Application of the concept maps in the realisation of university biological programme content

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Definition of concept maps

▶ **Concept maps** are visual technology designed to help in learning and teaching process.

▶ The concept mapping has been started to develop by Prof. Emeritus Joseph D. Novak (professor of education and biological sciences, Cornell University) since 1972 within Novak's research programme (Novak & Cañas, 2007).

▶ The great contribution in developing and analysing concept maps also belongs to Prof. Ian Kinchin (University of Surrey, UK). Prof. Kinchin holds a B.Sc. and M.Phil. in zoology from the University of London and a Ph.D. in science education from the University of Surrey.

- What has led both biologists to develop such a system that helps in the process of learning and teaching?

- What kind of science is biology? How many concepts and facts are contained in it? Certainly, an immeasurable number. It is a very broad science of life, all its aspects.

- It was necessary to create a system which in a very concise way, precisely summarize everything what is the most important and expose it. These are just the concept maps.

► Concept maps are more concisely, more precisely, more structured, more formal and more specific in comparing with other similar visual technologies such as mind maps ("idea mapping") and conceptual diagrams (Davies, 2011).

► For these reasons, a large amount of teaching content, in particular biological programmme content (Anathomy and Morphology of Invertebrates, 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 summarised and highlighted.

- Concept maps have their origin in the learning movement called constructivism (Dammani, 2012). It is explicitly grounded in David Ausubel's assimilation theory of learning in which the central idea is meaningful learning (Ausubel, Novak & Hanesian, 1978).

- 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 **individual cognitive structure** (Ausubel, Novak & Hanesian, 1978).

- Concept maps are composed of concepts linked by appropriate **correlations** in a hierarchical structure. The most important concepts are usually linked by highly informative **linking statements** which are settled on the labelled lines (Kinchin, 2011). Linking statements need to be valid and to relate to concepts in some meaningful way (Buntting, Coll, & Campbell, 2006).

▶ Figure 1 shows an example of a concept map. Each concept is enclosed in a box.

▶ There are some **linking words** which specify the relationship between the two concepts.

▶ Two or more concepts which are connected with linking words are **propositions**.

▶ Those propositions are meaningful statements and can be called **semantic units** or **units of meaning**.

Figure 1. Concept map: Honey bee

(Stanisavljević & Stanisavljević, 2017).
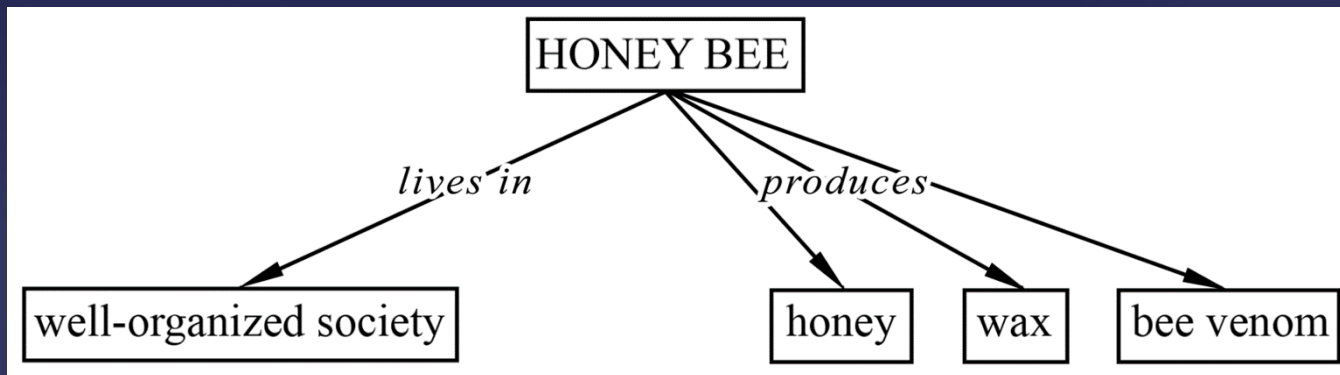
▶ In Figure 1, the concepts are: Honey bee, well-organised society, honey, wax and bee venom. The linking words/statements are: "lives in" and "produces".

▶ The propositions (semantic units) are:

1. Honey bee lives in well-organised society.

2. Honey bee produces honey, propolis wax and bee venom.

Functions of concept maps

▶ Concept maps can be applied in different phases of the teaching process:

1. Planning and preparation

2. Formative learning

3. Revision/summarising

4. Assessment (Kinchin, 2000).

▶ Figure 2 presents many different functions of concept maps in the teaching process.

Figure 2. Functions of concept maps.
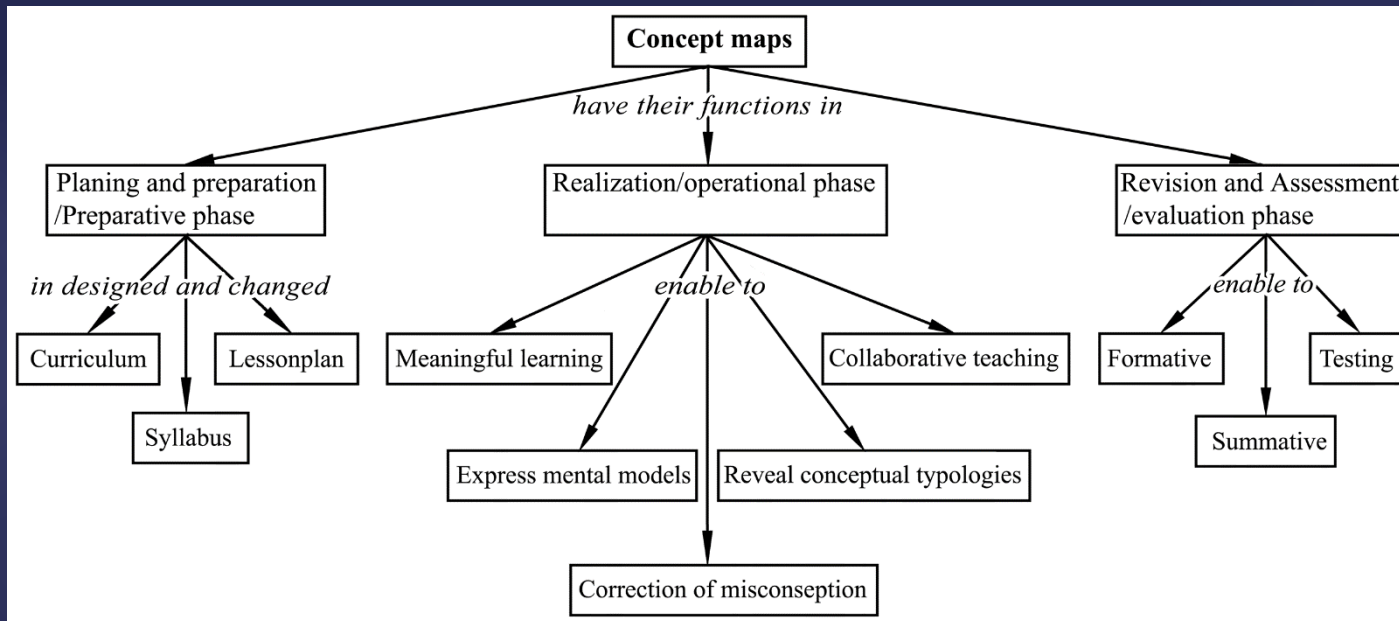
Construction of concept maps

▶ The first step is **to define the domain (area) of knowledge**. This creates a context that help in determination of the hierarchical structure of the concept map (Novak & Cañas, 2008).

▶ For the purpose of determining the context, it is necessary **to construct a focus question.** This question clearly and concisely specifies the problem or issue that the concept map should help to resolve it (Novak & Cañas, 2008).

▶ The next step is **to identify the key concept applying to this domain**. These concepts should be listed (in rank: the most general, more general, general, specific, more specific, the most specific...). The list of concepts is a **parking lot**. Usually, 15-25 concepts are sufficient (Novak & Cañas, 2008).

- The process of making a concept map begins with selecting concepts from a list of concepts (parking lot) and their placement in the scaffold. Some concepts may remain in the parking lot after constructing the map if good connections among these concepts and other concepts in the map wasn't noticed (Novak & Canas, 2008).

- Figure 3 presents an example for the defined domain Echinoderms, the focus question: "What are Echinoderms"? and a parking lot (concept list) for this domain. The first designed map is a preliminary map (Figure 4).

Figure 3. Echinoderms: Starting point of a concept map with a focus question and a parking lot with specific concepts that will be placed in the concept map.
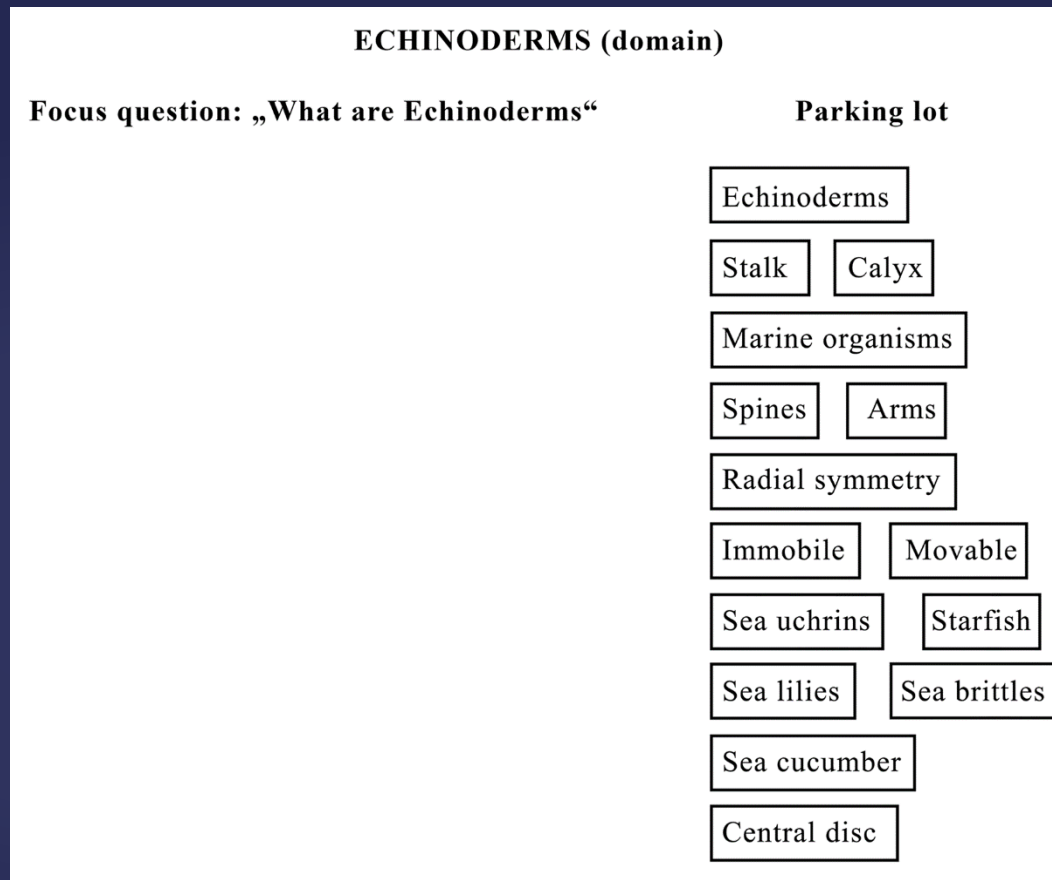

ECHINODERMS (domain)

Focus question: „What are Echinoderms"

Parking lot

- Echinoderms
- Stalk
- Calyx
- Marine organisms
- Spines
- Arms
- Radial symmetry
- Immobile
- Movable
- Sea uchrins
- Starfish
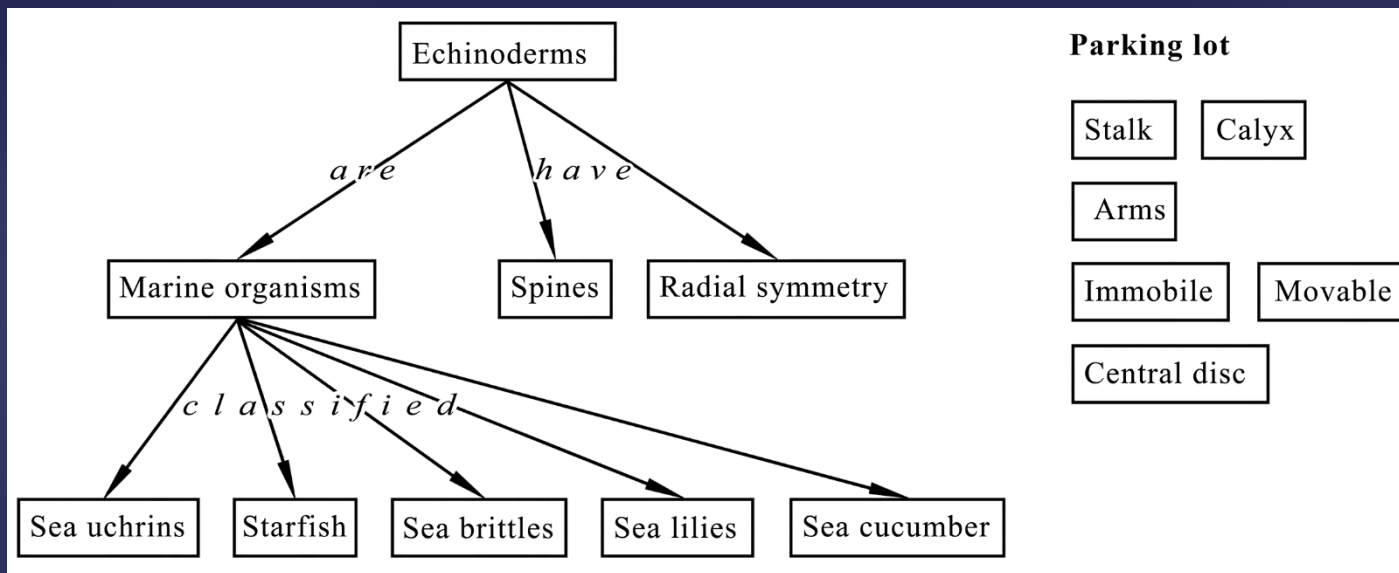- Sea lilies
- Sea brittles
- Sea cucumber
- Central disc

# Figure 4. The first designed concept map (preliminary map).

► When the preliminary map is constructed, than it is necessary to be revised. Specific concepts can be involved or restructured and **cross links should be sought**. **Cross links** are the links between concepts in different segments or domains of knowledge (Novak & Cañas, 2008).

► It is important to recognise concepts that are related to one another in some way. Therefore, it is very important to be selective in defining cross-links (Novak & Cañas, 2008).

► The links between different domains of knowledge on the map help to illustrate how these domains are related to one another. This process involves the high level of cognitive performance, i.e. the evaluation and synthesis of knowledge (Novak & Cañas, 2008).

▶ After revision, a concept map is improved. Good maps usually undergo three or more revisions. The final map contains concepts positioned in a way that leads to clarity (Novak & Cañas, 2006).

▶ Figure 5 presents the final concept map *Echinoderms* after revision. All concepts from the parking lot are placed into the map structure.

Figure 5. Echinoderms (final concept map).
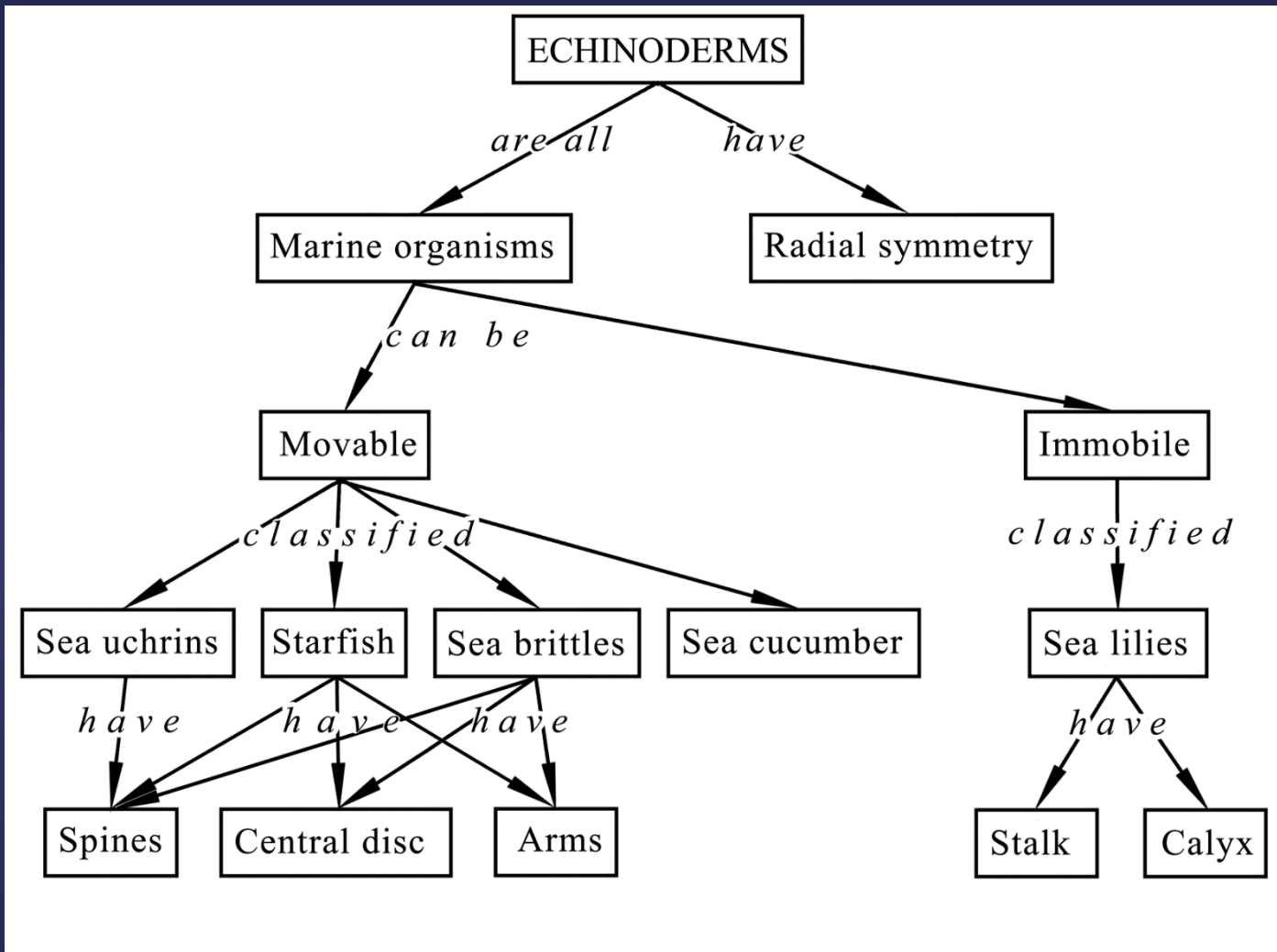
- One of the most popular software programme for construction of concept maps is called CmapTools (Cañas et al., 2004). It is available for download at: http://cmap.ihmc.us (Novak & Cañas, 2008).

- This software helps in construction and modification of concept maps. Also, it allows support for collaborative work over a long distance in the construction of maps and their publishing (Novak & Cañas, 2008).

- „The concept maps built using CmapTools can be stored on servers (CmapServers, see: Cañas et al., 2003) where anybody on the Internet can access them" (Novak & Cañas, 2008).

▶ Although, there are numerous types of software for constructing concept maps in the world, students themselves can develop their own style of concept maps (Davies, 2011; Kinchin, 2013).

▶ Taking into account the fact that learning/teaching process is increasingly becoming a digital "game" in the world of Internet technologies, it is very important not to neglect or abolish the direct „face to face" contact between students and teachers (Kinchin, 2013). In this way, we will not lose the pedagogical aspect of teaching/learning process.

A comparative review of the efficiency of applying concept maps in higher education

▶ By using concept maps students can organise their knowledge. Moreover, they can solve problems in learning/teaching process and understand how they learn. Concept mapping is a very effective strategy, helping students to learn meaningfully by making the links between scientific concepts explicit (Fisher, Wandersee, & Moody, 2000).

▶ Meaningful learning is an outcome of concept mapping and can reduce subject-based anxiety (Kinchin, 2000). A qualitative approach to a concept map analysis can be applied to improve the teaching process in the sense of achieving more effective learning and helping students to integrate their knowledge and build upon their existing naive concepts (Kinchin, Hay, & Adams, 2000).

▶ Concept maps prevent the existence of gaps in knowledge and misunderstandings (Willson & Williams, 1996), and generally have positive effects on students' attitudes and achievements (Horton et al., 1993).

► Some other studies also examined the use of concept maps in measuring tertiary science students' understanding of fundamental concepts in science education. The results confirmed that concept maps contributed to the clarification of students' misconceptions and to meaningful learning (Roberts, 1999).

► It has been shown that the use of the concept mapping can significantly add to the quality of university teaching. Concept mapping can be used in measurement of learning quality. By using concept maps teachers can identify new concepts that students find troublesome or difficult to acquire Also, It enables the engagement of teachers and students in the processes of discovery and makes learning visible. Teachers can use it to promote meaningful learning among their students (Hay, Kinchin & Lygo-Baker, 2008).

- A study on concept mapping, designed to support university teachers' analysis of a course content, shows that the concept mapping process provides an alternate means to rethink the course content. The findings of this study show that concept maps also highlight relationships among concepts and frequently make the types of thinking required in the course explicit (Amundsen, Weston & Mc Alpine, 2008).

Analyzes of the application of concept maps (University of Belgrade-Faculty of Biology)

- ▶ Particular consideration of the structure of the physiology course content, together with the findings about the use of programmed materials and concept maps, shows the suitability of programmed instruction (linear programmed material), which includes the elaboration of concept maps in the "Human Anatomy and Physiology" course . In terms of the quantity and quality of knowledge acquired by the students in the tested teaching field, the experimental model of programmed instruction with concept maps proved to be more effective (Stanisavljević & Djurić, 2013; Stanisavljević & Đurić, 2013a).

- ▶ Based on the survey results and the students' views on the application of programmed instruction including concept maps, it can be concluded that most students accepted this manner of work (Djurić & Stanisavljević, 2011). They were motivated to acquire the contents and thus gained quantitatively and qualitatively better knowledge (Nervous System).

- The effectiveness of applying concept maps in accomplishing the zoology curriculum for the course the Anatomy and Morphology of Invertebrates for undergraduate students was experimentally verified. The research question was: "Does the application of concept maps contribute to the better acquisition of knowledge?"

- It has been proven that the concept maps helped students to select and organise relevant information from this course. Furthermore, they summarised a large amount of information and integrated their knowledge. It can therefore be concluded that the application of concept maps directly contributed to better learning and knowledge acquisition in the teaching of zoology content (the phylum Annelids) (Stanisavljević & Stanisavljević, 2014).

- A great number of students expressed a wish to apply concept maps in the future in mastering the related zoological programme contents (Stanisavljević, Djurić & Stanisavljević, 2014).
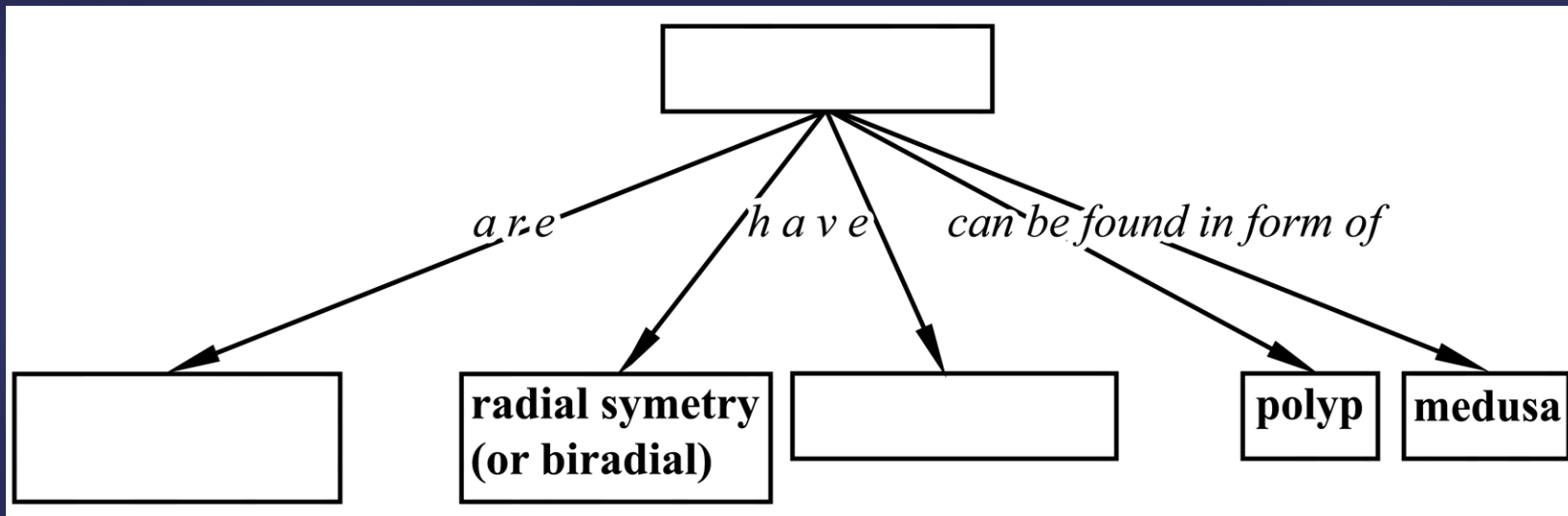
Examples of the concept maps used in teaching subjects (University of Belgrade-Faculty of Biology)

A concept map for the syllabus of *Anathomy and Morphology of Invertebrates*
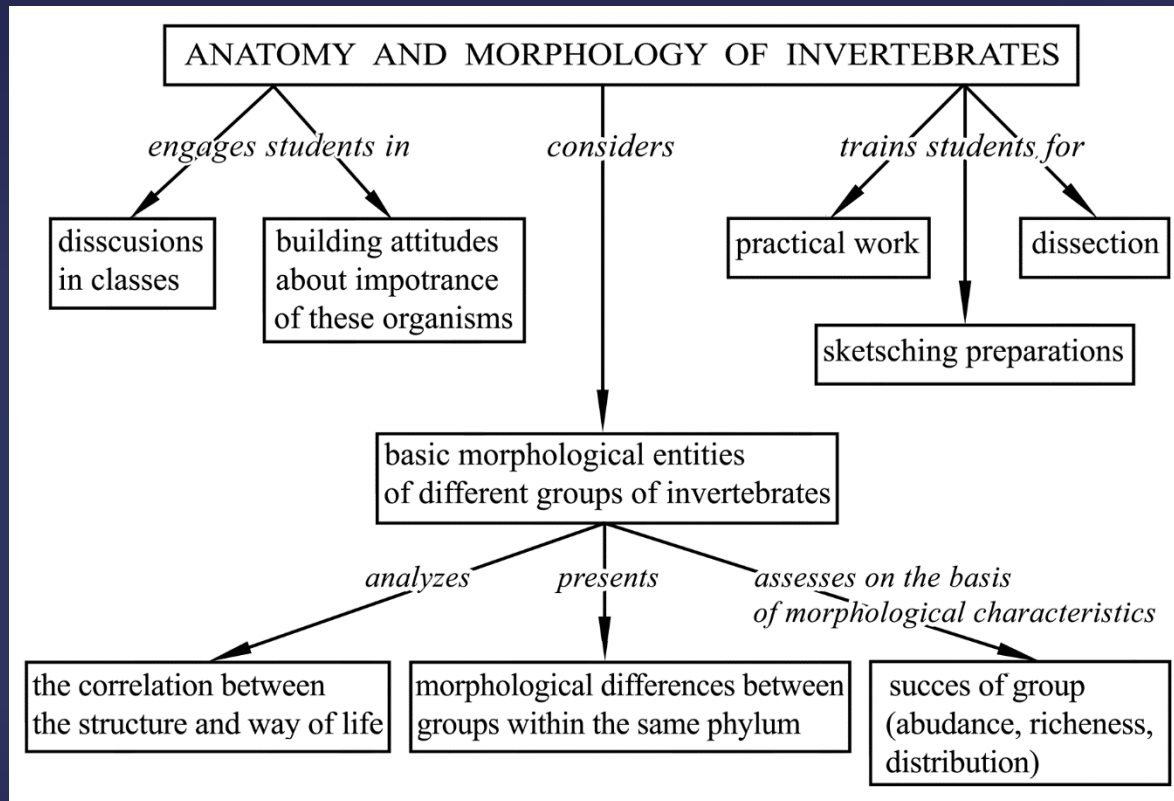
Example of concept map for evaluation of acquired knowledge (Anathomy and Morphology of Invertebrates)

A concept map of cnidarians: environment, symmetry and forms.

Conclusion and implications

▶ Application of concept maps directly contributed to better learning and knowledge acquisition.

▶ It is necessary to provide training for teachers and students to apply this technology.

▶ The intention is that in future it becomes usual teaching technology in many zoology courses and in other courses (Faculty of Biology, Belgrade).

▶ The teachers and students will be gradually trained for the application of this teaching/learning technology.

▶ Based upon the obtained results, concept mapping will be further implemented at the University of Belgrade - Faculty of Biology, to improve the curriculum and the teaching/learning process.

▶ Further research is planned in the field of revision of the curriculum for other zoological subjects. Thus, the concept maps will be used for organising and structuring the curriculum of these subjects. It is expected that this will allow university teachers to easily create and organise the curriculum, as well as connect and quality present teaching units.

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