Implementation of an Interactive Concept Mapping Technique in an Engineering Course

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Abstract

Incorporation of proven principles of teaching and learning in engineering education can lead to development of alternate and, sometimes, more effective problem solving approaches. Concept mapping is an established teaching and problem solving technique that has potential to be used as a powerful tool in engineering education. Concept maps can be developed to create or illustrate structures, to communicate complex ideas in different ways and viewpoints, to aid learning by allowing one to see relationships, contradictions, and gaps in the material, and to encourage creativity and discovery. Several mechanical engineering courses such as thermodynamics, dynamics, and fluid mechanics can effectively use this technique to build the subject concepts and solve numerical problems in class. The present paper discusses and describes possible ways of using concept mapping in a thermodynamics course. Possibilities of developing a computer based system for interactive problem solving are also discussed. Some unique advantages of a computer based system include visualization of problem, extensive monitoring and evaluation of students' performance at each problem solving step, instant feedback and fair evaluation. Extensive data gathering on students' performance leading to better identification of each student's weak points will help in deciding the future orientation of the course at each step. The course selected for this purpose is a one-semester thermodynamics course taught at Southern University.

Introduction

Mechanical Engineering has several courses that require strong problem solving approach. Thermodynamics, dynamics, solid mechanics and fluid mechanics are

examples of some such courses. These courses require a combination of strong knowledge of mathematic, fundamental principles of the subject and ability to visualize the problem and its solution approach. Knowledge of mathematics and subject related principles can be acquired by theoretical study. However, visualization of problem and its solution route require a problem solving approach in the student. Proven concepts of learning and teaching emphasize primarily on two concepts. The first one is building a problem solving approach instead of relying on rote memory and the second one is interactive methods of problem solving. Among the techniques of problem solving concept mapping is a promising method that can be utilized in mechanical engineering courses. The possibility of using modern technology such as computers and software tools to make the problem solving process interactive can lead to effective way of mechanical engineering education.

In the present study a thermodynamics course taught at Southern University is taken up for study. A scheme of making the instructional scheme more interactive is proposed. The solution is cost effective and requires only some commonly used software tools. This scheme allows students to visualize and solve problems of thermodynamics in an interactive manner. Data on the students' performance at each step of the problem solving process can be collected and stored for evaluation. Such an approach allows identifying specific weak points of each student even in large classes.

Mindful Learning

Proven concepts of education that can lead to problem solving approach give emphasis on "meaningful" and "mindful" learning [1,2]. Mindful learning is associated with observations and analysis, which are integral part of problem solving approach. Memorization of concepts without in-depth knowledge leads of rote memory and lacks generalization of concepts. In engineering some governing equations are used as universal laws. However, in most cases modification of these equations is required to adapt for certain specified conditions for a given problem. These conditions may be different for different problems. Therefore, mere memorization of governing equations cannot lead to the solution of the problem. It needs to be learnt to modify governing equations based on the given conditions to reach the solution, which is mindful learning. Hence, mindfulness is required to develop problem solving approach in students.

Concept Maps

Concept Mapping is a technique of representing the information in a visual form. This technique was developed by Dr. Joseph Novak in 1960s [3]. Concept maps divide information into two parts, concepts and the relation between them. Concepts are represented as nodes and relations between various concepts are represented as lines connecting these nodes. Hence, the concept mapping presents information in the form of

a network graphically presenting flow of all possible variables and demonstrating relationships between them.

Several variants of concept maps have evolved over the years [4]. These maps are based on the same basic principle of graphically presenting the information by means of some concepts and connections but differ in graphical representation. With the aid of modern computer based tools, it has become possible to develop concept mapping technique into an interactive learning and problem solving method.

Application of Concept Mapping in Thermodynamics

Thermodynamics is taught at sophomore and junior level in mechanical engineering. Principles of thermodynamics are used in several other courses as heat and mass transfer, internal combustion engines and fluid dynamics. Few governing equations form the foundation of this subject. However, there are large number of variations of these equations that are used to solve different problems.

Interactive Scheme for Problem Solving

Concept mapping based problem solving scheme can be made interactive by the use of various software tools. In most cases the solution steps in thermodynamic problems are similar to any other engineering problem. Figure 1(a) shows a generalized solution scheme of any engineering problem. Figure 1(b) gives an example of a simple thermodynamic problem based on Gas Law.

Using software tools the simple scheme presented in Figure 1 can be developed for interactive solution of thermodynamic problems. At each step values provided by the student can be compared to the values stored in the solution manual in the software. Wrong choices will ask the student to make the selection or provide the input once again. Such feedback based solution process can be continued till the student reaches the correct solution of the problem. Use of concept maps can make it possible to present the information in graphical format for better visualization. A generalized concept map can be developed for thermodynamics that can be used as the starting point for all problems. One such map may be a pie chart where each slice of the pie represents a different phase, which a student can select in order to start his solution process. The subsequent steps will lead to name and values of variables and constants.

Figure 2 shows organizational map for outlining the solution scheme for thermodynamic problems. Based on this scheme a simple software is developed using Microsoft-Power Point™ software. Some of the advanced functionalities such as Visual Basic scripts and Active X controls have enabled to make an interactive problem solving software. Figure 3 and Figure 4 show screen shots of the step of a problem solving process.

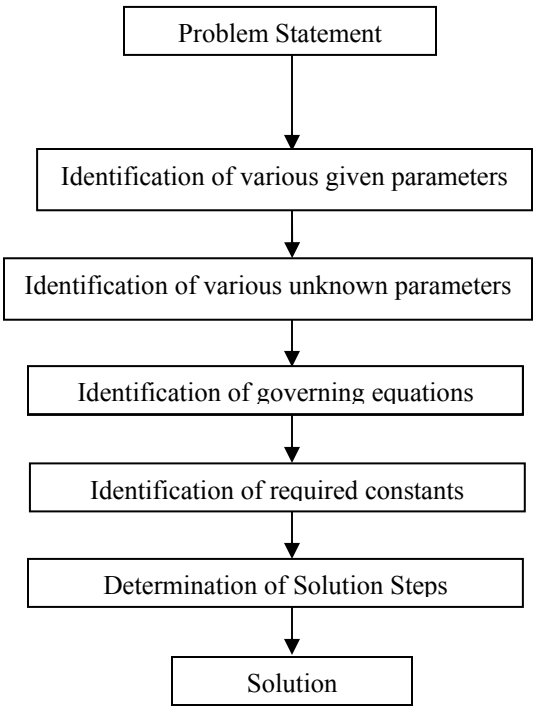

Figure 1(a) generalized solution scheme of any engineering problem.

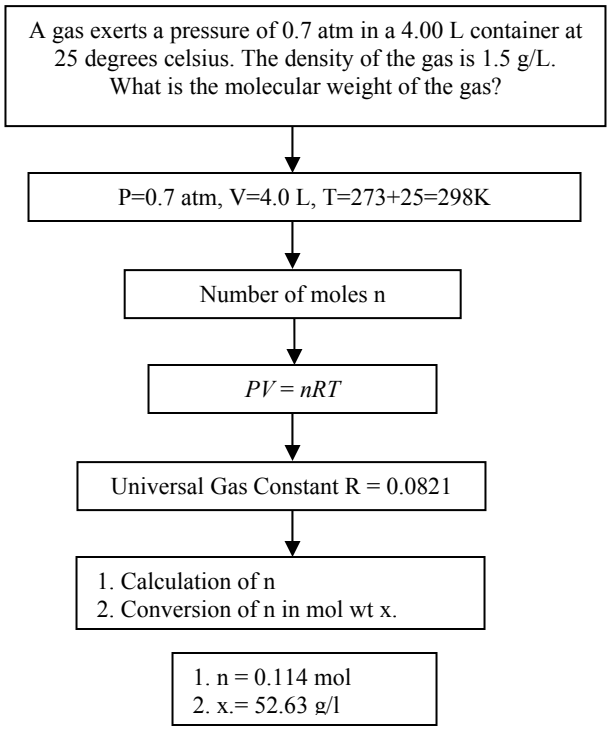

Figure 1(b) Example of a thermodynamics problem according to the solution scheme outlined in Figure 1a.

In Figure 3 a wrong choice of pie slice has prompted the student to reselect the correct solution. In figure 4 the correct choice made by the student confirms validity of his solution step and makes him move to the next step. Such feedback controlled process enables interactive nature of the solution process.

Functionality of the software can be enhanced if the state-of-the-art hardware and softwares are available. Java script and Java applets can be used to develop graphic versions of the problem to walk the student through the problem and the solution. However, the present software shown in this work is inexpensive and compatible with personal computers commonly used by students or universities.

Evaluation Method

One of the main advantages of concept mapping based interactive solution approach is the automatic comprehensive feedback on each student's performance. The software can be made to keep track of all choices made by the student. Hence, performance data for

each solution step can be collected for every student. This will allow the instructor to pay special attention each student's weaknesses. Such an approach makes it possible to evaluate each solution step of each student even in classes with large enrollment. The automatic evaluation eliminates all kinds of possible inconsistencies or bias in the grading process and instantly provides grades to students.

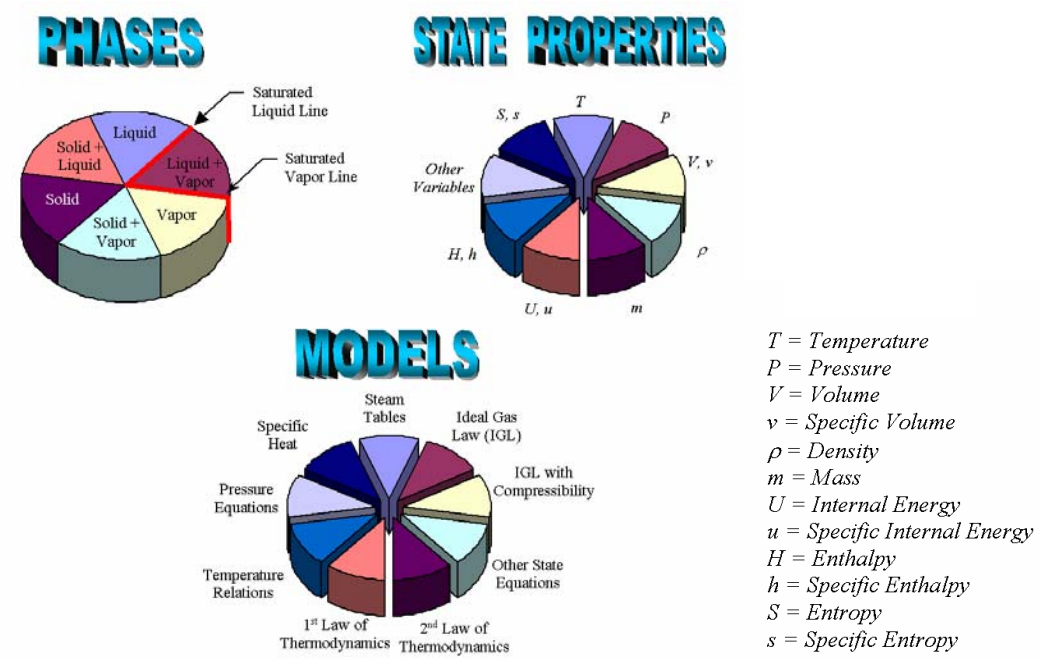

Figure 2 Organizational map for fundamental thermodynamic topics.

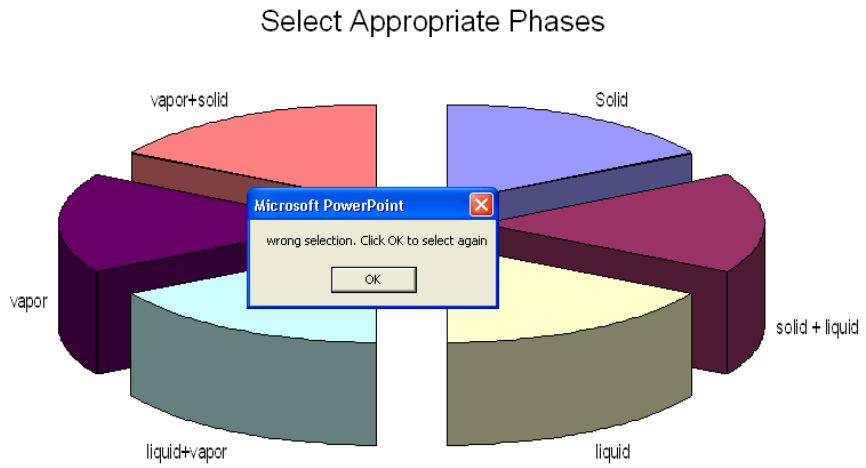

Figure 3 Wrong selection in the solution step prompts the student to select again.

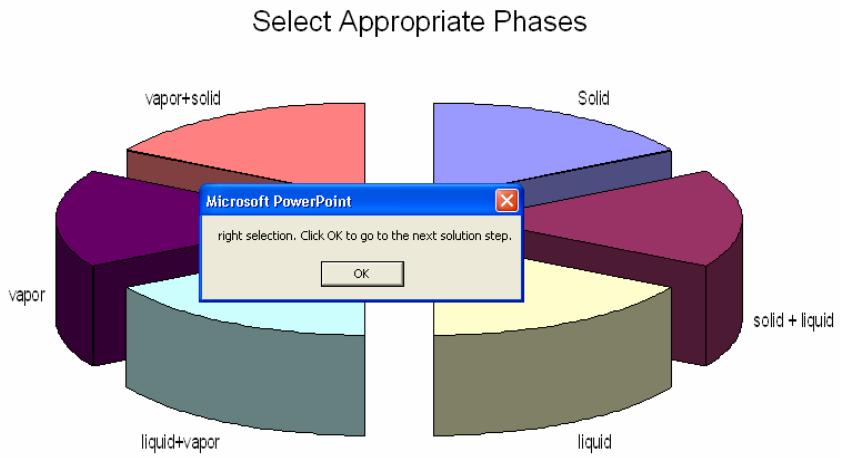

Figure 4 Correct selection in the solutions step lets the student proceed with the solution.

Summary

Concept mapping based interactive learning scheme is outlined in the present paper. A simple software tool is used to demonstrate solution scheme for a model thermodynamic problem. Such solution process is helpful in promoting mindful learning and developing problem solving ability in mechanical engineering students.

References

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