Effects of Vocabulary Instructional Strategies on related Achievement in Biology in Secondary School Students

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Abstract- *This study premise that words are fundamentally conceptual, that science and literacy share a core of set of meaning making strategies, that text can play a set of dynamic roles in inquiry processes and the related science learning outcomes. This paper reports the effects of graphic self-instructional material on vocabulary in four broad areas of biology in class X (SCERT, Kerala), direct vocabulary instruction and collaborative self- learning of vocabulary in the unit Movement and locomotion of class XII biology (NCERT). The vocabulary instruction intervention was preceded by content analysis of respective textbooks that resulted in listing of 250 terms from class X and 1351 terms from class XII text books. Based on morphological analysis the terms from class X biology were incorporated into a graphic self-instructional material for students to learn these terms. Larger list of terms from class XII were reduced into 420 words which were then rated for difficulty by undergraduate biology students and accordingly units with higher number of difficult terms were identified. The vocabulary in the unit with maximum and most difficult terms, Movements and locomotion, were incorporated into a vocabulary instructional intervention, which were administered either through direct instruction or through collaborative self-learning. The vocabulary instruction, of less than a few class periods, could enhance achievement of vocabulary allied concepts among both class x and xii students, over and above the equivalent control groups who had completed regular biology instruction and learning in these units. These effects were all very large, except in one intervention where the effect size was yet large.*

Acquiring Vocabulary in science are valid learning outcomes

Every branch of knowledge needs a study of its language. Academic terms, referred as vocabulary are the units of that language. Miller (1983, 1986) suggests terms and concepts as the first of three dimensions of scientific literacy. Understanding of meaning and using them is an essential outcome of learning every subject. Science is rich with technical words with specific meanings. It also gives scientific meaning to common words. Learning science vocabulary is an outcome of learning science in school. Words being the currency of science are really tool for

thinking. Without terminology, learning the principles involving deeper, complex and abstract concepts are impossible. Vocabulary learning in science is in effect learning science concepts. Hence, in learning a discipline, Bruner (1956, 1960, and 1966) stressed building a coherent conceptual structure for it and capacity to manipulate idea symbolically through medium of language. Gagne (1970) also suggested mastery of principles, the prerequisite for problem solving, requires learner be acquainted to related concepts. Evidence of representational thought emerges from use of language (Piaget. 1953). NCF (NCERT, 2005) recognize this while stating that good science education is true to the child, true to the life and true to science. Validity of a science curriculum comprise cognitive and content validity. Cognitively, the content, process, language and pedagogical practices of the curriculum need be age appropriate, and within is the learner's reach. However, content-wise, it must convey significant and correct scientific information. Simplification of content, for adapting curriculum to the cognitive level of the learner, must not be trivialized.

Authentic learning of science implies interaction and communication

Overarching goal of science education is to create scientifically literate students who can make informed decisions when the questions they are confronted with require scientific knowledge or processes. This requires some focus on building content specific vocabulary. Hence, learning science requires engaging in authentic inquiry, combined with reading, writing, and verbal communication as the latter helps to go beyond what is presented in class. Kerala Curriculum Framework (KCF, 2007) recognize that in science education tendency of promote rote learning of concept exists at the expense of scientific temperament and science literacy. Students who access to interesting texts along with observation, and interaction of scientific phenomenon gain greater conceptual knowledge of the science and engagement than those without the literacy connection (Swan 2003). Hence, literacy skills -Reading, writing and speaking, communicating - are integral to knowing, comprehending, and doing science. Vocabulary is required for proper, precise, vivid and consistent, exact and effective communication and interaction. Without terminology science appears as a labyrinthine maze.

Science vocabulary instruction impacts learning the allied concepts.

Learning vocabulary seems the easiest things about learning a discipline**.** But at higher levels of a discipline it is one of hardest**.** Science textbook all too often forms the backbone of the secondary and higher secondary science classroom**.** Heavy use of scientific terminology makes readability levels of many science textbooks higher than the levels for which they are targeted **(**Wrights, 1982**).** However, Science learning historically has been seen as an active meaning-making process, while language acquisition has been viewed as a passive meaning-taking process **(**Yore, Craig and Maguire 1998**).** Underestimating the role of scientific vocabulary in science learning has led to less than optimum use of science books in the classroom **(**Di Gisi 1993; Gottfried and Kyle 1992**).** Science teachers are averse to text centric approach to science curriculum because of the heavy emphasis on learning words as definitions**.** Songer and Linn **(**1991**)** point out that if students view science as a collection of facts reported in textbooks, then memorization of these

facts would be a logical approach to studying science**.** This can lead students to prefer memorizing, rather than trying to understand, scientific information**.** Songer and -Linn further point out that this method of studying science can lead to **"**static beliefs**"** rather than **"**dynamic beliefs**."** Adherence to static beliefs is associated with negative attitudes toward science and the idea that science is not very relevant**.** It is clear that, underestimating the role of scientific vocabulary in science learning has led to less than optimum use of science books in the classroom **(**Gottfried and Kyle, 1992**).** Thus, student interest in science may be extended through a rich vocabulary environment**.**

Vocabulary and comprehension is especially evident in science class where many words required for understanding the text, relevant literature, classroom activities or teacher lecture are not encountered in everyday language. Additionally, science terms can have meanings that are different than the use of the word in everyday language (Rupley and Slough, 2010; Young, 2005). "The meanings are and carry the concepts represented in the test" (Rupley and Slough, p.100). In fact, words used in science class often embody the concepts themselves. If understanding of these terms is lacking, students will not only have trouble with conceptual understanding but may fail to be engaged at all. Teaching vocabulary can create a link between the words used in science and the words used by the students. Additionally, vocabulary instruction can link science terms and concepts to background knowledge (Young, 2005). Word knowledge allows students to conceptualize what the text is describing, connect meaning between different sections of the text and determine relationship between what is being read and what the student already knows. Students with more vocabulary knowledge show higher comprehension of science texts (Cromley, Synder-Hogan and Luciw Dubas, 2010). The success, along with the ability to understand the ideas behind the language of science, can be difficult if a student cannot read text in a fluent manner (Rupley and Slough, 2010). On the other hand, if a student's ability to access the text is increased through vocabulary acquisition, the text will further develop their knowledge of the word meanings (Taylor, Mraz, Nichols, Rickelman and Wood, 2009) along with the concepts described by the test (Rupley and Slough).

Vocabulary instruction impacts other valid learning outcomes as well.

Vocabulary learning is a combination of learning of both word form and word meaning. Word meaning is the sense of the word or the word's referent (Biemiller, 2006; Bloom, 1998). Root words are language-building blocks. Scientific words are often made up of several components. Biology too has huge vocabulary denoting its concepts are learned through the scientific term denoting them. Biology especially at secondary level abound with academic terms which students often memorize rote (Songer and Linn, 1991) leading to "static beliefs" rather than "dynamic beliefs.", ensuing negative attitudes toward science and its relevance. It is clear that, underestimating the role of scientific vocabulary in science learning has led to less than optimum use of science books in the classroom (Gottfried and Kyle, 1992). Biology is loaded with terminology and originated form Greek and Latin words (White, 1990). Knowing these

components, especially the ones commonly used in a discipline, help to remember them or help to work out their meaning. Several terms have common root words.

Objective

This paper summarizes three interventions, and their effects on related achievement, targeting select academic terms in biology of class X (SCERT, 2014) and class XI (NCERT, 2014) which were identified as difficult for students in Kerala through pilot survey schools.

Methodology

Class X sample was provided graphic self-instructional materials (SLM) and class XI students were provided with either direct instruction by teacher or collaborative instruction on vocabulary among peers. The various procedures followed in the three instructional interventions are summarized in Table 1.

Table 1. Summary of pro-intervention content analysis, survey and interventions on biological vocabulary in class X and class XII students.

Strategy	SLM strategy	Direct instruction	Collaborative learning
Class	X	XI	XI
Content analysis	250 terms identified from SCERT class X biology textbook like: • Names of concepts, objects, reactions, state, quality • Terms which are not commonly used • Words are originated from other languages like Greek or Latin • . Words having suffix, prefix or root words Terms from 9 areas regrouped into 4 broad areas.	1351 zoological terms (from 12 zoology chapters of XI biology-NCERT book) Vocabulary rich units were identified: Cell and Cell Cycle Structural Organization in Animals Locomotion and Movement Animal Kingdom Neural Control and Coordination	
Survey to identify difficult	Nil	30 B.Sc. zoology students reported their perception of difficulty from 421 terms	

vocabulary		identified by experienced teachers as difficult on 3-point scale 400 class XII students were tested on 100 terms with weightage to all 12 chapters	
Results from survey	Four categories of terms based on content a. Cell Biology and Genetics b. Physiology of Plants and Animals c. Taxonomy and Evolution d. Ecology, Environment, Applied biology	High, moderate difficult and easy terms in each unit in class XI 30 most difficult terms in Class XI zoology 12 units by their vocabulary difficulty	
Experimental design	nonequivalent dependent variable (NEDV) design	Pretest posttest non-equivalent control group design (with two intervention and one non-treatment control group)	
Independent variable	Vocabulary Instruction in four groups (n=125) on:	Direct instruction	Collaborative learning
Contents covered	Instructional manual on origin, structure and exact meaning of scientific terms. Structural analyses/Morphemic analysis done. Seven types of Graphic organizers are used	Discuss the origin, structure and exact meaning of scientific terms on the most difficult unit identified from survey viz., Locomotion and Movements using **Morphemic Analysis focusing on** Prefix, suffix, root words	
Learning process	After initial orientation on the self-instructional material, each class learned the four sets in as	Question answer Response	Collaborative learning in groups with minimal teacher guidance

	many groups	analysis Using flash cards	
Control	Non-equivalent Dependent variables	No treatment group	
Control Variables	Locality of school (Urban and Rural) Type of management school (Govt., Aided, and Unaided) 3 Gender (male, female)	Previous achievement in zoology (average of score of two terminal examination were matched)	
Dependent Variable measure	40 items Achievement test covering the 4 broad areas with 10 items / area	Achievement in zoology vocabulary (30 items) on the unit locomotion and movements	
Nature of test	Items constructed in such way that recall from instruction is not allowed		
Sample Size	500	24	24
Technique	Stratified random sample	Simple random	
Locality	Malappuram revenue district of Kerala		
No. of schools	11	Single school	

Findings

Effect of biology vocabulary instruction in Class X students

250 terms in class x biology (SCERT, 2014) identified and categorized in to four broad areas Cell Biology and Genetics, Physiology of Plants and Animals, Taxonomy and Evolution and Ecology, Environment, Applied biology. Most students fail even to decipher the meaning of root words of the term biology.

Table 2. Summary of t value for the test scores of Vocabulary Instructions in each sub tests and Achievement in Biological Vocabulary.

Variable	Experimental Group			Control Group			*t*-value	Cohen's *d*
	M_1	$S.D_1$	N_1	M_2	$S.D_2$	N_2		
Cell biology and Genetics	7.21	1.18	125	2.87	1.61	375	32.28**	2.70
Physiology of Plants and Animals	6.38	1.90	125	2.62	2.09	375	17.75**	1.80
Taxonomy and Evolution	6.68	1.79	125	2.06	1.53	375	27.93**	3.02
Ecology Environment and applied biology	7.39	1.35	125	2.35	1.59	375	34.33**	3.17
Overall (mean) Achievement in Biology	6.92			2.48				

It was found that vocabulary instruction in all the four groups on the topics, Cell biology and Genetics, Physiology of Plants and Animals, Taxonomy and Evolution, and Ecology Environment and applied biology had significantly increased achievement in vocabulary related concepts over above the control groups which have learned these units, but did not receive the vocabulary instruction. Hence, there is significant and very large effect for vocabulary instruction in all the areas of biology for class X students.

Vocabulary Intervention on class XII zoology topics

62.5 percent of students could not identify appropriate terms in higher secondary Zoology when after they have completed the lessons.

Among the most vocabulary rich chapters, Structural Organization in Animals, and Locomotion and Movements, are having larger number of highly difficult and moderately difficult terms. However, except locomotion and movements of above-mentioned chapters are moderate or low difficult for tertiary students. Thirty most difficult (with difficulty index .25 or less) terms for higher secondary students in class 11 zoology identified.

Table 3. Comparison of Mean Scores of Achievement in Zoology Vocabulary between Students Who Received No Zoology Vocabulary Instruction, Collaborative Vocabulary Instruction and Direct Instruction

	N	mean	SD.	When compared with	t	
Collaborative self-learning	24	22.50	5.21	Direct instruction	1.19	-
Direct instruction	24	24.13	4.18	Non-treatment control group	5.36**	1.30
Non-treatment control group	24	15.71	6.46	Collaborative self-learning	4.01**	1.05

**p<.01

Table 3 shows that vocabulary instruction in the chapter Movements and locomotion of class XII biology using direct instruction had very large effect and collaborative self-learning had large effect.

Conclusions and Implications

Secondary school biology is very rich in difficult and complex terms that needs to be attended by textbook and curriculum planners, teachers and learners. Left un-noticed such terms affects biology learning outcomes especially comprehension, concept attainment, and critical understanding. Learning the common roots, prefixes and suffixes is an effective strategy for biology vocabulary learning. The level of difficulty of these terms reveal that even experienced teachers in our secondary schools are not using vocabulary teaching-learning or even instructional strategies for imparting effective attainment of the vocabulary objectives envisaged through science education. This aspect be brought to limelight in in-service course by familiarizing them with new, modern and effective instructional strategies. At least a few hours per every term can be set apart to develop vocabulary in all subjects. Vocabulary instruction is not a panacea, and the fact that it is made necessary after regular instruction indicates that quality of instruction has to see sea change in order for well-set learning outcomes are achieved by learners at every stage of education.

Possible Exhibits

1. List of biology terms identified from class x biology (SCERT Kerala, 2014)
2. Graphic Self-instructional material on biology vocabulary for standard X students
3. List of terms identified in class 11 biology text book categorized by units
4. 421 terms are categorized by unit name into three levels. 1) High difficult terms (5 or above tertiary students perceived as difficult) 2) moderate difficult (1 to 4 tertiary students perceived as difficult) 3) easy terms (no one identify as difficult).
5. Thirty most difficult (with difficulty index .25 or less) terms for higher secondary students in class 11 zoology.
6. Handouts for class XII students on vocabulary in Unit Movement and locomotion

References

Biemiller, A. 2006. Vocabulary Development and Instruction: A Prerequisite for School Learning. In *Handbook of Early Literacy Research*, ed. D K Dickinson and S B Neuman, New York: Guilford, 2, 41-51.

Bloom, L. (1998). "Language Acquisition in Its Developmental Context." *In Cognition, Perception, and Language* (Vol 2 of *Handbook of Child Psychology*, 5th ed.), Ed D Kuhn and R S Siegler, 309–70. New York: Wiley.

Bruner, J. S., Olver, R. R., and Greenfield, P. M. (1966). *Studies in cognitive growth*.

Bruner, J.S., (1960). *A Study of Thinking*, Wiley,

Bruner, J.S., 1956. *The Process of Education*, Harvard.

Cromley, J. G., Snyder-Hogan, L. E., and Luciw-Dubas, U. A. (2010). Reading comprehension of scientific text: A domain-specific test of the direct and inferential mediation model of reading comprehension. *Journal of Educational Psychology*, *102*(3), 687.

DiGisi, L. L. (1993). "Textbook Use in the Biology Classroom: What Teachers Report." Ph.D. dissertation Harvard University. Finn, P J. 1977/78. "Word Frequency, Information Theory, and Cloze Performance: A Transfer Feature Theory of Processing in Reading." *Reading Research Quarterly* 13(4): 508–37.

Gagne, R.M. (1970). *The Conditions of Learning*, Holt, Rinehart, and Winston (2nd Ed).

Gottfried, S S, and W C Kyle, Jr. (1992). "Textbook Use and the Biology Education Desired State." *Journal of Research in Science Teaching* 29, no 1 (January): 35–49

Miller, J. D. (1983). Scientific literacy: A conceptual and empirical review. Daedalus, 112(2), 29–48.

Miller, J. D. (1986). Scientific literacy in the United States. In D. Evered, & M. O'Connor (Eds.), Communicating science to the public London: Wiley. 19– 40.

NCERT, (2005). *National curriculum framework 2005*. New Delhi. (No. id: 1138).

Piaget, J. (1953). *The Origins of Intelligence in Children (*London, Routledge and Kegan Paul).

Rupley, W. And Slough, S. (2010). Building Prior Knowledge and Vocabulary in Science in the Intermediate Grades: Creating Hooks for Learning. *Literacy Research and Instruction*, 49(2), 99-112.

SCERT (2007). Kerala Curriculum Framework 2007. SCERT. Thiruvanthapuram

Songer N.B. and Linn, M.C. (1991). How do student's Views of science influence knowledge integration? Journal research in science teaching 28,761-784.

Swan, K. (2003). Learning effectiveness online: What the research tells us. *Elements of quality online education, practice and direction*, *4*(1), 13-47.

Taylor, D., Mraz, M., Nichols, W., Rickelman, R., and Wood, K. (2009). Using Explicit Instruction to Promote Vocabulary Learning for Struggling Readers. *Reading and Writing Quarterly*, *25*(2), 205-220.

White, T. G., Graves, M. F., and Slater, W. H. (1990). Growth of reading vocabulary in diverse elementary schools: Decoding and word meaning. *Journal of Educational Psychology*, *82*(2), 281.

Wright, J. D. (1982). The effect of reduced readability text materials on comprehension and biology achievement. *Science Education*, *66*(1), 3-13.

Yore, L. D., Craig, M. T., and Maguire, T. O. (1998). Index of science reading awareness: An interactive-constructive model, test verification, and grades 4–8 results. *Journal of Research in Science Teaching*, *35*(1), 27-51.