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# CONCEPT MAPPING APPLIED TO DESIGN

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**Abstract**-This paper covers an overview of the uses of concept mapping in a senior design course at Vanderbilt University. Concept maps have been used as a semi-quantitative measurement tool for evaluation of student understanding of the information content and interrelationships at three different points during a year long course. These maps may be compared with those generated by graduate students and the course instructor. Concept maps have also been used to assist students in the generation of contradiction maps for project design solution search methods. Concept maps are also being used to introduce chapter topics to classes, using an overview map to introduce the topic and a complete map at the end of the chapter to completely describe the contents and concepts of a given chapter. The effects of this mode of introduction and summarizing will be the topic of several years of classroom investigation.

**Keywords** - Concept maps, evaluation, objectives, design alternatives, design

## I. INTRODUCTION

Concept maps were first reported in the literature in the 1970s<sup>1</sup>, their primary use has been to assist in the elucidation of the relationship between concepts in situations under study. A concept map consists of a series of boxes containing labels (concepts), arrows connecting boxes assist in explaining the perceived interrelationship between concepts, an arrowhead denotes the direction of the relationship. A single arrow may have multiple connections (one to many) in order to denote options. Complete paths may be generated in a completed concept map (denoting a feedback system, for example) or the map may appear to be more of a flowchart, dependent on the knowledge being mapped. Figure 1, below, shows the elements of concept

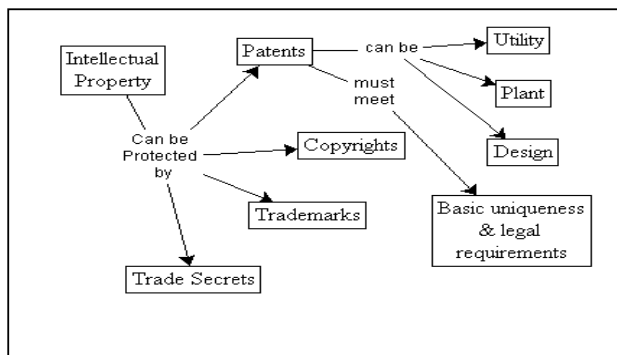


Figure 1: Elementary Concept Map For Intellectual Property

maps as applied to intellectual property. The linking terms “can be”, “should be”, and “must meet” give the essence of the interrelationships between the concepts.

## II. METHODOLOGY

Two groups of two students each in the 2001-2002 senior biomedical engineering design course were asked to generate concept maps regarding their understanding of the process of design. These requests were fulfilled at one and three months into the course lecture sequence. (A final mapping will be requested at the end of the design project completion period in April, 2002.) Two graduate students who had previously taken the same course (one and two years prior) were also asked to accomplish the same mapping task. The undergraduate maps were scored by instructor King for completeness and interconnectivity, the graduate maps were subjectively analyzed.

Instructor King also generated, using a course objectives listing and the course outline for the semester, a “gold standard” concept map for the course in order to have a statistic relating to this particular course.

The generation of a problem formulation diagram for use in a design package (Innovation Workbench, Ideation International, Detroit MI) has been a difficult point for several students in this course. The problem formulation process involves interrelating portions of a design problem with the linking verbs “produces”, “is produced by”, and “counteracts”, the design concepts are designated as “useful” or “harmful” effects. Students were encouraged to use the concept mapping techniques to develop an intermediate step in this design process.

Two students were asked to investigate the concept mapping further and were requested to investigate the use of concept mapping in textbook chapter summarization. Further, they were asked to consider the use of concept maps in instruction.

## III. RESULTS

The two student groups initial maps averaged 20 concepts per map at the initial evaluation stage, this rose to 28 at the end of lecture sample. The number of interconnections rose from 22 to 32 at the end of the term. The valid link score rose from an average of 1.5 to 2.6 (where 3 is perfect. 0 is wrong) as judged by the instructor. The subjective evaluation of the graduate student maps was that they tended to be more generic in nature (overall concepts of design) rather than explicit with respect to “just covered” lecture material<sup>2</sup>.

The instructor course concept map contained 74 concepts and 85 interconnects.

Student concept maps were generated for one senior project that had begun with too simplistic an initial problem formulation. This diagram was used to regenerate the problem formulation and the diagram was independently judged by a

specialist in the innovation workbench approach. The new[2] J. M. T. Walker, P. H. King, "Concept Mapping as a diagram was judged much improved. Form of Student Assessment and Instruction", to be published 2002 Proceeding of the ASEE.

Concept maps were generated for two chapters in a forthcoming design textbook. These chapters were then evaluated by the author and were found to be very comprehensive in structure, especially as might have been generated from recall after a lecture on the subject.

#### IV. DISCUSSION

The undergraduate maps showed a definite increase in the number of concepts and interconnects as the semester continued. The validity of the links and the overall structure of the maps (complexity and interrelationships) was judged to have increased as the term progressed. The inference here is that the use of concept maps may thus be used as a measure of overall understanding of the course material and a measure of the interconnectivity of the concepts covered.

In fact, in a post second map interview, both groups noticed the increase in complexity and comprehension of material when asked to compare drawings one and two.

The fact that the graduate students maps tended to become more general in nature is not unexpected, as it was felt that being one to two years out of the lecture mode for this endeavor would result in a generalization of the topic material.

That the instructor map was so comprehensive, and allowed for enough interconnects to reflect the iterative nature of design, is to be expected.

The use of concept maps to help structure the statement of design conflicts appeared to be useful for the one group that completed this task.

Students, when asked to do so, generated comprehensive concept maps of assigned chapters, as judged by the author. The use of these concept maps in teaching the chapter material looks to be an interesting approach to giving a good overview of material to be covered.

#### V. CONCLUSION

The use of concept maps in the evaluation of student understanding, in the structuring of problem solutions, and in the generation of material to summarize and more effectively teach design material will continue to be pursued by this group. Specific lectures involving the use of concept maps will be a part of the course sequence next year and this use will be part of the specific course evaluation package.

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