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CONCEPT MAPS, A MUST FOR THE MODERN TEACHING-LEARNING PROCESS

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Abstract. This paper stands up as an argument for a broadening of the methods used in the science teaching process. The main goal of the authors is to point out ways of achieving learning excellence by usage of modern educational means. This bold aim can be reached by resorting to concept maps within the teaching and evaluation processes. We focus upon the advantages of this method taking as an example a Harmonic Oscillation Motion concept map.

Key words: concept map, harmonic oscillatory motion, outstanding achievements, assessment.

1. INTRODUCTION

In order to transform the student in an active person which, guided by teachers, discovers and scrutinizes new knowledge territories, there are new teaching strategies in agreement with student's learning manners:

• the lesson has as a starting point certain student's experiences, and embraces questions and activities that involve the student;

• as part of the lesson, one uses a combination of activities that tackle different learning manners that the student prefers: visual, auditory, practical;

• the lesson involves an active participation of the student in the learning process, through accomplishing experiments, simulations and problems by means of a computer.

The development of permanent learning competences and of the students' and the teachers' creative skills determine the efficiency increase of the education.

It is possible for the student to actively get involved in the learning process, by taking part together with the teacher in the developing of concept maps.

According to Ausubel, "the most important single factor influencing learning is what the learner already knows".

Thus, meaningful learning results when a person consciously and explicitly ties new knowledge to relevant concepts they already possess. Ausubel suggests that when meaningful learning occurs, it produces a series of changes within our entire cognitive structure, modifying existing concepts and forming new linkages between concepts. This is why meaningful learning is lasting and powerful whereas rote learning is easily forgotten and not easily applied in new learning or problem solving situations which the present science curricula so advocate [1].

The usage of such modern methods as the concept maps is a must for the modern educational process.

The use of concept maps as a teaching strategy was first developed by J. D. Novak of Cornell University in the early 1980's. It was derived from Ausubel's learning theory which places central emphasis on the influence of students' prior knowledge on subsequent meaningful learning.

A *concept map* is a diagram showing the relationships among concepts. They are graphical tools for organizing and representing knowledge.

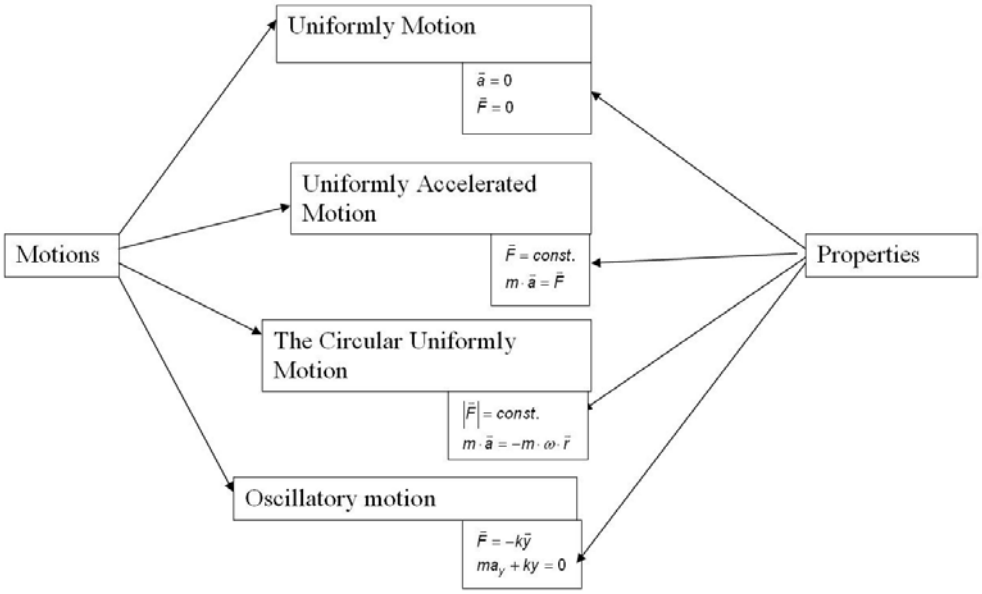

Fig. 1 – A concept map for types of movement.

A concept, as defined by Novak, is the regularity in objects or events designated by a specific label. Concept maps are diagrammatic representations which show meaningful relationships between concepts in the form of propositions. Propositions are two or more concept labels linked by words which provide information on relationships or describing connections between concepts. The most useful form of a concept map for teaching and learning is one arranged in

a hierarchical organization which the more general and more inclusive concepts at the top of the map and the more concrete and specific ones at the bottom [2].

The user creates statements in the visual language, and interacts with the statements through popup menus whose content is specific to each node type. The action initiated is context-sensitive and allows complex activities to be initiated by natural user actions. Node types and content may be edited by users, as may a database of information attached to the nodes that provides links to other concept maps and files, either locally or across the Internet.

They include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts.

In the teaching and learning of Physics (or any other science subject) concepts do not exist in isolation. Each concept depends on its relationships to many others for meaning.

As an example, if we refer for the Harmonic Oscillatory Motion, we can integrate this concept in a larger one: the motions, in general.

A concept map depicts hierarchy and relationships among concepts. It demands clarity of meaning and integration of crucial details. The concept map construction process requires one to think in multiple directions and to switch back and forth between different levels of abstraction. In attempting to identify the key and associated concepts of a particular topic or sub-topic, one will usually acquire a deeper understanding of the topic and clarification of any prior misconceptions. Concept mapping is a type of knowledge representation.

Jonassen & Grabowski state that structural knowledge may be seen as a separate type of knowledge. "Structural knowledge provides the conceptual basis for why. It describes how prior knowledge is interconnected. Structural knowledge is most often depicted in terms of some sort of concept map that visually describes the relationships between ideas in a knowledge domain". Representing knowledge in the visual format of a concept map allows one to gain an overview of a domain of knowledge. Because the nodes contain only a keyword or a short sentence, more interpretation is required of the reader, but this may be positive [3].

2. CONCEPT MAP FOR HARMONIC OSCILLATORY MOTION

Concept mapping can be used for several purposes:

- to design complex structures;
- to assess understanding or diagnose misunderstanding;
- to aid learning by explicitly integrating new and old knowledge;
- to communicate complex ideas.

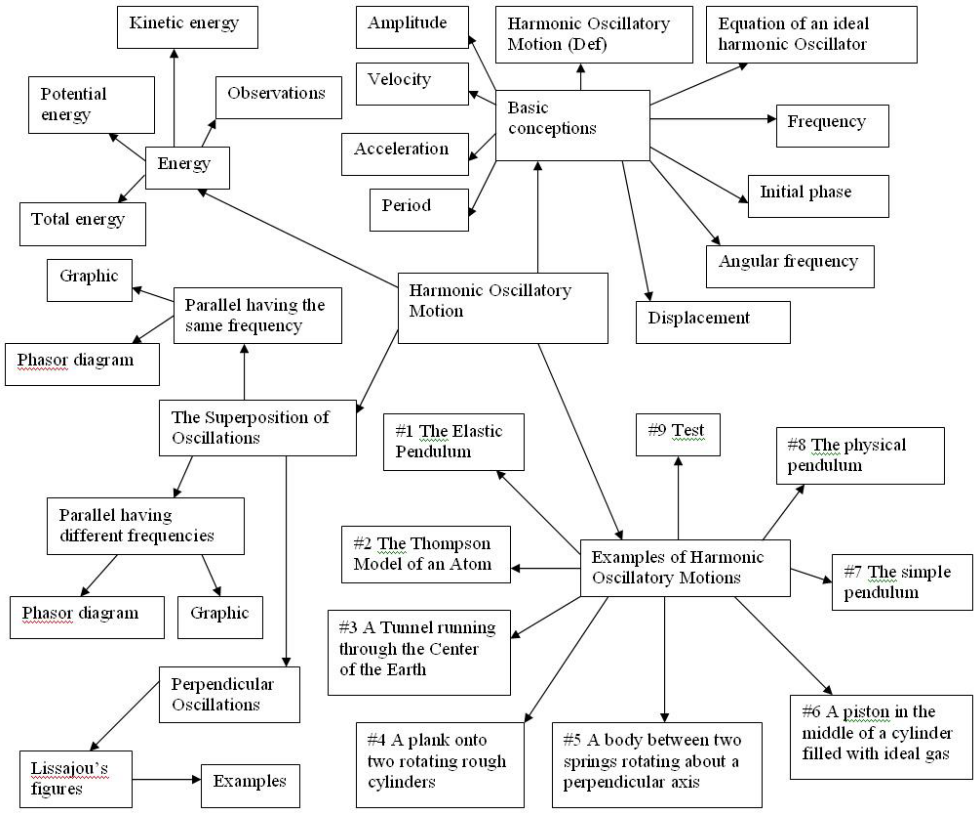

Fig. 2 – A concept map for harmonic oscillatory motion.

In order to show the way complex ideas can be communicated and to point out the advantages of using concept maps, we chose a type of concept map regarding mechanical oscillations. We chose this example because this is a very difficult physics topic and the concept maps method allows for a better understanding. This section of the classical physics is a very vast and a very intricate one, complex, and sometimes difficult to understand by the students [4]. It contains a multitude of connections and the cross-links helps the student to see how a concept in one domain of knowledge represented on the map is related to a concept in another domain shown on the map. In Fig. 2 it is shown the concept map we propose for the Harmonic Oscillatory Motion.

3. ADVANTAGES OF USING CONCEPT MAPS

The main advantage of this method is providing a powerful representation tool to show complex interrelations, respectively establishing a transparent link, between different concepts [5].

The advantages are:

1. *Teaching and revision topic*. As one can observe in Figure 3, difficult concepts can be clarified and can be arranged in a systematic order. Using this concept map in teaching Oscillatory Motion, teachers could be more aware of the key concepts and relationship among them. This helps teachers to convey a clear general picture of the topics and their relationships to their students. In this way, it is less likely to miss and misinterpret any important concepts. In this section of the map one can see how easy the student can compare the superposition of the oscillation and the different types of superposition.

2. *Reinforce understanding*. Using concept maps can reinforce students' understanding and learning more easily. This enables visualization of key concepts and summarizes their relationship (e.g., the most important notions involved in the Harmonic Oscillatory Motion), as shown in Fig. 4.

3. *Check learning and identify misconceptions*. The use of concept maps can also assist teachers in evaluating the process of teaching. They can assess the students' achievement by identifying misconceptions and missing concepts. Concept mapping is also gaining inroads as a tool for problem-solving in education. Concept mapping may be used to enhance the problem-solving phases of generating alternative solutions and options. Since problem-solving in education is usually done in small groups, learning should also benefit from the communication enhancing properties of concept mapping [5].

In Fig. 5 we present a number of oscillatory motion examples chosen in order to get a better phenomenon understanding.

4. *Assessment*. Students' achievement can be tested or examined by concept mapping, as the concept maps can also be used as assessment tools (see Fig. 6). The research team around Joseph Novak at Cornell found that an important by-product of concept mapping is its ability to detect or illustrate the "misconceptions" learners may have as explanations of content matter. The conceptions students may have are often incomplete and deficient, leading to misunderstanding of instruction. Concept maps drawn by students express their conceptions (or their misconceptions) and can help the instructor diagnose the misconceptions that make the instruction ineffective [6].

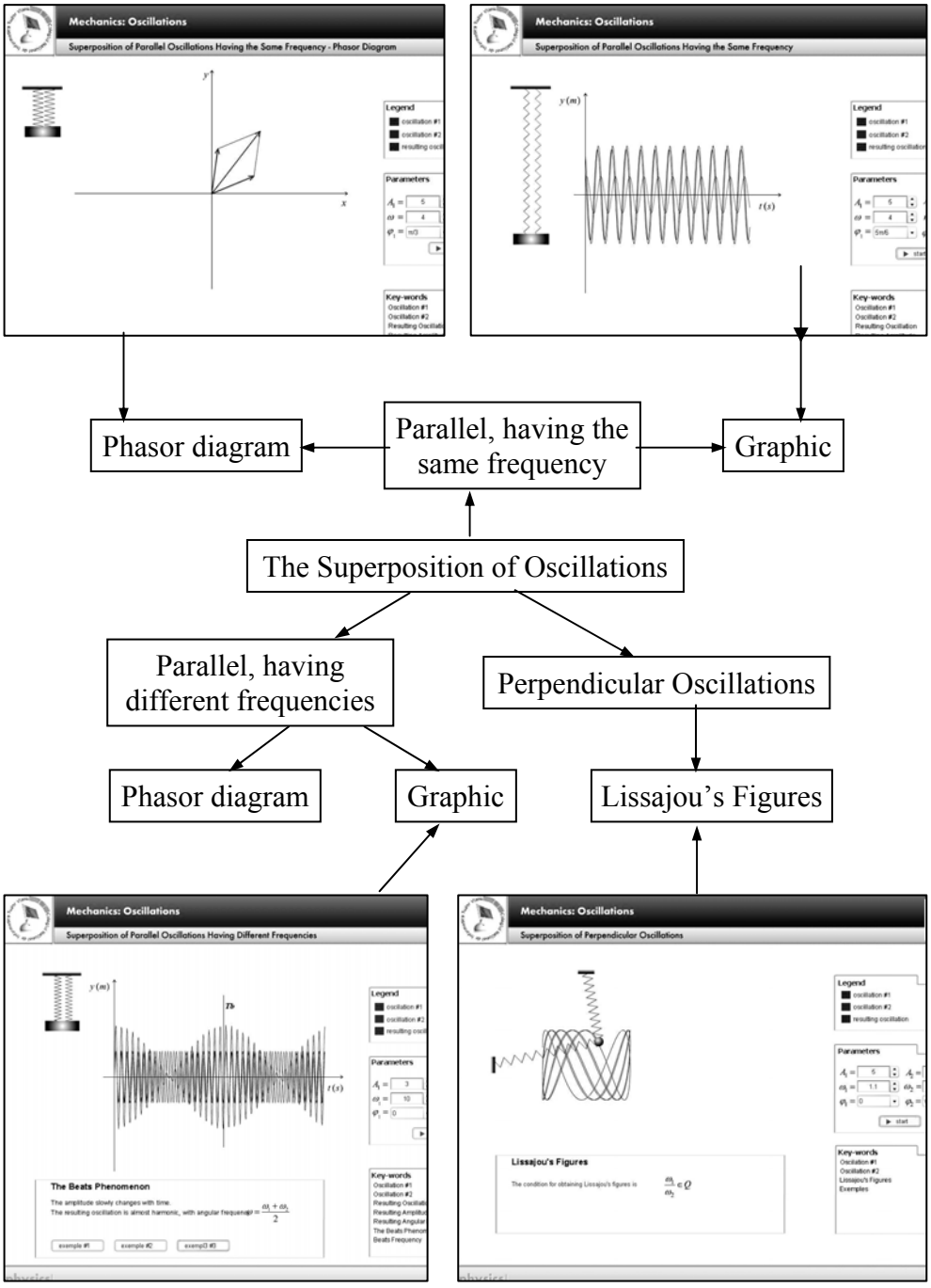

Fig. 3 – An example of difficult concepts clarified through a concept map.

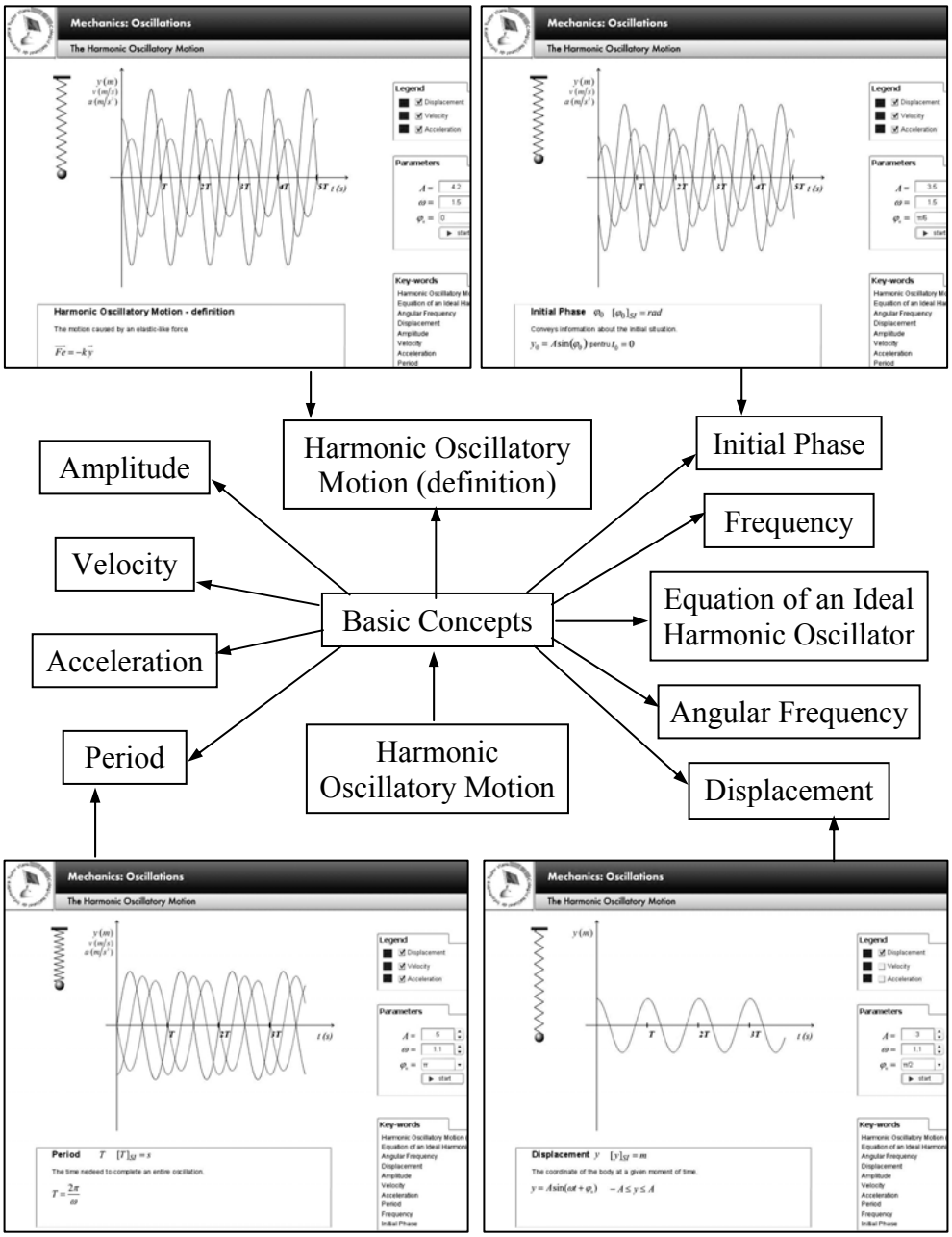

Fig. 4 – Key concepts visualization through a concept map.

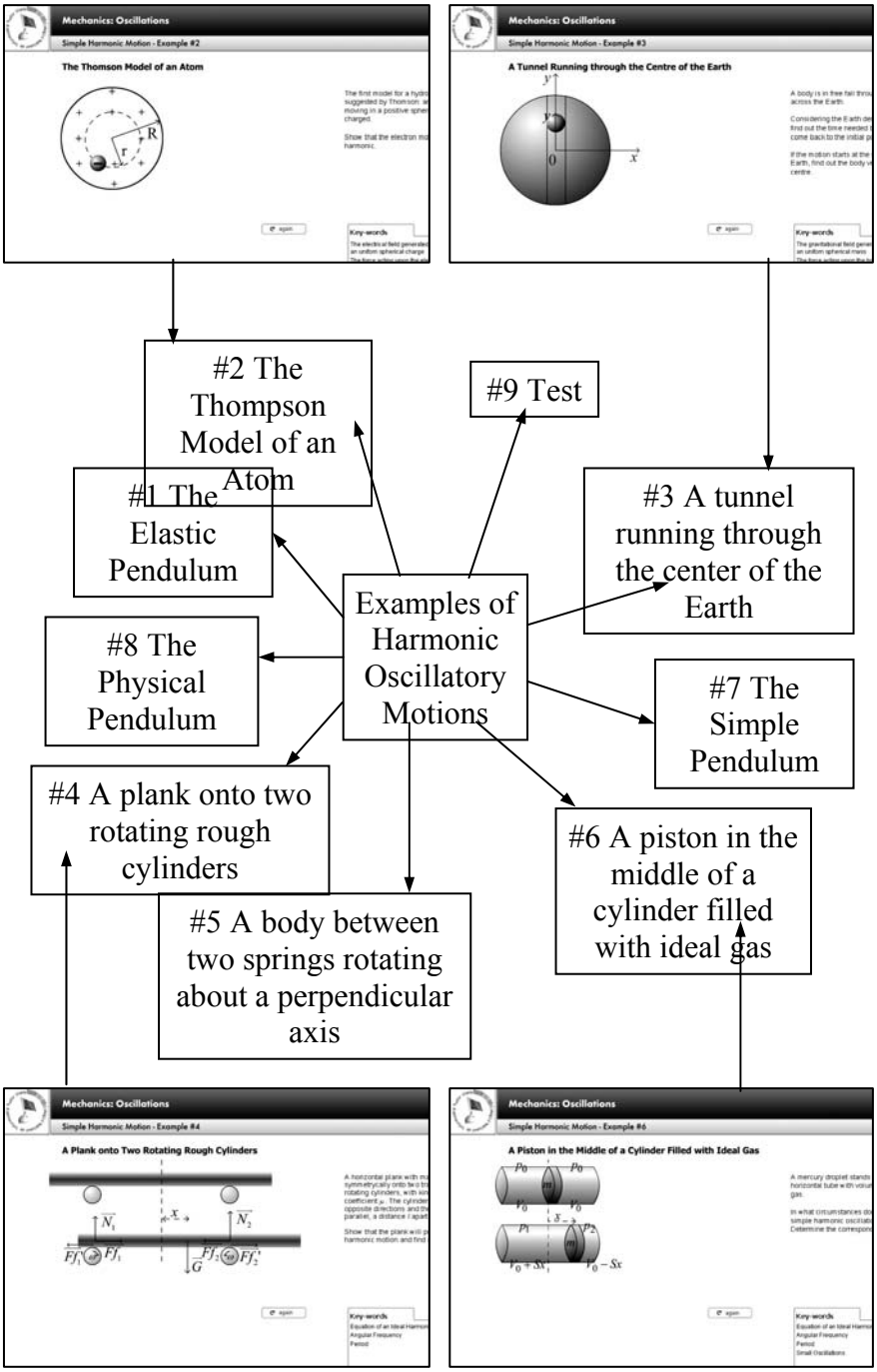

Fig. 5 – Examples of oscillatory motions chosen in order to get a better phenomenon understanding.

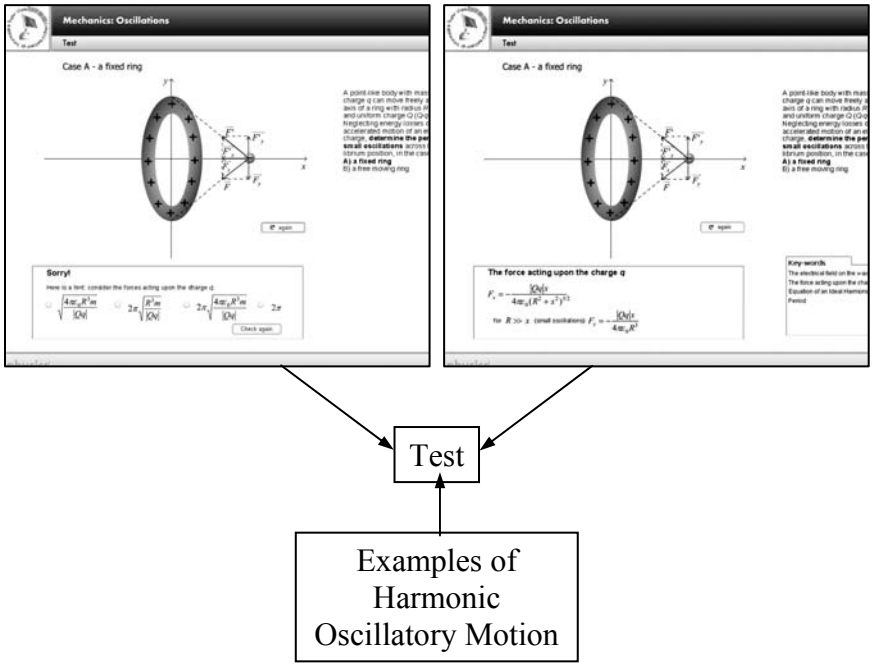

Fig. 6 – An example of assessment combining a concept map and an educational software.

4. CONCLUSIONS

Concept map can be integrated with other applications, and user interaction with graphical structures in the visual language can be used to control any activity supported on the host computer or network. Actions can include the opening of other concept maps, making it possible to index large bodies of material through layers of connected maps.

Drawing a concept map can be compared to participating in a brainstorming session. As one puts ideas down on paper without criticism, the ideas become clearer and the mind becomes free to receive new ideas. These new ideas may be linked to ideas already on the paper, and they may also trigger new associations leading to new ideas.

Concept maps can lead to other teaching and learning tools:

• concept card mapping tool [7]: Concept card mapping is a variation on the familiar strategy of concept mapping. Instead of constructing their own concept map from scratch, students are given cards with the concepts written on them. They move the cards around and arrange them as a connected web of knowledge. They create linkages between the concept cards that describe the relationship between concepts. Moving the cards provides an opportunity for students to explore and think about different linkages.

• hypertext design tool [8]: A concept map placed on the Web in hypertext may also serve as a Web navigational tool if there are clickable areas on the concept map that take the user immediately to indicated parts of the hypertext document [9].

• learning tool: Novak's original work with concept mapping dealt with learning. Constructivist learning theory argues that new knowledge should be integrated into existing structures in order to be remembered and receive meaning. Concept mapping stimulates this process by making it explicit and by requiring the learner to pay attention to the relationship between concepts. Jonassen, D. H. argues that students show some of their best thinking when they try to represent something graphically, and thinking is a necessary condition for learning [10]. Experiments have shown that subjects using concept mapping outperform non-concept mappers in longer term retention tests [11].

• multi-layered concept maps: Concept maps allow the researchers to identify new conceptions that are implicitly or explicitly expressed by the interviewees [5].

We strongly believe that the usage of concept maps is a must for the educational process, an addition to the classical methods, appealing to the individual character of each student.

REFERENCES

1. D. Ausubel, *Educational psychology: a cognitive view*, Holt, Rinehart, and Winston, New York, 1968.
2. J. D. Novak, D. B. Gowin, *Learning how to learn*, Cambridge University Press, New York, 1984.
3. D. H. Jonassen, B. L. Grabowski, *Handbook of individual differences: learning & instruction*, Lawrence Earlbaum Associates, Hillsdale, NJ, 433, 1993.
4. I. Stoica, *Mechanics: Oscillations*, Proceedings of the 1st International Conference on Hands on Science, Ljubljana, 2004, pp. 111–113.
5. C. Henderson, E. Yerushalmix, K. Heller, P. Heller, V. H. Kuo, *Multi-Layered Concept Maps for the Analysis of Complex Interview Data*, Roundtable Discussion presented at the Physics Education Research Conference August 7, 2003, Madison, WI, 2003.
6. B. Ross, H. Munby, *Concept mapping and misconceptions: a study of high-school students' understanding of acids and bases*, International Journal of Science Education, **13**, *1*, 11–24 (EJ 442 063), 1991.
7. P. D. Keeley, *Science formative assessment: 75 practical strategies for linking assessment, instruction and learning*, Corwin Press, Thousand Oaks, CA, **68**, 2008.
8. E. J. Conklin, *Hypertext: an introduction and survey*, Computer, **20**, *9*, 17–41, 1987.
9. R. A. Botafogo, E. Rivlin, B. Schneiderman, *Structural analysis of hypertexts: identifying hierarchies and useful metrics*, ACM Transactions on Information Systems, **10**, 142–180 (1992).
10. D. H. Jonassen, *Computers in the classroom: mindtools for critical thinking*, Merill/Prentice Hall, Eaglewoods, NJ, 1996.
11. J. D. Novak, D. B. Gowin, G. T. Johansen, *The use of concept mapping and knowledge vee mapping with junior high school science students*, Science Education, **67**, 625–645 (1983).