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THE APPLICATION OF CONCEPT MAPS IN THE TEACHING OF POLLINATION AND POLLINATORS IN ELEMENTARY SCHOOL

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Abstract. *Teaching biology is characterized by a great number of concepts and facts. It is very difficult to concisely represent all important concepts and facts. In order to effectively present important concepts such as pollination and pollinators, concept maps have been applied. In particular, the pedagogical experiment was applied to determine whether the concept maps are effective as teaching technology compared to the usual teaching approach without this technology. The research involved 110 elementary school students who were divided into one experimental (E) and one control (C) group. The E group covered programme content related to pollination and pollinators by applying concept maps. The C group was exposed to the same content, without these maps. It is evidenced a difference of the attained knowledge in favour of the experimental group after the introduction of the experimental factor (application of concept maps). The application of concept maps directly contributed to better learning and knowledge acquisition in teaching the biology content Pollination and Pollinators. Based upon the obtained results of this research, concept maps will be further implemented to improve teaching process and the teachers will be gradually trained for the application of this teaching technology.*

Keywords: *concept maps, programme content, pollination, pollinators.*

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Introduction

Teaching biology is characterized by a great number of concepts and facts. It is very difficult to concisely represent all the important concepts and facts. But numerous teaching technologies can be applied to overcome this problem. Very often, these are different visual technologies. Among them, concept maps can be applied.

Concept maps are two-dimensional visual teaching technology through which the structure of biology programme content can be introduced (Kinchin, 2011). They include concepts, usually enclosed in circles or boxes of some kind, their mutual relation indicated by the connecting line linking two specific concepts. The words on the line referred to as linking words or linking phrases, specify the relationships between the two concepts (Novak & Cañas, 2008).

Concept maps were created at the beginning of 1970's as a part of a research project of Novak and collaborators. Within this study, the researchers interviewed many children and they found it difficult to identify specific changes in their understanding of science concepts by examining the interview transcripts. As a result of the necessity to find a better way to represent children's conceptual understanding, there emerged the idea of representing children's knowledge in the form of a concept map. Thus, a new tool was created not only for the purpose of research, but also for many other purposes (Novak & Cañas, 2008). This programme was based on the theory of learning psychology, developed by David Ausubel. According to Ausubel's theory, learning is based on the assimilation of new concepts and assumptions in the concept framework that the student already has. This structure of knowledge is also referred to as the individual cognitive structure.

It is best to construct concept maps with reference to some particular question on which answer should be found. This question is focus question. A concept map may pertain to some situation or event that we are trying to understand through the organization of knowledge in the form of a concept map, thus providing the context for the concept map (Novak, 2010).

The first structure of concept maps, the so-called preliminary maps, is checked and revised at least several more times, to assume the final form to be applied in the classroom. When reviewing draft concept maps, we can add new concepts and observe cross-links between those concepts. Cross-links help us to see clearly how a concept from one domain of knowledge relates to a concept from another domain on the map, thus creating the potential for deeper thinking and finding creative solutions, and promoting more forms of mental processes and creative thinking (Novak & Cañas, 2008).

According to the results of educational research, concept maps have several benefits for their users, as they:

- allow students to perceive concepts, thoughts and ideas more clearly (Fisher, Wandersee, & Moody, 2000), encourage the work of both hemispheres of the brain, are useful in the development of higher cognitive activities (analysis, synthesis, evaluation ...) (Fischer, 2009);
- help students in creative thinking and developing new ideas, integrate and reorganize knowledge and influence the development of critical thinking (Kinchin, 2000b; Kinchin et al., 2010);
- serve as a tool for the evaluation of knowledge and for measuring the adopted courseware (Hay & Kinchin, 2006). Students can independently assess the level and quality of the knowledge acquired, and teachers may monitor and evaluate the acquisition of knowledge by students (Peters & Beson, 2010);
- can be used for organizing and structuring the curriculum of a certain subject (Novak & Cañas, 2008), which allows teachers to easily create and organize the curriculum, as well as connect educational units (Loertscher, 2011).

By using concept maps at preschool age, children become familiar with the abstruse phenomena, processes and concepts, learn how to learn, how to separate the important from the unimportant and how to explain and relate concepts and information (Birbili, 2006).

Although the idea is to use concept maps to evaluate the progress of students in a clear and simple way, one should be cautious with this approach as students tend to leave out some very important information when constructing concept maps (Kinchin, 2014).

Concept maps are used to organize, plan and display information of entire programmes, modules, themes and parts of a curriculum. Any domain of knowledge can be revised by using the maps of terms. Thus, both students and teachers are provided the basic facts/ knowledge, having an insight into their structure and interaction (Simon, 2009).

One of the key issues concerning the application of concept maps in teaching is the nature of the curriculum in which they will be incorporated. The degree of freedom that should be offered to students needs to match the degree of freedom that a student may have within the curriculum (which is especially complex in natural sciences), in order to develop a personal understanding of the teaching material (Kinchin, 2014).

The qualitative analysis of concept maps also led to the examination of their morphology in terms of their functionality. The different morphologies that are commonly encountered- chains, circles or networks- are associated with orientation in learning. These structures have a role in learning and they are not mutually exclusive, and one structure may develop into another over a certain period of time. Thus, for example, the structure of one branch can be developed into a chain or network, as the student develops understanding in the process of further learning. It is also clear that some structures are more or less contextually appropriate in a given situation, and students need to create their maps accordingly (Kinchin, 2013b).

There are numerous types of software for constructing concept maps in the world, but students themselves can develop their own style of concept maps. In view of the fact that teaching is increasingly becoming a digital "game" in the world of Internet technologies, it is of utmost importance not to neglect or abolish the direct face to face contact between students and teachers, knowing that we are constantly moving from the analogue to the digital educational environment, the focus being shifted from the student to the technology used today (Kinchin, 2013a).

Concept Maps Applied to the Concepts of Pollination and Pollinators

Pollination is a fundamental, essential process in any ecosystem that allows reproduction of plants and the production of food for humans and animals (Klein et al., 2007; Stanisavljević, 2012).

Pollination is the transfer of pollen between the male and female parts of flowers to enable fertilization and reproduction.

Depending on the type of pollinators, the pollination process can be divided into abiotic and biotic pollination. The most important factors of abiotic pollination are water and wind. Biotic pollination means the presence

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of another organism, which is the mediator in the process and which is related to the species pollinated. This organism must visit the flower all the time, and such visits are therefore integrated into its daily routine. Most of the cultivated and wild plants depend on animal vectors, known as pollinators, to transfer pollen.

In nature, animal pollination plays a vital role as a regulating ecosystem service. Worldwide, approximately 90% of wild flowering plant species depend, at least in part, on the transfer of pollen by animals (Potts et al., 2016).

Contribution to the pollination of numerous leading global food crops come from wild insect pollinators, which include bees, flies, butterflies, moths, and beetles (Klein et al., 2007; Kleijn et al., 2015; Garibaldi et al., 2013). The majority of animal pollinators important to agriculture are insects, of which the best known are bees (honeybees, bumblebees, stingless bees and solitary bees) (Kevan, 2007). Birds, bats and some other mammals frequently visit large flowers with plenty and easily accessible nectar (Groeneveld, Tscharntke, Moser, & Clough, 2010).

In any given ecosystem should be treating pollination as a complex web of interactions between plants and pollinators, because pollination is not their simple connection. These interactions can be studied using ecological networks (Moreira, Boscolo, & Viana, 2015).

Relations among organisms developed during evolution through various attractants (nectar, pollen, specific odours) while others were created by accident (Pyke, 2010).

The process of pollination explains why so much energy was invested in the structure of the flower and reproductive organs, the production of nectar and sexual reproduction throughout the evolution, as reproduction is of vital importance for plants and for animals, as well as for the production of genetic variability (Berenbaum, 1995).

For the many angiosperms, reproduction depends on attracting animals that provide pollination. Flowers offer various traits that can attract animals through visual, olfactory, and tactile signals and some of these features may result from selection conducted by pollinations. Such plant attractants can provide information about the presence, quality, and location of reward (Valenta, Nevo, Martel, & Chapman, 2017).

Pollinator communities may be changed in a nonrandom way, because of global change (e.g. climate, land-use intensification and farming systems), resulting in losses of specific functional groups or species (Rader, Bartomeus, Tylianakis, & Laliberte, 2014). Risks for food production and society is a worldwide problem coming from loss of diversity of wild pollinators.

Important support of pollinators and pollination come from higher education and training programs for agronomists, veterinarians, farmers, and policy-makers (Dicks et al., 2016). Education projects focused on pollinators and pollination that combine awareness raising with practical training and opportunity for action have a good chance of making real behavior change, and there is direct evidence for this in a few cases. Worldwide, there are many pollinator-focused education and outreach projects of which most are relatively new and so effects on broader pollinator abundance and diversity might not be seen yet (Dicks et al., 2016).

Based on the foregoing, it can be concluded that the concepts of pollination and pollinators are very important in education. Considering that students should correctly understand the concepts of pollination and pollinators, it is essential to bring these scientific concepts closer to their current understanding of this field, to make an analogy between these concepts and botany, particularly when it comes to the parts of the flower already familiar to students. The reciprocal links that exist between animals and plants, the fascinating and intriguing ways of understanding the process of pollination as essential to the functioning of the ecosystem, open the door to interdisciplinary approaches in the methodology of teaching and learning in this field. For many, pollination is not a sufficiently and correctly understood concept, which is why it is necessary to introduce a new course on or a model of concept maps, making special reference to this particular scientific concept (Sessions & Johnson, 2005). Concept map can point out the analogy between pollination and pollinators on the one hand, and the parts of the flower on the other (Appendix 1).

The terms relating to pollination can be incorrectly presented, since teachers tend to simplify them to make them clearer to their students. Moreover, there are biology textbooks, in which bees are the only pollinators mentioned, while many species of insects and other invertebrates and vertebrates are omitted. Also, there is no mention of how important the process of pollination and pollinators are for the life on Earth, as well as of how people have harmed pollinators and plants by their actions and by using different materials, nor there is mention of what they can do to facilitate the flow of the process of pollination.

Using concept maps in understanding the processes of pollination of plants is a very suitable model of teaching the content related to these processes. Using a concept map the student can learn how plants attract pollinators (Appendix 2).

Concept maps as a teaching technology can equally well be used at all levels of education. The efficiency of

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concept maps in teaching was shown by the results of several researches conducted at the University of Belgrade - Faculty of Biology. It was proved that these maps had a positive effect on acquiring knowledge (Stanisavljevic & Djuric, 2013a; Stanisavljević & Djurić, 2013b; Stanisavljević & Stanisavljević, 2014) and developing a positive attitude in students (Djuric & Stanisavljevic, 2011).

Considering that biology (as a science and teaching) is filled of numerous concepts and facts, and that these maps as teaching technology are extremely concise and determined, their application can present in a very clear, precisely defined and concise manner, numerous biological concepts and facts. These maps are more concisely, more precisely, more structured, more formal and more specific in comparing with other similar visual teaching technologies such as mind maps ("idea mapping") and conceptual diagrams (Davies, 2011). For these reasons, a large amount of teaching content, in particular about pollination and pollinators can be presented concisely with the help of concept maps, and the most important concepts and their relations (from this topics) thus can be briefly summarized and highlighted.

Although concept maps are significant in the field of biology, they are unfortunately not widely used in the Serbian educational system.

Based on the above, testing and verifying the application of concept maps were started in biology teaching concerning the programme contents of pollination and pollinators in the sixth grade of elementary school.

The aim of this research was to determine whether the concept maps are effective as teaching technology compared to the usual teaching approach without this technology, in terms of acquiring knowledge of the programme content of pollination and pollinators in the sixth grade of elementary school.

Specifically, the intention of the research was to answer the following research question: Does the application of concept maps in realizing programme content pollination and pollinators contribute to a greater quantity and quality of the acquired knowledge?

It is expected that the difference in the quality and quantity of the acquired knowledge between the experimental and control groups will be in favour of the experimental group. The goal is to identify and measure this difference.

Methodology of Research

General Background

In this research, pedagogical experiment with parallel groups of students (experimental and control groups) was applied. The data was gathered through the pre-test and post-test with the aim to determine whether the concept maps (experimental factor) are effective as teaching technology for presenting the concepts of pollinator and pollination compared to the usual teaching approach without this technology. The research was conducted in April 2016 at the elementary school in Belgrade.

Sample Selection

The research included the total of 110 sixth grade students from the elementary school from Belgrade, Serbia. In order to achieve the aim of research, the pedagogical experiment with parallel groups [experimental (E) and control (C)] was applied (Appendix 3).

The students were grouped into Group E (N=58) and Group C (N=52) (Killermann, 1998). Before the introduction of the experimental factor (concept maps) in experimental group, the groups were made uniform concerning the number of students, gender and general knowledge of biology, as determined by the results of a pre-test of knowledge.

Before research was performed, for the research participants informed consent was obtained from parents, teachers and school board, in accordance with the permission of the ethics committee of the Faculty of Biology, University of Belgrade.

Instruments and Procedures

The pre-test included twelve tasks in total, classified into three broad categories of the cognitive domain: Rank I (remembering and understanding), Rank II (applying and analysing) and Rank III (evaluating and creating).

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In order to facilitate the categorization of the knowledge test, the tasks were divided based on the revised Bloom's taxonomy (Anderson & Krathwohl, 2001), where the cognitive domain is divided into six categories (remembering, understanding, applying, analysing, evaluating and creating). The test is based on all programme contents preceding the contents of pollination and pollinators.

After equalizing the experimental group (E) and the control group (C), Group E was taught the prepared biology content *Pollination and Pollinators* by applying concept maps. After a brief oral PowerPoint presentation by the teacher, the students were distributed partly completed concept maps (Appendix 4: 4.1., 4.2., 4.3., 4.4.), related to the basic characteristics of pollination and pollinators. They had to fill them out (to write adequate concepts in the blank fields) within one instruction period (Appendix 3). After the teacher's presentation, each student from Group E used the textbook to process the information on the topic, and, finally, filled out the concept maps.

The students in Group C were exposed to the usual teaching approach without concept maps, for the same content; namely, the teacher used PowerPoint to present this content through the following teaching methods: oral presentation, illustrations and demonstrations (throughout the instruction period). The teacher did ask some questions about the content, but the discussion was short. The students from this group were mainly listening to what the teacher was saying or watching what the teacher was showing.

The E and C groups were separated from each other. They underwent this teaching period (in the same time) in different classrooms. Also, in order to prevent any contamination of the design, the students of the E group had no contact with the concept maps outside of the planned periods (Kember, 2003).

After that, a post-test was distributed in order to evaluate the knowledge acquired by the students who used concept maps and those exposed to the usual teaching approach without concept maps. This test measured the quantity and quality of the students' knowledge in the teaching field *Pollination and Pollinators*. The post-test consisted of nine tasks (divided into three ranks/categories, as was the case in the pre-test) (Appendix 5).

Data Analysis

The data were analysed by using standard statistical indicators (sum, percentage frequency, mean, standard deviation, coefficient of variation and Student's t-test for testing any differences between the E and C groups) (Student, 1908). All these analyses were conducted using the statistical software package Statistica 6 (StatSoft, 2001).

Results of Research

The results of the pre-test are presented in Tables 1 and 2. The standard statistical indicators (mean of the number of achieved points-M, standard deviation-SD and coefficient of variation-CV) are presented in the table 1. Table 1 shows the students' achievement on the pre-test expressed in above mentioned terms, in all three ranks of tasks, as well as on the test as a whole. The E group students achieved 73.98% points and the C group students 73.08% points (in total).

Table 1. Basic statistical data for the pre-test.

Group	Rank I			Rank II			Rank III			Total		
	M	*SD*	*CV*	*M*	*SD*	*CV*	*M*	*SD*	*CV*	*M*	*SD*	*CV*
E (N=58)	28.79	4.76	0.16	23.31	4.67	0.20	21.88	6.74	0.31	73.98	15.85	0.21
C (N=52)	28.31	4.17	0.15	23.19	4.59	0.20	21.58	6.23	0.29	73.08	14.79	0.20

Note: M-mean of the number of achieved points, SD-standard deviation, CV-coefficient of variation.

Table 2 shows relations between E and C group, according to t-value (for pre-test).

Table 2. Testing group uniformity in the pre-test, using an independent two-sample t-test.

Relation	Rank I	Rank II	Rank III	Total
E : C (t-value)	0.56	0.13	0.24	0.31

Note: t-test for significance level of p≤ .05 and critical value of t≥1.96.

Based on the results presented for the pre-test for Groups E and C, it can be observed by using Student's t-test for a significant level of p=.05 and a critical value of t=1.96, there is no statistically significant difference in the achieved number of points between Groups E and C in all three ranks of tasks and in the test as a whole (Rank I: t=0.56<1.96; Rank II: t=0.13<1.96; Rank III: t=0.24<1.96; Total: t=0.31<1.96). These two groups were balanced in terms of their general knowledge of biology before the introduction of the experimental factor (concept maps).

The results of the post-test are presented in Tables 3 and 4. Table 3 shows the students' achievement on the post-test expressed in above mentioned statistical indicators (M, SD and CV), in all three ranks of tasks, as well as on the test as a whole. The E group students achieved 83.72% points and the C group students 73.56% points (in total).

Table 3. Basic statistical data for the post-test.

Group	Rank I			Rank II			Rank III			Total		
	M	*SD*	*CV*	*M*	*SD*	*CV*	*M*	*SD*	*CV*	*M*	*SD*	*CV*
E	33.24	1.84	0.56	26.60	2.66	0.10	23.88	6.47	0.27	83.72	10.83	0.13
C	30.73	3.58	0.12	23.31	4.36	0.19	19.52	6.43	0.33	73.56	14.07	0.19

Note: M-mean of the number of achieved points, SD-standard deviation, CV-coefficient of variation.

Table 4 shows relations between E and C group, according to t-value (for post-test).

Table 4. Testing group uniformity in terms of the post-test, using a t-test.

Relation	Rank I	Rank II	Rank III	Total
E : C (t-value)	4.48	4.70	3.52	4.16

Note: t-test for significance level of p≤ .05 and critical value of t≥1.96.

By comparing the average values of the results achieved, a clear difference can be observed between Groups E and C in terms of the individual ranks and in the test as a whole, favouring the former. On the basis of the results presented for the post-test of knowledge for Groups E and C (Table III and IV), we can notice that there are statistically significant differences in the number of points achieved in all three levels of tasks and in the test as a whole, in favour of Group E (Rank I: t= 4.48>2.58; Rank II t=4.70>2.58; Rank III: t=3.52>2.58; Total: 4.16>2.58).

Discussion

The obtained results show that the experimental group to which the content of pollination and pollinators was presented through concept maps achieved better results in the final test of knowledge than the control group to which the same content was presented without them.

It was proved that the experimental group had a greater quantity and better quality of knowledge acquired as compared to the control group. This can be particularly seen in Rank II (applying and analysing), where the value

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of *t*=4.70 is outstanding as compared to Rank I (remembering and understanding) and Rank III (evaluating and creating). This research is aimed at improving the quantity and quality of the knowledge acquired, as well as the methodical approach, which is often missing when it comes to the traditional way of presenting an educational content. This changes the role of the teacher in the teaching process; the teacher is no longer merely someone who teaches, but someone who becomes the creator and organizer of the teaching process.

The results of the above studies can be compared with the results of related studies.

It should be particularly pointed out that concept maps have proved to positively affect the realization of some zoological programme contents (*Annelids*) regarding the quality and quantity of the knowledge acquired by students (Stanisavljević & Stanisavljević, 2014).

Application of concept maps in realization of botanical curricula in high schools (in Serbia), proved to be a very effective for acquiring knowledge (Stanisavljević & Jovanović, 2014).

The analysis of applying concept maps in the implementation of programme contents concerning evolution (sixth grade of elementary school/secondary school) also shows that the application of concept maps, in accordance with this courseware, is efficient (Ilić, Đurić, & Stanisavljević, 2015).

A study of the application of concept maps in programmed teaching (programme contents: *Human Anatomy and Physiology*) at the University of Belgrade - Faculty of Biology, indicates that concept maps are very effective in acquiring knowledge of physiology (Stanisavljevic & Djuric, 2013a).

Dhaaka (2012) indicates that the application of concept maps is an efficient mode of biology teaching that motivates students to learn and develop skills. The teaching process becomes more interactive and interesting. The results of this research show that the students using concept maps achieve significantly better results than those who are exposed to the traditional lecturing without concept maps.

Kinchin and Hay (2008) have proved the efficiency of concept maps in the classroom in measuring students' previous knowledge. They showed that simple mapping exercises may affect the quality and quantity of students' and teachers' knowledge.

A special group (phylum-type) of invertebrates (*Phylum Tardigrada*) can be explained using the constructivist approach and presented by applying concept maps. It is believed that this small phylum represents the direct ancestor of the largest phylum in the world (*Phylum Arthropoda*). Despite its great importance, students often ignore *Phylum Tardigrada* (Kinchin, 2000a).

Examining the contents of ecology, it has been proved that concept maps are very effective in representing and understanding the concepts related to pollution and environmental protection (Kinchin et al., 2008).

Novak's concept mapping has the potential to make a major impact on the development of higher education. This can be achieved by increasing the availability of multiple perspectives of knowledge that can be discovered and used for transcending the epistemic confusion lying beneath the seemingly coherent curriculum, which actually limits the impact of university teaching and creates the impression that universities are not for studying (Kinchin, 2015).

Patrick (2011) conducted a study on whether concept maps might improve the success of students in tests. The study was conducted after noticing that both high school and university students have a very poor knowledge of biology. The poor quality of knowledge was due to a lack of resources available to teachers. The lack of laboratories in schools led to the need to find alternative methods, which could be available in most schools, to replace laboratory work. Concept maps seemed to be the best solution.

Youssef and Mansour (2012) showed in their study that students, overwhelmed with information on a daily basis, had hard time managing information and distinguishing important from unimportant terms. The results showed that the use of concept maps, created both by professors and students, had greatly improved the quality of teaching in this case.

Edmodson (1994) points out that adequate concept maps are an excellent way of presenting a teaching content to students. By using concept maps it is possible to study in a clearer and easier way.

Concept maps can be used for teaching and learning within elementary school curricula. Seventh grade students were presented a part of the curriculum in the classical way and another part through concept maps. Testing was conducted at the end of each session. The results showed that the tests relating to the contents covered through concept maps were much better done by the students than those that did not contain contents presented through concept maps. (Lemos, Moreira, & Mendonça, 2008).

Daley (2004) conducted a study on the use of concept maps with university students. The aim of the study was to determine whether different learning strategies, in this case concept maps, contributed to changing the models and understanding of teaching materials. During the one-year research, he conducted testing to determine the way of changing the scores achieved in tests with concept maps and in those containing teaching contents that the students only listened to, without using the maps. The results showed that the material acquired through concept maps was much better and more durable, and almost all of the students stated that the concept maps had made their studying much easier.

To achieve maximum results, the maps should not be the only method used; they should rather be combined with other teaching methods and activities. There is no universal map that would suit all students in every teaching situation (Kinchin, 2000c). The introduction of concept maps in teaching should be carried out slowly. Teachers should first use them when explaining certain parts of the teaching content that are already known to their students, and then slowly introduce them when dealing with concepts which the students have never encountered before (Stanisavljević & Jovanović, 2014).

The results of the previous similar research (Đurić & Stanisavljević, 2011; Stanisavljević & Jovanović, 2014) show that the majority of students think that the manner in which teaching contents are processed is extremely important. They are convinced that learning particular contents through concept maps helps them learn much more, facilitating their understanding of biology.

Based on the survey results and after summarizing the views of students on the application of concept maps in implementing zoological educational contents, it can be concluded that most students accept this manner of work. Students realized that this approach to learning zoology had facilitated their understanding and mastering the course content *Annelids*. Nearly two-thirds of them confirmed that they had been motivated to adopt the materials by applying concept maps, and, therefore, had acquired better knowledge of *Annelids* both in terms of quantity and quality. The negative attitudes of students show that the theoretical contents of university subjects are mainly taught in the traditional way by lecturing. Therefore, students are somewhat uncertain and cautious about each new method that is unknown to them (Stanisavljević, Djurić, & Stanisavljević, 2014).

Conclusions

The teaching content *Pollination and Pollinators* was implemented through concept maps in the experimental group, while in the control group it was implemented through the usual teaching approach without this technology.

After introducing the experimental factor (concept maps) in Group E, this group achieved better results in the post-test of knowledge than Group C. The high level of statistically significant difference is particularly noticeable between the groups (in favour of the experimental group) in Rank II (application and analysis of knowledge in the given teaching field).

There is a statistically significant difference in mastering the given contents between the students in the experimental and the control group. It is evidenced a difference in level of the attained knowledge in favour of the experimental group after the introduction of the experimental factor (application of concept maps).

It can therefore be concluded (the answer to research question) that the application of concept maps directly contributed to better learning and knowledge acquisition in teaching the biology content *Pollination and Pollinators*. In other words, the high quality of the knowledge acquired by the students in the tested teaching field was especially significant in Rank II (application and analysis of knowledge).

Concept maps allow teachers to present certain contents more easily. Quality and quantity of students' knowledge has been increased. Furthermore, teachers gain a better insight into students' knowledge by using concept maps. However, in order to improve biology teaching by using concept maps, it is necessary to provide training for teachers to apply this technology.

The intention is that in future it becomes usual teaching technology in many zoology courses at the Faculty of Biology in Belgrade. The teachers and staff will be gradually trained for the application of this teaching technology.

Based upon the obtained results of this research, concept mapping will be further implemented at the University of Belgrade - Faculty of Biology, to improve the curriculum and the teaching process (subjects: Anatomy and Morphology of Invertebrates and Biology of Bees with Beekeeping). Further research is planned in the field of revision of the curriculum for zoological subjects. Thus, the concept maps will be used for organizing and structuring the curriculum of these subjects. It is expected that this will allow teachers to easily create and organize the curriculum, as well as connect teaching units.

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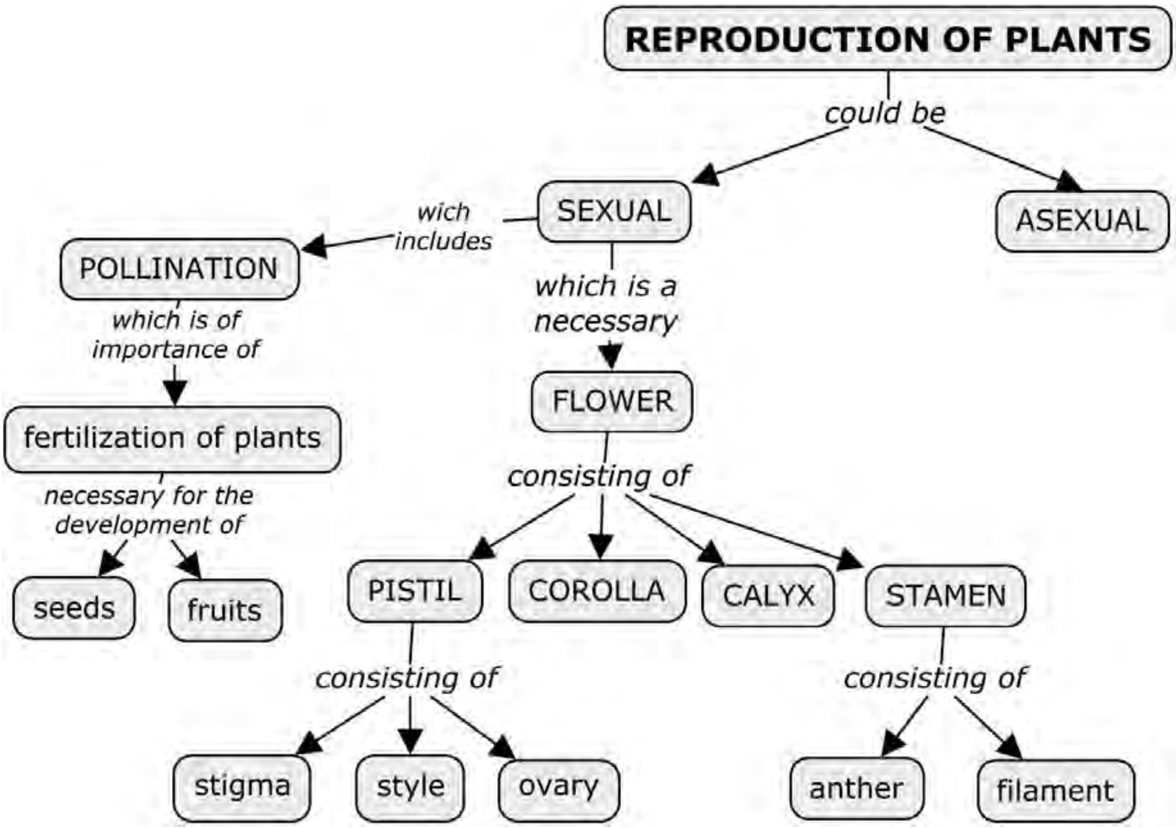
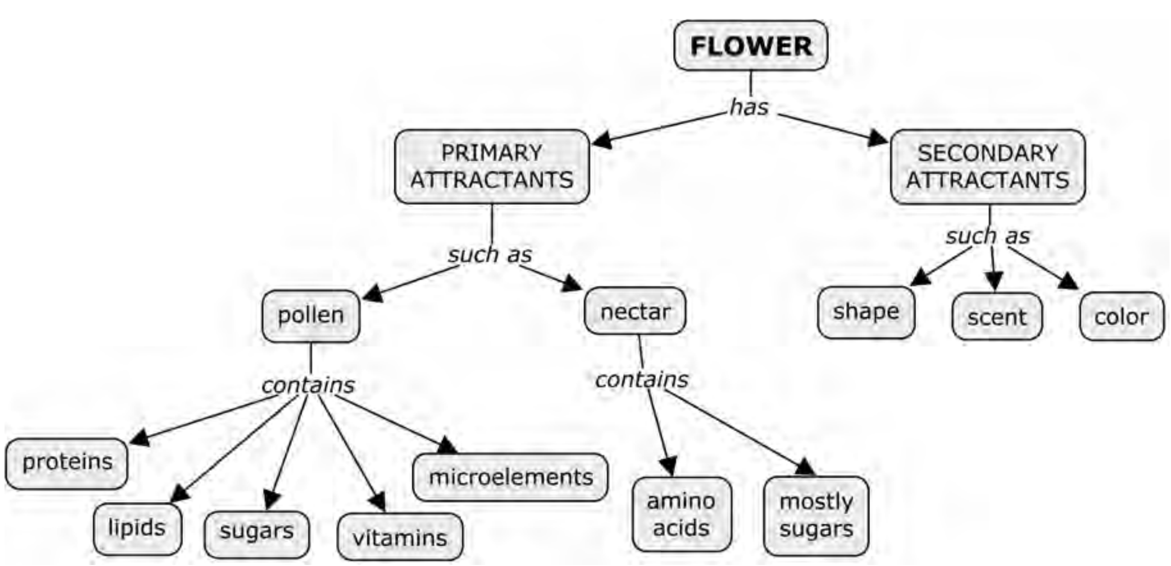
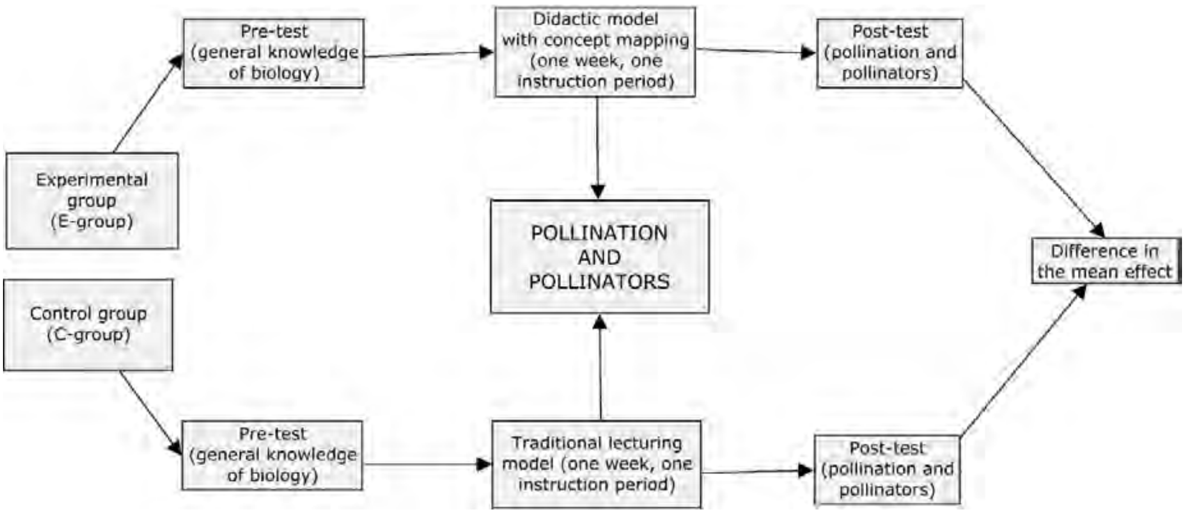
Appendix 1. A concept map: the meaning of the term *reproduction in plants.*



Appendix 2. Concept map: the principal characteristics of the flower essential to attracting pollinators.

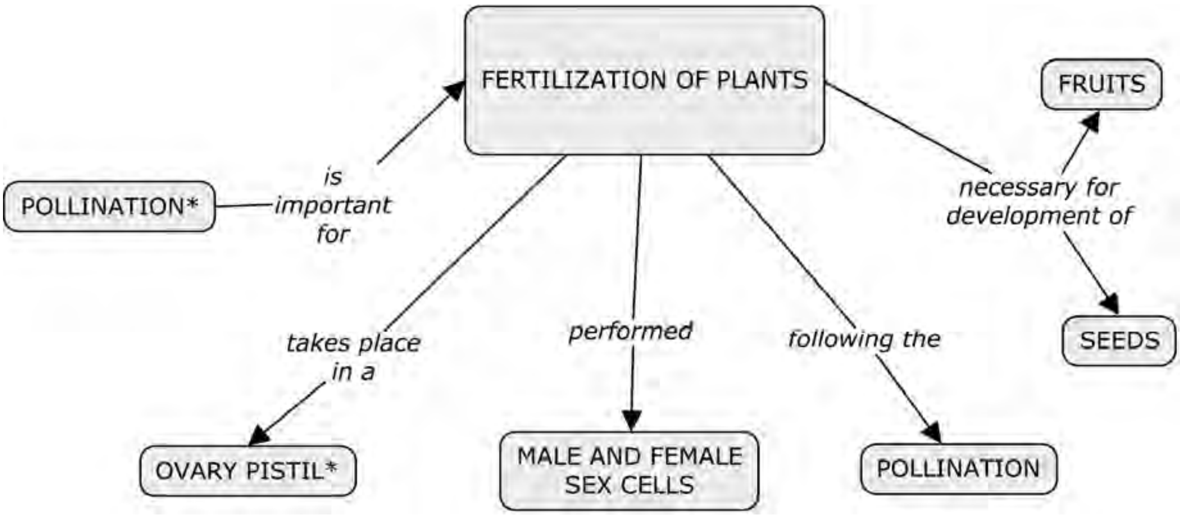


Appendix 3. The model of pedagogical experiment with parallel groups.



Appendix 4. An example of filled out concept maps on the topic of pollination and pollinators. The fields marked by an asterisk were blank at the beginning (students fill them out during the mastery of the teaching content).

Fertilization of plants.



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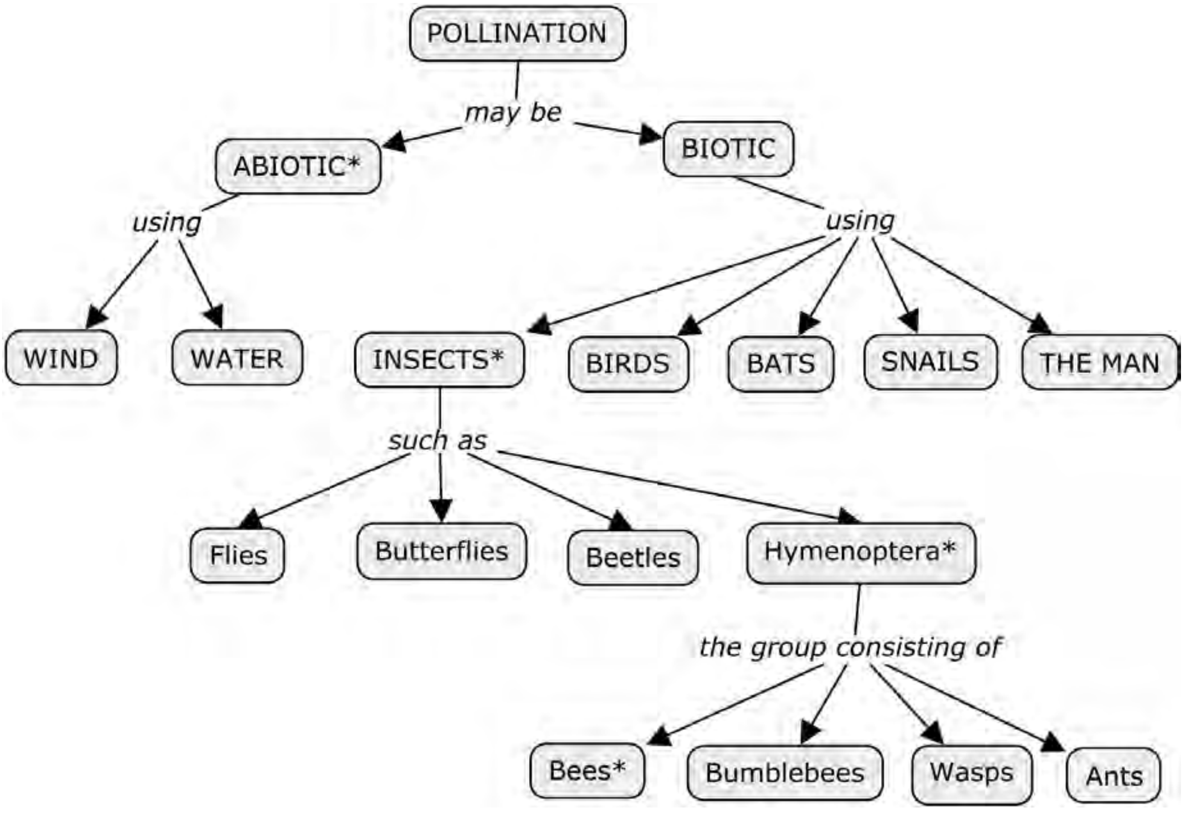
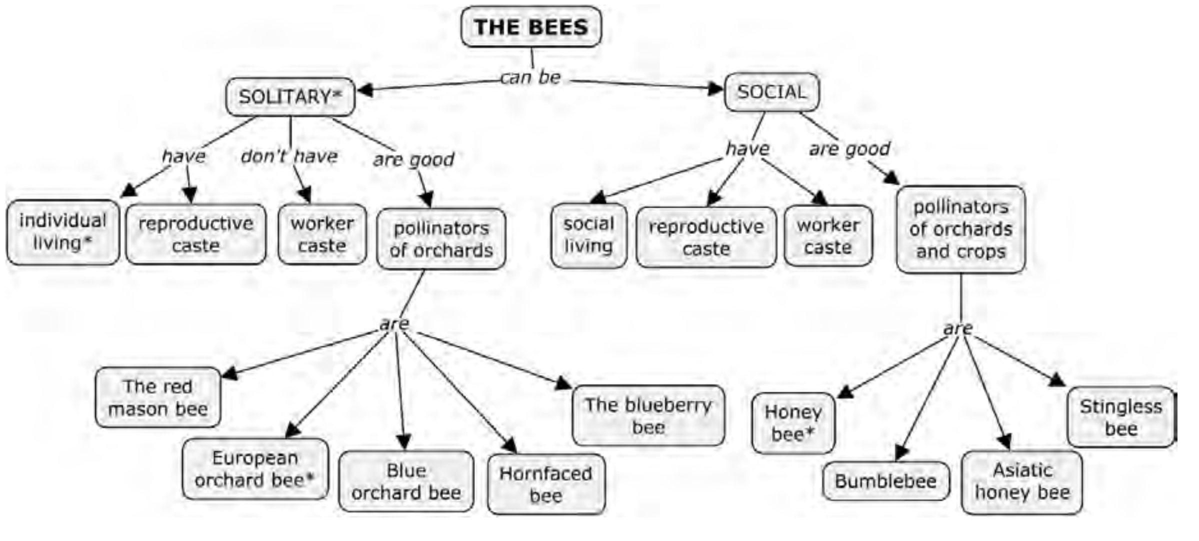
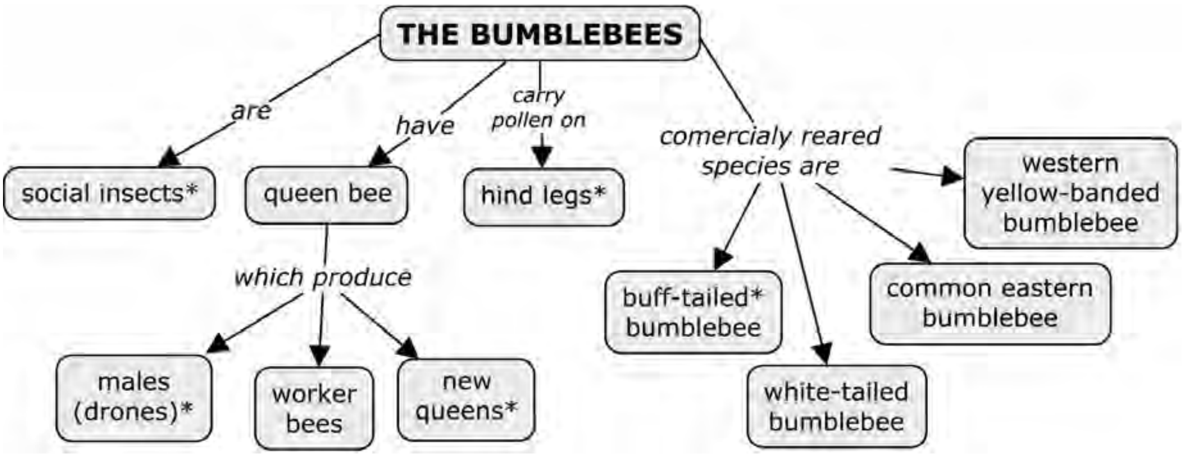
Pollination.



The bees.



The bumblebees.



Appendix 5. Example of some tasks used as an indicator of Ranks I, II and III.

Rank I
Circle the letter of correct answer:

Pollination is defined as:

a) The process of propagation of Algae and other Thallophyta
b) The process of transferring pollen grains from the anthers of one flower to the stigma of another flower
c) The process of transferring the nectar from one plant species to another.

Rank II

Description of concept	The concept/ pollinators
Searching for food (such as pollen and nectar) they perform pollination. They are attracted by the smell, shape, color, or the heat of the flower.	
They are adapted to pollinate certain flowers, which are so constructed that precisely these pollinators can accept.	
They accidentally passes through the flowers and carry pollen which accidentally stuck on their bodies.	
They are attracted by the vivid colors of the flower from which they suck nectar and catch small insects.	
They are nocturnal animals, they pollinate the plants that bloom at night.	

Fill in the table: Based on the description, determine and name the concept in the table.

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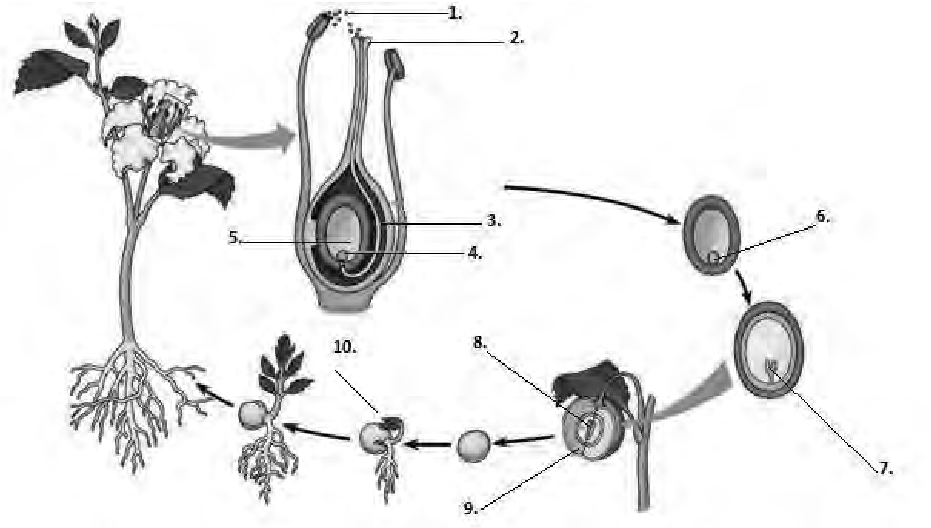
Rank III

9. Carefully watch scheme of pollination and fertilization of plants. Determine and name the concept in the table.



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