EUROPEAN JOURNAL OF EDUCATIONAL RESEARCH Vol. 1, No. 1, 55-64

Concept Maps: An Instructional Tool to Facilitate Meaningful Learning

Muhammad Safdar[1], Azhar Hussain[2], Iqbal Shah[3], Qudsia Rifat[3]

[1]*Federal Directorate of Education, Islamabad, Pakistan.*
[2]*Govt. Islamia College Civil Line, Lahore, Pakistan.*
[3]*Department of Science Education, AIOU, Islamabad, Pakistan.*

This paper describes the procedure of developing an instructional tool, 'concept mapping' and its effectiveness in making the material meaningful to the students. In Pakistan, the traditional way of teaching science subjects at all levels at school relies heavily on memorization. The up-to-date data obtained from qualitative and quantitative research strongly supports the value of concept mapping as an instructional tool both for cognitive and affective gains. This study seeks to contribute to this development by considering how the insights of Ausubel can be converted into an effective and efficient instructional method. It was found that concept maps help improving achievement of the students and make learning more meaningful so that retrieval is possible.

Most of the studies on students' learning suggest that students bring their own conceptions of science to explaining the natural world (Driver, 1983; Osborne, 1986). The information processing view divides learning into three phases: (i) attending to new information (ii) acquiring and retaining information, and (iii) retrieving information from memory and transferring it to new situation. The way that information is processed in learning has been summarized in the model presented by Johnstone (1993). It represents the flow of the information through the memory system and the processing of such information. Such a model makes predictions about how input information is dealt within the human mind so that meaningful learning can take place.

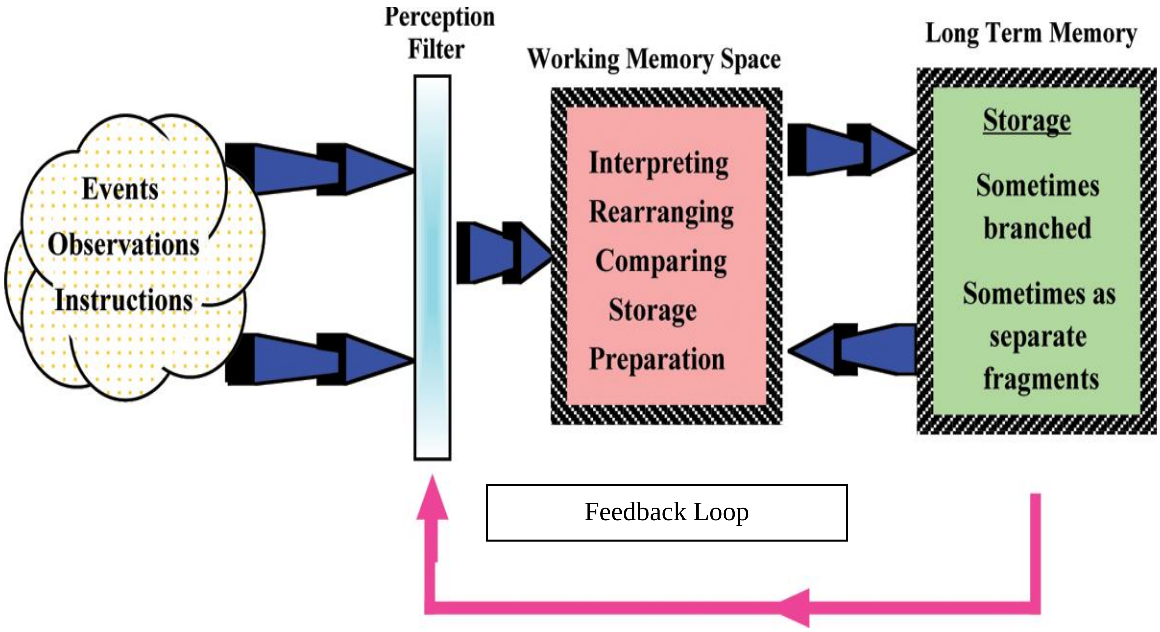
In Figure 1, the learner is seen to view new events, observations and instructions through a perception filter, which is influenced by what is already stored in the long-term memory. In this way, the learner selects and interprets new information in terms of what he/she already knows. The diagram also represents that previous knowledge affects new knowledge. It includes the ideas of Ausubel. Ausubel (1968) argues that: the most important single factor influencing learning is what the learner already knows. The use of concept maps stems from the information processing theory of learning. According to this theory, knowledge is organized in a propositional network. Each individual's network is unique due to each person's unique experiences. The propositional network is not stable; as new information is learned, the network changes and more linkages are formed between concepts. Rote learning occurs when a student simply memorizes information with no attempt or motivation to relate that information to prior knowledge. Therefore, the rote learner will have a less extensive network than the meaningful learner and less retrieval paths between knowledge concepts.

Safdar (2010) quotes from Ausubel, that meaningful learning takes place when new knowledge is linked to what a student already knows. Hence, before planning classroom instruction, it is important to identify in advance ways to relate new knowledge to some broad concept or generalization already familiar to a student. This gives rise to the term advance organizer. Gupta (1995), describes that advance organizers can assume many forms: (a) structure of a discipline (can be used to relate parts to the

ISSN 2165-8714

http://www.akademikplus.com/eujer/index.html

whole) (b) a question (c) a diagram. Ausubl believes that information /scientific concept is learned more easily if it is organized and sequenced logically.



Source: Johnstone, A. H. (1993, p.702).

Figure 1. Information Processing Model of Johnstone

Ausubel's theory (some time called expository teaching/deductive teaching) consists of three principles: (1) Concepts are meaningful only when the student can visualize them (i.e. it elicits an image in the "content of one's consciousness) and subsume them within a cognitive structure. (2) Always proceed from the most generic concepts to the most specific one. (3) Students' readiness; which include their current knowledge, stage of cognitive development, and predominant mode of intellectual functioning. This study was conducted to construct the concept maps and to find out is there any significance difference between the achievement of the students through meaningful learning and rote learning.

A concept is something conceived in the mind: a principal, an idea, a general or abstract thought, or notion. According to Ebenezer and Conner (1998), "concepts are an invention of the human mind, ways of organizing the world. Novak (1991) defined that a concept is a perceived regularity in events and objects, or records of events or objects, designed by a label. In the view of Pines (1985), the concepts are the "furniture of the conscious mind".

According to Collette and Chiappetta (1989), "concept learning is an active process that is fundamental to understanding science concepts, principles, rules, hypotheses, and theories. Bruner, Goodnow, and Austin (1956), in Collette and Chiappetta (1989) state that a concept has five important elements: (1) name, (2) definition, (3) attributes, (4) values, and (5) examples. They believe that all these elements are necessary for understanding concepts and that these elements can be the focus of instruction for concept attainment.

Concept Mapping

Ebenezer and Conner (1998), state that a concept map is a schematic device for representing a set of interrelated, interconnected conceptual meaning. They further go on to say that it is a semantic network showing the relationships among concepts in a hierarchical fashion. Concepts and ideas are linked with phrases that illustrate the relationships among them. The conceptual (theoretical) foundation of concept mapping is Ausubel's theory of learning, which tells us that meaningful learning depends on integrating new information in a cognitive structure laid down during previous learning.

Novak and Gowin (1984) have developed a theory of instruction that is based on Ausubel's meaningful learning principles that incorporates "concept maps" to represent meaningful relationships between concepts and preposition. According to them "a cognitive map is a kind of visual road map showing some of the pathways we may take to connect meanings of concepts." Nowak, (1991) states that concept maps serve to clarify links between new and old knowledge and force the learner to externalize those links.

Concept maps are useful tools to help students learn about their knowledge structure and the process of knowledge construction. In this way, concept maps also help the student learn, how to learn (meta-learning). Concept mapping requires the learner to operate at all six levels; knowledge, comprehension, application, analysis, evaluation, and creation (synthesis) of Bloom's educational objectives of cognitive domain. According to Nowak and Gowan, (1984) "concept maps can make clear to the student (and the instructor for curriculum development purposes) how small the number of truly important concepts they have to learn." they further say that concept maps externalize a person's knowledge structure and can serve to point out any conceptual misconceptions, the person may have concerning the knowledge structure. This explicit evaluation of knowledge and subsequent recognition of misconceptions allows for finely targeted remediation. Since concept maps are visual images therefore they tend to be more easily remembered than text.

Lambiotte and Dansereau (1991), state that the students that viewed or made concept maps would have a broader knowledge base and therefore be more able to solve problems compared to those students that learned by rote memorization. They also found that the students with low prior knowledge learned better with concept mapping than the other. Science teacher can use concept maps to determine the nature of students' existing ideas, and make evident the key concepts to be learned and suggest linkages between the new information to be learned and what the student already knows. Cognitive structure and concept mapping are highly personal as each individual's knowledge is unique. Hence, concept maps are idiosyncratic. There is no one "correct" concept map. However, this does not mean that all concept maps are correct: it is possible to identify errors, such as the absence of essential concepts or inappropriate relationship between concepts.

Concept Mapping For Teachers

In the view of Safdar (2010), "If teachers learn how to construct concept maps and use them for planning and assessing lessons, they will be able to teach students better how to make concept maps to organize their thoughts and ideas." He further goes on to say that concept mapping is probably done better first in groups so that pre-service teachers can interact with each other. Group members can then compare and debate the construction of their concept maps and subsequently compare their maps with those of other groups. Finally, individuals should construct and present their own concepts map for a science lesson.

Ebenezer and Connor (1998), produced a list to construct a concept map;

- ✓ Choose a passage from a science textbook.
- ✓ Circle or underline the main concepts in this passage.
- ✓ List all the concepts on paper.
- ✓ Write or print the concepts on small cards or stickers so that the concepts can be moved around. If you prefer to use a computer-based semantic network, use SemNet, Learning Tool, Text Vision, CMap, or Inspiration software (Jonassen, 1996).
- ✓ Place the most general or all-inclusive concept on the top of the paper.
- ✓ Arrange the concepts from top to bottom (from most general at the top to most specific at the bottom) so that a hierarchy is indicated. In constructing this hierarchy, place concepts next to each other horizontally if they are considered to have equal importance or value.
- ✓ Relate concepts by positioning linking verbs and connecting words on directional arrows. Support the concepts with examples.
- ✓ Have members of a cooperative group critically analyze the concept map to improve on and further extend your ideas.

Purposes of Concept Maps

Concept maps can be used for; (1) knowledge construction: how students construct their knowledge (2) learning (3) evaluation (to evaluate how students organize their knowledge) (4) assessment: used as a pre-post assessment of what students have learned (5) record of understanding (6) problem solving (7) application (8) integration (9) and Instruction.

Ausubelian Teaching Method (Meaningful Learning)

In Ausubel's (1960), view, to learn meaningfully, students must relate new knowledge (concepts, proposition, rule, principles) to what they already know. He proposes the notion of an advance organizer as a way to help students link their ideas with new material or concepts. Ausubel's theory claims that new concepts to be learned can be incorporated into more inclusive concepts or ideas. These more inclusive concepts or ideas are advance organizers. Advance organizers can be verbal phrases, a graphic, a model, or a question. In any case, the advance organizer is designed to provide, what cognitive psychologists called "mental scaffolding" to learn new information.

Advance organizers are concepts given to students prior to the material actually to be learned to provide a stable cognitive structure in which the new learning can be subsumed. These organizers are introduced in advance of learning itself, and are also presented at a higher level of abstraction, generality, and inclusiveness. Ausubel (1960) emphasizes that advance organizers are different from overviews and summaries which simply emphasize key ideas and are presented at the same level of abstraction and generality as the rest of the material. Advance organizers serve three purposes: (1) They direct attention to what is important in the coming material; (2) They highlight relationships among ideas that will be presented; (3) They remind the students of relevant information already in memory.

After presenting an advance organizer, the next step in Meaningful Learning is to present content in terms of basic similarities and differences by using specific examples. To learn new material, students must comprehend the similarities between the material presented and what they already know. They must also see the differences so that confusion can be avoided. Along with the comparisons, specific examples must come into play. The best way to point out similarities and differences is with examples.

A lecture has three parts: the introduction, the body, and the conclusion. It is during the introduction that Ausubel's theory is most useful. According to Johnson (1979), the teacher, during the introduction, should want to: (1) Arouse student interest by indicating the relevance of the lecture to the goals, and to build bridges from the material to be presented to the interest of the students.(2) Provide motivation cues, such as telling students that the material to be covered is important and difficult and will be included in the test.(3) Make the objectives of the lecture clear and explicit.(4) Use advance organizers by telling students in advance about how the lecture is organized. Announce the topic, summarise the major points to be made in the lecture, and define the terms they might not know. Give them a cognitive structure to fit the material being presented into. This will improve their comprehension of the material, make it meaningful to them, and improve their ability to recall and apply what they hear. (5) Prompt awareness of students' relevant knowledge by asking question and by using short discussions about knowledge or experience related to the topic. Give and ask for examples. Ask questions to show how the students' prior knowledge relates to the material covered in the lecture. Explicitly relate students' prior knowledge to the topic of the lecture."

Safdar (2010) quotes the statement of Ausubel (1960) that if someone asks me to define the whole educational psychology in one sentence, "I would like to say what the learner already knows." The main elements of Ausubel's teaching method are shown below in the table.

Table 1. Ausubel's Model of Meaningful Learning

Phase One Advance Organizer	**Phase Two** Presentation of Leaing Task or Material	**Phase Three** Strengthening Cognitive Organization
Clarify aim of the lesson	Make the organization of the new material explicit.	Relate new information to advance organizer.
Present the lesson	Make logical order of learning material explicit.	Promote active reception learning.
Relate organizer to students' prior knowledge	Present material in terms of basic similarities and differences by using examples, and engage students in meaningful learning activities	

Objectives of the Study

The present study aimed:

- ✓ development of concept maps for the three units of the physics text book for 9th classes, published by Punjab Text Book Board Lahore (Pakistan),
- ✓ to make the concepts more meaningful to the learners in the science classroom by using constructivist and traditional approach.

Hypothesis of the Study

There is no significant difference between the achievement scores of the students in the subject of Physics taught through constructivist and traditional teaching method.

Methodology and Procedure

To represent meaningful relationships between concepts, the researcher identified the key concepts in the three chapters of the physics book, ranked them, and prepared a network of concepts (concept maps) of each unit .The mega concept (general concept) was placed at the top and included less general concepts, and then more specific, to make the concepts progressively differentiated by their level of specificity. Every chapter was started with mega concept and then the specific concepts were taught by keeping in view the logical and psychological relationship between the concepts as presented in the concept maps, shown in the appendix-A.

The more meaningful connections a person can show in the map, the better he will understand the material. The process of mapping a map and the final product are dependent on prior knowledge, context, and constructed understanding. Keeping in view the content, the researcher used the following procedure to construct the concept map for both units.The researcher analyzed the content, identified the important terms / concepts that he wanted to include on the map and then arranged the concept in a pattern that best represents the information. After then the important terms and concepts are enclosed with circles/ovals/rectangles. (Each circle or rectangle enclosed only one term or concept)

Each concept is connected by using straight line with arrows (single or double-headed). Each line linked only two concepts. However, there was not limit to the number of links stemming from any one term. Each concept was defined by its relation to other concepts within the topic. Relations include: part-whole, superset, subset, attribute, etc. the researcher then designated the relationship by using a word or phrase as labels along the line between two connected terms where necessary.

Study Groups

There were 4 sections (A, B, C, and D) of science students in a government comprehensive high school, Jhelum during the 2008-2009 session. Clustered sampling procedure was used to select the two groups which are section B and section C. Section C is taught by an approach shaped with Ausubel's Meaningful Learning Model and by using concept maps. Section B is taught through traditional approach (rote memorization). At the beginning of the experiment, section C contained fifty-one students but during the experimental period of two months, three students of the experimental group (section C) died. Therefore, 48 students of experimental group (section C) and all the 50 students of the control group (section B) completed the whole experimental period.

Data Collection Tools

Keeping in mind the content of the study and the Blooms Taxonomy of Educational objectives, an achievement test for 9^{th} class physics lesson was developed by the researcher. The test was tried out, improved and administered to the whole sample of 98 science students (48 students of section C and 50 students of section B). The test was administered to the groups at the end of the experimental period. The test was evaluated and the marks achieved by the students were saved for further statistical procedure.

Test construction was made in four phases: (1) Planning Phase (2) Preparation Phase (3) Try-out Phase, and (4) Administration/evaluation Phase. The reliability of the test was calculated by using KR-

21, and was found to be 0.81. Although the test was prepared on the basis of proper specification yet to ensure the content validity of the questions /test items, the test was validated by two professionals in the field of science education. In the light of their suggestions, some items were revised.

Content of the Study

Three chapters i.e. Kinematics, Dynamics (force and motion), and Static (equilibrium) of Physics text-book for 9th classes, published by the Punjab Text Book Board, Lahore for secondary classes were the syllabus for this study.

Data Analysis

In this study, t-test for independent samples was used to determine whether there is a significant difference (at the level of .05) between the means of the two groups.

Table 2. Comparison of mean scores of 9th class students

Treatment	**N**	**Mean**	**SD**	**t**	**p**
Ausubelian Teaching & Concept Maps	48	33.90	5.50	4.30	<.05
Traditional Teaching	50	28.30	5.30		

The t-test was applied to evaluate whether there was any significant difference between the over-all achievement scores of the students. The t value indicated that the mean value for the first group ($\overline{X}$ = 33.9, SD = 5.5) was significantly greater than the mean value of the second group ($\overline{X}$ = 28.3, SD 5.3), t (100) = 4.30. Therefore, the hypothesis "There is no significant difference between the achievement scores of the two groups which were taught through Ausubelian teaching & concept maps and traditional teaching" is rejected.

Discussion

The result of this study is consistent with the views of Ausubel (1960): specifically the importance of pre-learning, the linking of new ideas to previous knowledge. And also with the findings of Kinchin (2000), Lewis (1987) that the Ausubel's teaching strategies found to enhance significantly the conceptual understanding of the students.

The traditional teaching method (lecturing/ book learning by rote / memorization of facts, theories, principles etc.) are widely being used in teaching of science subjects at secondary level in Pakistan, despite of knowing their merits and demerits. The researchers, educationists and the curriculum planners are seriously thinking about how to improve the quality of science education through the effective use of these instructional methods. Therefore this study was taken up to compare the relative effectiveness of constructivist and traditional approaches in the teaching of physics at secondary school level in Pakistan. The study proved that the results shown by Ausubel's teaching methods in physics theory are better in achievement than the controlled group and it has made it easy to pave the way for research in order to lead the teachers to adopt Ausubel's teaching strategy, in the teaching of physics specifically at secondary level.

References

Ausubel, D. P. (1963). *The Psychology of Meaningful Verbal Learning.* New York: Grane and Stratton.

Ausubel, D P. (1966). *Meaningful Reception Learning and Acquisition of Concepts in Analysis of Concept Learning*. New York: Academic Press.

Bloom, B. S. (1956). *Taxonomy of Educational Objectives--The Classification of Educational Goals*. New York: David Mc Kay

Bruner, J. S., Goodnow, J. J., and Austin, G. A. (1956). A study of thinking. New York: John Wiley.

Collettee A. T. & Chiappetta E. L. (1989). *Science Instruction in the Middle and Secondary Schools* (6th ed). Columbus: Merrill Publishing Company.

Cross, A. (1992). Pictorial concept maps-putting us in the picture. *Primary Science Review*, 21, 26-28.

Driver, R. (1983). *The pupil as scientist.* Milton Keynes: U.K opens University Press.

Ebenezer, J. V. & Connor, S. (1998). *Learning to teach science: A model for the 21st Century.* London: Prentice-Hall International (UK).

Johnstone, A. H. (1993). The development of chemistry teaching; a changing response to a changing demand. *Journal of Chemistry Education*, 70(9), 701-05.

Kilshaw, M. (1990). Using concept maps. *Primary Science Review*. 12, 34-36.

Lambiotte and Dansereau (1991). *Concept Mapping: a learning theory-based instructional tool: specific uses of concept mapping in science education*, lancraftt@email.spjc.cc.fl.us (June 08, 1996)

Novak, J. D. & Gowin, D. B. (1984). *Learning how to learn.* Cambridge: Cambridge University Press.

Novak, J. D. (1991). Clarify with concept maps. *The science teacher*. 45- 49.

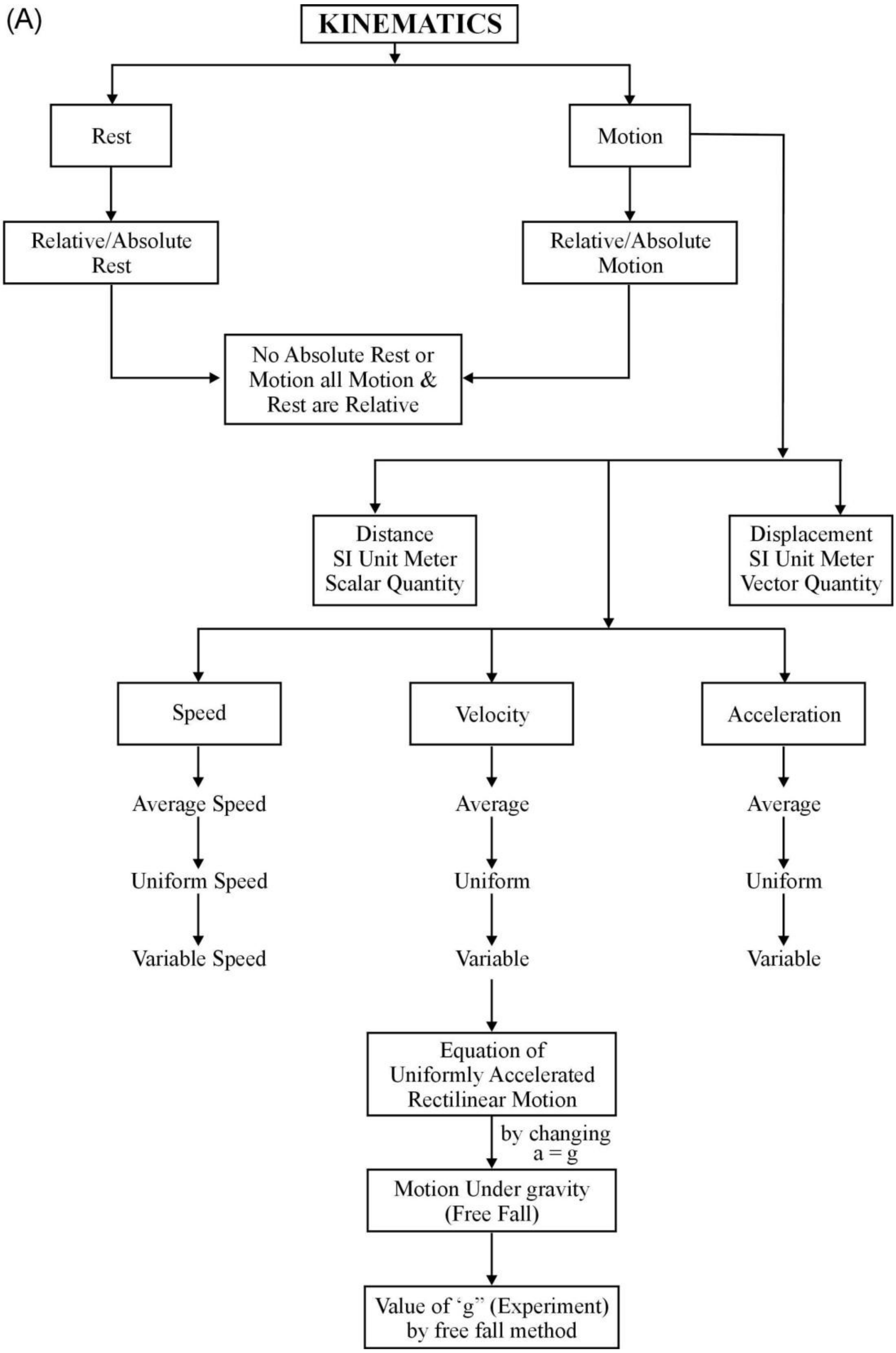
Osborne, C. (1986). *International Year Book of Educational and Instructional Technology.* Kogan Page / eichols.

Pines, A. L. (1985). Towards a taxonomy of conceptual relations and the implications for the evaluation of cognitive structures. In L.H.T.West & A.L. Pines (Eds.), *cognitive structure and conceptual change.* Orlando, FL: Academic Press. 101-116.

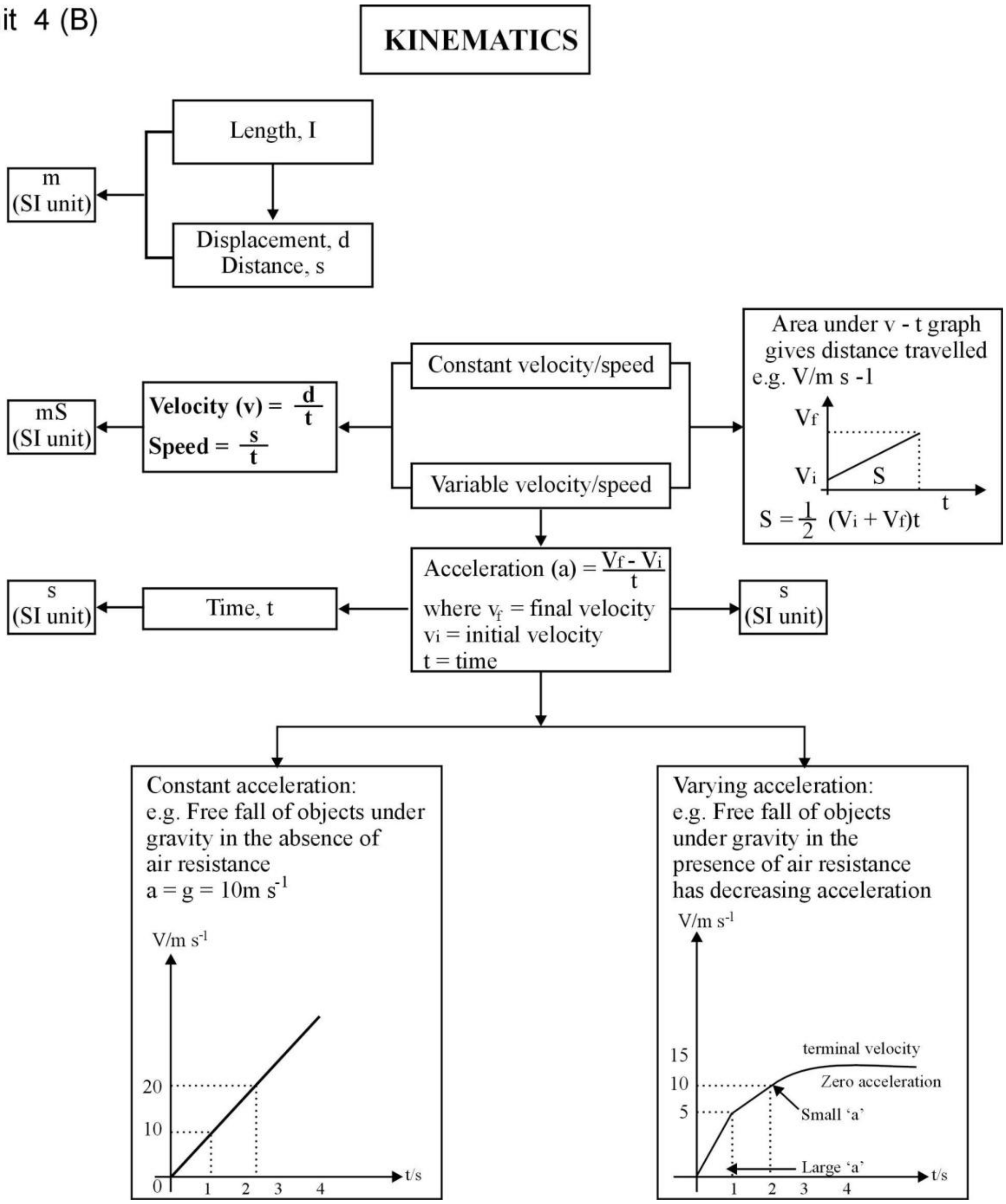
Safdar, M. (2010). *A comparative study of Ausubelian and Traditional methods of teaching physics at secondary school level in Pakistan.* Unpublished Ph.D thesis. Islamabad. National University of Modern Languages, Islamabad. pp. 66-70.

Appendix- A

Unit 4 (A)



Unit 4 (B)


KINEMATICS
Length, I
m (SI unit)
Displacement, d
Distance, s
mS (SI unit)
Velocity (v) = d/t
Speed = s/t
Constant velocity/speed
Variable velocity/speed
Area under v - t graph gives distance travelled
e.g. V/m s -1
Vf
Vi
S
t
S = 1/2 (Vi + Vf)t
s (SI unit)
Time, t
Acceleration (a) = (Vf - Vi)/t
where vf = final velocity
vi = initial velocity
t = time
s (SI unit)
Constant acceleration:
e.g. Free fall of objects under gravity in the absence of air resistance
a = g = 10m s-1
V/m s-1
20
10
0
1
2
3
4
t/s
Varying acceleration:
e.g. Free fall of objects under gravity in the presence of air resistance has decreasing acceleration
V/m s-1
15
10
5
terminal velocity
Zero acceleration
Small 'a'
Large 'a'
1
2
3
4
t/s