Facilitating the Learning of Science and Mathematics Concepts: Insights from Cognitive Theory

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Introduction

One crucial problem faced by most Filipino learners today is the lack of competence in both reading and writing. These two basic skills are significantly needed for success in their academic pursuits as well as in preparation for their future jobs in the workplaces. Cummins (1984) identified two factors that often affect language comprehension: context and cognitive complexity which make academic language more difficult and longer to learn than social language. The latter is often laden with more verbal cues that facilitate interaction and understanding but which are definitely absent in the former. Academic language is decontextualized and deprived of verbal and interactive reinforcements and thus, makes the cognitive complexity of the text difficult to comprehend. O'Malley and Chamot (1994) stressed that the language used for simple, familiar information on a task is easier to understand than language used to impart new and complicated information. Obviously, the purposes for which academic language is to be used are very specific and cognitively-demanding such as in imparting new information, describing abstract ideas and developing students' conceptual understanding. All these often make the understanding of academic language more difficult for the students to tackle.

Imperatively, there is a need to address this problem of most learners' inability to comprehend reading materials and in putting across their understanding through writing. Several studies in the past unanimously bared this dismal performance of most learners in school. This may explain why current

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knowledge in science and technology has remained partially tapped and human resources have so far been minimally harnessed in hastening the country's economic growth.

One way to address this problem is to create classroom instruction that would develop in the learners an awareness of, and control over their cognitive processes and dispositions for learning academic knowledge. With a clear understanding of these processes and dispositions, they shall gain a motivated commitment to employ them in facilitating learning of science and mathematics concepts.

English: The World's Lingua Franca for Science and Mathematics

Since English, the world's *lingua franca*, is the medium for knowledge transmission for science and mathematics, there is a greater literacy demand for learners to develop their comprehending and composing skills in this language. The Philippines recognizes this significant need by maintaining the use of English to gain access to scientific and technological knowledge and to establish mutual relations with other nations. This has been explicitly defined in the 1987 Bilingual Education Policy which underscored the functional role of English as the medium of instruction for science, mathematics and technology.

Furthermore, the focus at the moment on content and language teaching expects learners to be able to understand materials associated with scientific and technological pursuits. Thus, learners should be able to develop skills in processing information from texts and other references relevant to their fields of specialization primarily to cope with the demands of their future professions as well as in the immediate requirements for academic skills. This is basically true for those who deal with science and technology subjects where they read a wide variety of information. Hence, the learners' inability to derive maximum understanding of information from science and technology materials will adversely affect their academic success and further, will leave them less-prepared to face future challenges in the workplace. This serious problem faced by Filipino learners has spurred the interests of language educators to find ways of helping them become independent readers and writers by increasing their comprehension and composing skills.

Scardamalia and Bereiter (1985) point out that teaching poor readers to read better does not necessarily lead to reading with understanding, nor for that matter, does teaching content knowledge lead to understanding the content. This suggests that for students to derive understanding and applications, another kind of knowledge is necessary which is the knowledge about

how the mind works and how to control that process. It follows then, that academic activities should enable students to read and write effectively on their own and gain control of their own learning. Getting input for writing through reading can be best achieved by providing the learners with extensive strategy training in the manipulation of language and the opportunity to organize their ideas prior to the task of understanding the writing demands.

The ideal experience in the classroom should be that learners are helped initially by their mentors in their reading comprehension skills development so that eventually they are able to do so by themselves. However, many students remain passive and fail to develop affective learning strategies unless they recieve explicit instruction in their use. Wenstein (1987) argued that to effectively develop reading strategies and skills in the learners, instruction in comprehension skills be incorporated into the regular subject matter classes. Anderson *et. al.* (1985) added that to acquire and integrate most cognitive processing skills, students need guided practice and feedback. By providing these experiences, content area teachers can play an important role in helping students develop effective learning and study strategies. Then, the teacher gradually passes on the responsibility for learning to the students, thereby enabling them to become independent learners.

Palincsar and Brown (1986) found out that students' awareness of their own reading strategies, their alternative strategies, their choice of appropriate strategies and with their techniques for self-monitoring, all result to sizable gains in their reading comprehension. Thus, there is a reason to believe that students can easily learn reading strategies that will improve their learning skills.

To emphasize on meaning and to encourage students to view the reading process as one of acquiring meaning, should constitute the instructional activities for reading comprehension. Authentic reading materials should be used since they are read for real applications.

The basic assumption drawn from past studies and literature all point to the significant role of learning strategies in comprehending academic language and content more effectively. Put simply, learners who employ strategic approaches to learning will comprehend written and spoken language more effectively, acquire new information with greater facility and be able to retain and use their second language better than students who do not use learning strategies (Chamot and O'Malley, 1994). As learners acquire and develop learning strategies, they too, would be able to gain significant insights and perspectives of their own learning, discover the difference between the strategies they have employed and their own learning effectiveness, plan for an reflect on their learning and gain greater autonomy as a learner. Chamot and O'Malley (1994) further stressed the fact that learning strategies can be taught and that, the teacher has an important role in conveying to the stu-

dents the importance of using strategies, defining various strategies and their use with academic tasks, and supporting them in their efforts to become more strategic, independent and self-regulated.

Research here and abroad which capitalized on cognitive theories have paved the way for promising pedagogical approaches that will potentially develop the learners to become effective knowledge decoders and encoders.

Learning Strategies and Cognitive Theory

Chamot and O'Malley (1994) outline two major reasons for the integration of learning strategies into the instruction of academic language and content. Firstly, they claimed that there is compatibility between learning strategies with the cognitive view of learning. Secondly, there is a vast and impressive body of research that support the use of learning strategies with academic language and content information.

Gagne (1985) defines cognitive model of learnings as an active, dynamic process whereby learners are given the freedom to select information from their environment, organize the information, link such to what they have previously learned (prior knowledge), retain what they consider to be important, use the information in appropriate contexts, and reflect on the success of their learning efforts. Chamot and O'Malley (1994) observe that this type of learning is often conscious and deliberate, although some learners who got used to learning in this manner may not have conscious awareness of their thoughts. They added that what is most important is that the model is able to describe the selection, organization, and other mechanisms that constitute active and dynamic learning processes as well as to indicate why learning sometimes occurs without awareness. Chamot and O'Malley (1994) further argue that learners can easily transfer strategies from a familiar to a new task after they have recognized the similarity of both tasks. They added that in the cognitive view of learning, strategies have a prominent role because they represent the dynamic mechanisms underlying learning which can be described within the cognitive model.

Drawing from the theory and research related to learning strategies, the following assumptions offer helpful directions for classroom instructions:

Firstly, learners who have learned to use learning strategies in approaching their reading tasks comprehend faster than those who simply apply rote memorization.

Secondly, learners will have a better way of developing learning strategies if they have been incorporated in their lessons in a meaningful manner.

Thirdly, learners who have learned to use learning strategies and use them regularly in approaching their learning tasks will also develop a positive

attitude toward reading and writing.

Fourthly, strategies developed by learners in their reading tasks can easily be transferred from a familiar to a new task after they have discovered the familiarity of both tasks, and will eventually help learners develop their writing skills.

Science and Mathematics Concepts and the ESL Students

Blough and Schwarts (1990) explicitly defined the goals of the science curriculum in terms of concepts and generalizations, processes of inquiry and discovery, scientific attitudes, and interest and appreciation. Aside from deriving science and mathematics concepts, learners should be able to make suitable applications of these concepts to solve problems emerging in today's world. Hence, new information are discovered through the process of scientific inquiry which will often require the learners to gather data, measure, classify, organize, predict and solve problem. As students gain gradual discovery of the world they live in, they too, will develop scientific attitudes of open-mindedness to consider data-gathering, experimentation and willingness to challenge and assert what they believe as true and valid in order to correct a possible misconception. In addition, as learners strive to uncover the mysteries of the world and enrich their naive understandings of natural phenomena, they too, will cultivate an interest and appreciation of science.

What seems to be the reality nowadays in science classes is that learners who are learning about science concepts are also faced with language-related problems of tackling new vocabulary and the complexity of the discourse, grammatical structures, language functions and academic study skills needed (O'Malley and Chamot, 1994). Besides, learners are also expected not just to listen and understand, but to follow directions and to carry out reasonably sophisticated instructions as in laboratory experiments.

Furthermore, learners are compelled to tackle impressive body of technical and scientific terms aside from learning them, that in most instances, nontechnical vocabulary has specialized meanings in science and thus, they need to consider them in the context of their use. As learners progressed in school, the vocabulary load they need to tackle has become so technical that poses difficulty even to native English speakers. This is often observed in words with Latin and Greek derivations used for scientific terms that ESL students, including the Filipino learners, may have difficulty in understanding the meanings of roots and affixes derived from these languages.

The demand for discourse comprehension in science classes is needed by the learners to understand new concepts in science and mathematics textbooks. There are italics of significant words, sub-headings in several sections and a series of related facts given that will require learners to make their

guesses to develop their own conclusions. ESL students will certainly find this type of discourse structure quite different from their past experiences with English literature which are less cognitively-demanding in nature than those of the very complex information often found in scientific texts.

In addition, as learners increase in grade levels, grammatical structures and syntax become increasingly complex that may be difficult for ESL students to comprehend (O'Malley and Chamot, 1994).

Learners need to develop their receptive skills on top of their oral communication skill that goes with the experiential learning. This is seen important especially as they endeavor to explain a process, describe an observation, classify into categories scientific items, make predictions, and develop hypotheses. As learners advanced into higher grade levels, they are demanded to learn many important science concepts through lectures which often may lack concrete illustrations. In addition, higher grade levels will demand broader literacy skills owing to the learners' need to be able to read for information and then to put into writing what was learned.

Adding to the language need for students learning English, they need to alter their simple scientific understanding through instruction that will make possible a linkage between a concept with other information in memory schemata, develop a new schemata altogether, or change the concept itself (O'Malley an Chamot, 1994). Linn (1983) obseved that students who are less-experienced in science tend to organize information poorly and therefore have less information readily available to retrieve during problem-solving. Since the way in which the information is organized plays a role in making the information available for use in solving problems as claimed by O'Malley and Chamot (1994) then students therefore need ways to link important concepts as much as they need accurate important based on scientific view of the world.

And finally, science learners are required to retrieve information in textbooks, reference books and other library resources. Note-taking activities will be very frequent for them including oral reports and presentations of non-verbal information such as diagrams, charts and tables to other members of the class. Thus, it becomes a must for students studying science and mathematics to develop cognitive strategies to cope with their academic demands in the content areas.

Cognitive Strategies Repertoire

Chamot and O'Malley (1994) have provided a list of cognitive strategies which can be applicable to academic content learning.

Strategy Name	Strategy Description	Strategy Definition
Resourcing	Use reference materials	Using reference materials such as dictionaries, encyclopedias, etc.
Grouping	Classify Construct graphic organizers	Classifying words, terminology, quantities, or concepts according to their attributes.
Note-taking	Take notes on idea maps, T-lists, etc.	Writing down key words and concepts in abbreviated verbal, graphic, or numerical form.
Elaboration of Prior Knowledge	Use what you know Use background knowledge and made analogies	Relating new to known information and making personal associations.
Summarizing	Say or write the main idea	Making a mental, oral, or written summary of information gained from listening or reading.
Deduction	Use a rule/Make a rule	Applying or figuring out rules to understand a concept or complete a learning task.
Imagery	Visualize Make a picture	Using mental or real pictures to learn new information or solve a problem.
Auditory Representation	Use your mental tape recorder then hear it again	Replaying mentally a word, phrase, or piece of information.
Making Inferences	Use context clues Guess from context Predict	Using information in the text to guess meanings of new items or predict upcoming information.

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