Probing Nature of Links Amongst Physics Concepts

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Introduction

Novakian (Novak, 1998) concept maps represent meaningful relationships between concepts in the form of propositions. According to the D.P.Asubel's assimilation theory of learning, the cognitive structure of a student is organized hierarchically. Links between concepts are semantic relations. Our focus, in this paper is on classification of links amongst concepts in physics. Researchers have noted that knowledge acquisition is not just an accumulation of concepts but also comprehension of interrelation of these concepts (Mohapatra, 1995).

Methodology

We selected a group of 30 students studying physics in the B.Sc.program at the University of Mumbai. They had studied electrostatics during the earlier semester. We selected five core concepts in the area of Electrostatics, namely, Capacitors, Dielectrics, Charge distribution, Electric dipole and Conductors. Each of these concepts was presented to the students as a central concept. The students were asked to list in a given time, concepts related to the central concept.

We then prepared a grand concept map with the five core concepts listed above and 109 concepts generated by students. Their links and cross-links were carefully established. In this case, concepts are nouns or noun-phrases, whereas links between them are verbs or prepositions. The grand concept map showed clusters of concepts around nodes. These nodes included the five central concepts. Out of the five nodes 'capacitors' and 'Charge distribution' are prominent. This procedure of establishing links between the concepts is explained below.

Consider two concept labels "Capacitors" and "Direct Current"(dc). We have linked these two concepts by completing the following sentence:

Capacitor **blocks** *dc.*

In this case the verb '**blocks**' connects the two concepts, *capacitor* and *dc*. The link words are shown in bold type and the concept words are in italics.

Let us consider some more examples.

Capacitor **may have** *vacuum* **between** (its) *plates.*

Charges **can be** *like charges* and *unlike charges.*

Electric field **has** *direction.*

Having established the grand concept map with its links, we wished to probe further the nature of the links and to check whether particular types of links are more common in this map. We arrived at the types of possible links after consulting the literature.

Literature Survey

Nastase and Szpakowicz have given 44 types of semantic relations amongst noun and noun-modifiers (Nastase, 2003). Similarly, Sowa (Sowa, 1984) has listed 37 different types of semantic relations between concepts. Winston et al (Winston, 1987) have given taxonomy of part-whole relations. They have indicated six types of meronymic (part-whole) relations. Veda Storey (Storey, 1993) has identified seven types of semantic relations. One of the types, 'inclusion' consists of three subtypes class, meronymic and spatial. Their meronymic subtypes consists of seven subtypes, one more than those listed by Winston. Researchers (Rosario 2004) have examined the problem of distinguishing among seven relation types that occur between "treatment" and "disease". Rajwade et al (2001) have proposed a mechanism of quantifying the linkage of two concepts through a link number. In another paper the same authors (2003) have used this link number to develop a method for improving subject knowledge of students.

Sr. No	Class of relation	Example
1.	Causality	*Thermal energy* **disaligns** *electric dipoles.*
2.	Rate(Time)	*Charge flow* **per unit time** (is) *current.*
3.	Rate(Space)	*Current* **per unit area** (is) *current density.*
4.	Location	*Potential difference* **across** (its) *plates.*
5.	Arrangement	*Components* (can be) **arranged** (in) *series.*
6.	Source	*Charges* **come from** *battery.*
7.	Agent	*Capacitor* **blocks** *dc.*
8.	Measured by (Instrument)	*Potential difference* (is) **measured by** *voltmeter.*
9.	Measured in(Units)	*Potential difference* (is) **measured in** *volts.*
10.	Inclusion (class)	*Positive charges* **e.g.** *holes, electrons.* *Plates* **are** *conductors.*
11.	Inclusion (Member /collection)	*Charges* **make up** *charge distribution.*
12.	Inclusion (Component /Object)	*Capacitor* **may have** *dielectric.*
13.	Characteristics	*Like charges* **exert** *repulsive forces.*
14.	Attribute.	*AC* **has** *frequency.*
15.	Analogy	*Electric flux* ◄► *Magnetic flux.*
16.	Function	*Charge density* **depends** (on) *charge distribution.*
17.	Representation	*Electric field* (is) **represented by** *Electric field lines.*
18.	Name	*Charge loss* **is** *charge leakage.*
19.	Synonym	*Insulators* ◄► *Non-conducting medium.*
20.	Antonym	*Conductance* ◄► *Resistance.*

Discussion of results

We have used the grand concept map to identify similar relations in physics. We looked at the kind of linking words used in connecting any two concepts in the map. A thorough survey of the map suggested 20 different semantic relations amongst the concepts used. These relations have been listed in the included table

The frequencies of occurrence of these relations in a grand concept map diagram will be given in the paper.

Conclusions and Future work

The set of relations listed above forms, by and large a subset of the relations found in the literature. It must be noted that many relations quoted in the literature are not found here. Instead, some additional ones have been included to account for the nature of the subject, physics.

For example, "rate" (with respect to time and space both) is a frequently occurring type of relation in physics and is not mentioned explicitly in the literature. Similarly, measurement being a special aspect of physics "measured in (units) "is a relation peculiar to physics. Also, "measured by" has been included separately, though it is a particular case of the relation "agent" found in literature. This is because of the importance of measuring instruments in physics. Also, "arrangement" of components of an object is important in the present context. Also, the idea of "analogy" is often used in physical sciences. Further "Function" and "representation' are two other relations which we believe will be special to physics, mathematics and needs to be included.

The limitation of this study is that it covers only one topic in physics. Further investigation, with different set of central concepts may confirm the above list. Such a study may throw up few additional relations as well. Also, frequency of these relations amongst physics concepts requires more detailed study.

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