Clean rivers with fish, evergreen forests, deciduous forests (5), meadows, reservations	Biotope, cycle of matter, food webs, food chains, community vertical structure, reservations, national parks, ecological equilibrium

12. Non-living nature	Non-living nature (3)	Earth, water, air, river, sea, non-living nature, ozone holes	Caves, hills, lakes, stones, relief, rocks, mountains, ice, summits, sky	

The twelve criteria for classifying the concepts are chosen to embrace all the associations. They are subject to change and improvement and used as working tools for this investigation. Other investigations with other people in a different situation and at a different time will certainly show different results, because the associations on top of people's minds are liable to change.

The concept map was used for discussion with the teachers and for clarifying their ideas. It is not suitable for teaching students as it is very complex and meets other purposes. The students construct mind maps using content-analysis of the textbook and fewer criteria, which can refer to either the branches of biology, studying biodiversity or the levels of organization of biodiversity. One important shortcoming of the associations of all groups is the very poor presentation of the means for sustaining biodiversity and its connection with environmental equilibrium. The map, presented here in the form of a table for simplification, was used in succeeding courses with teachers and proved very valuable as a tool, initiating and sustaining discussion.

Questions for discussion:

1. What is the priority of each group, concerning biodiversity?
2. What do similarities between the groups show?
3. What do differences between the groups show?
4. Has the concept map heuristic significance?
5. Can you draw conclusions about conceptual structure of each group?

Some conclusions drawn by the participants from the map of associations to the stimulus word biodiversity were:

1. Diversity of type and unity of pattern in the living world;
2. Biodiversity is indispensable for life to continue on the Earth;
3. Biodiversity means health of human beings as well as of ecosystems;
4. Individual differences in associations show differences not only in conceptual structures and in personal experiences but also in education;
5. Every living thing is unique and adds to the biodiversity on our planet.

Conclusions

The continuous word association test, combined with concept mapping and discussion, as applied in this study was successful in revealing the conceptual structures of teachers and students to two key biology stimulus words – cell and biodiversity. Although the response terms given by the participants varied at some aspects, areas of similarity emerged, and with little exceptions the criteria for the associations were covered. The target groups showed good informational orientation, concerning the stimulus words and responsibility in answering the test. Teachers and supervisors took part in the discussions for assessing the concept map, clarifying the concepts and improving the structure of the map, thus brushing up their knowledge. Teachers practiced in the construction of concept maps using textbooks and acquired the corresponding skills that used later in the process of teaching. Concept maps made on associations were distinguished from concept maps, constructed as a result of content-analysis of textbooks. The former should be better called mind maps, association maps or intellectual maps, as not all word associations can be denoted as scientific concepts (Anglin,1977) ,

The investigation revealed the difference in the disposition of the target groups, the connection between concepts and feelings and the role of education in concept and intellectual development. The good and structured representation of the cytology concepts in the curricula, syllabi and textbooks insured the rich association map of biology teachers. Nevertheless some recommendations can be made in this direction. A better link should be established between cytology and biochemistry so that the chemical composition of the cell be better understood and remembered. That could be done by introducing unifying topics for connecting facts and concepts from the two branches. The concept maps, constructed on the unifying topics, should stress the generalizations revealing concept links. Thus, generalized pictures of the cell as well as of biodiversity in each grade and at the end of school could be formed and knowledge could be better remembered and used after. The cell and its environment and transport trough the cell membrane need better attention and clarification. Health and cell structure, normal function and damage are very near to neglect and that problem should be solved by changes in curricula, syllabi and textbooks.

Lack of appropriate experiments could be the cause of fewer associations with chemical composition of the cell and with biodiversity protection.

Associations with biodiversity were not well structured and information, concerning levels and protection needs improvement. The term biodiversity should occupy a better place in curricular and syllabi, well clarified and more precisely defined in the textbooks. Unifying topics and concept map construction could solve teaching and memory problems. Involving students in biodiversity protection activities could give meaning to the term and show its practical significance.

With the aid of the concept map, associations were classified, structured, visualized and logical connections between them determined. A compact, wholesome and generalized picture of the key concepts was created, that facilitated learning, memorizing and remembering. The mind seeks clarity and completion and the map stimulated the "discovery" of new links between concepts, generation of new ideas and enhanced its own improvement. Besides that, the association map stimulated reflection and self-reflection and enhanced studies of the key concepts.

Both methods – word association test and concept map construction, can be used together in teaching and learning and in evaluation of learning results in biology education.

Associative thinking is the first step on the road of creative thinking as it is closest to the material bases, that is, to the object of cognition. Therefore the process of association making is at the heart of all types of learning, but the interpretation of the concept and the attitude to it depend very much on the theoretical bases upon which they are discussed. Associative processes take place at different levels of learning. They are those processes that lead to the development or maintenance of cognitive connections (associations) between events, behaviors, feelings, thoughts, visual images, etc.

The word presented to the target people acts as a stimulus activating the memory and extracting the associated with it words which are on the top of their minds. A dynamic associative structure is created in memory that involves representations of the words themselves as well as connections to other words. This structure of scientific terms plays a crucial role in any task involving familiar words. People cannot create and retrieve representations involving familiar words, without relying on pre-existing associative structures created as a result of past experience. Thus the word association test can be used in order to reveal scientific conceptual structures.

Science conceptual structures depend both on science education and culture of the community in which students grow and develop, including the climate and culture within the schools themselves. They are not the result of studying only one subject but integrate studies in all subjects with

their everyday experience. There are individual differences in the speed and number of retrieval.

The study points out to some shortcomings of school subjects, curricula and modes of teaching. Measures for nature and biodiversity protection are barely discussed and poorly understood. Besides, students are not involved in activities for environmental protection and improvement. Different strategies of teaching facilitating the building of associations, such as content analysis and mind map clustering, intellectual concept map construction, visualization of conceptual structures, etc., are hardly used in school practice.

Notes

[1] http://cogprints.org/5543/1/Sharifian.pdf

[2] Nelson, D. L., McEvoy, C. L. & Schreiber, T. A. (1998). The University of South Florida word association, rhyme, and word fragment norms. http://www.usf.edu/FreeAssociation/.

[3] http://www.aifb.uni-karlsruhe.de/WBS/pci/lrec04.pdf

[4] Van Eck, N. J., Frasincar, F. & Van den Berg, J. Visualizing Concept Associations Using Concept Density Maps. 10th International Conference on Information Visualization, IV'2006, pp. 270–275

[5] http://InfomationR.net/ir/6-1/paper85:html

[6] Николов и др. (2001). *Биология и здравно образование. Учебник за 9 клас.* София: Анубис. Nikolov, T.et all (2001) Biology and Health Education. A Textbook for 9th grade students. Sofia, Anubis (In Bulgarian)

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