Teaching Science to English as a Second Language Students

Name: Christine Shaffer
SCI398
Prof. Percy
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Across Canada, classrooms are becoming more diverse linguistically and culturally (Atwater, 1994; Crandall, 1993; Kauffman, 1995). In Ontario specifically, English as a Second Language (ESL) students represent the fastest growing group of students, as Ontario receives the largest number of immigrants that select Canada as their new home (http://www.ipetitions.com/petition/ESL/). ESL students may be defined as those students whose primary language(s), or language(s) of the home is/are other than English, and who may require additional services to develop their English skills (http://www.bced.gov.bc.ca/esl/policy/definition.htm). To cope with rising demands, schools in the Greater Toronto Area (GTA) allocate approximately one ESL teacher for every 25 ESL students (http://www.ipetitions.com/petition/ESL/). Smaller school boards outside the GTA face a different situation. Where the number of ESL students does not warrant hiring a trained, full time ESL teacher, students may receive little to no specialized language training or may be grouped with special education students (http://www.ipetitions.com/petition/ESL/). Consequently, the number of students requiring ESL services and the availability of funds plays a large role in the type and quality of English language training these students receive. Mrs. Pospieszynski, an ESL teacher currently working at Saint Clares Catholic School in Mississauga, also ads that the length of time a student will spend in ESL classes depends both on the students’ needs and the school board, but the current government funding limits it to 5 years (http://www.ipetitions.com/petition/ESL/).

Insufficient programming for language minority students has real life consequences. While these students represent a growing portion of the Canadian
population, they are dropping out of high school at a higher rate than their English speaking peers (Barba, 1995; Rosenthal, 1996). In addition, the percentage of language minority students enrolled in science, mathematics and engineering programs at the university level remains comparatively low (Barba, 1995; Rosenthal, 1996). As children, ESL students are placed in transitional or maintenance bilingual education programs (Laplante, 1997). Transitional bilingual programs utilize the students’ native language to facilitate English learning (http://www.n cela.gwu.edu/pubs/classics/reading/section-three.htm). However, while instruction may initially occur in both languages, transition is planned, and the goal is an eventual shift to a monolingual English program. Maintenance bilingual programs are slightly different in that there is an intentional goal of building and extending competence in both the students’ native tongue and English (http://www.n cela.gwu.edu/pubs/classics/reading/section-three.htm). Other ESL students attend mainstream English classes where they might participate in ESL activities on a pullout basis, as well as some frequent immersion programs or sheltered English classrooms (Malakoff & Hakuta, 1990). While these programs vary considerably in their goals and approaches, there is growing pressure to integrate English learning with the other subjects in the curriculum to increase efficiency and effectiveness while minimizing costs.

Learning Principles

The American Association for the Advancement of Science (1989) outlines several principles of learning relevant to scientific literacy. Firstly, prior knowledge influences learning. ESL students come to science with previously existing worldviews and knowledge that may or may not correspond with the new concepts they will learn in
their English schools. This prior knowledge will affect for better or worse how new information is integrated with older concepts, as well as attitudes towards science in general. Secondly, learning moves from the concrete to the abstract. With new language learners it is especially important to build a foundation upon which abstract concepts can grow. Science investigations can provide such a foundation by actively involving students in the processes of science from observing and measuring concrete objects to classifying, hypothesizing, and interpreting results (Rupp, 1992). Thirdly, learning requires practice in new situations. This means going beyond the textbook and using the classroom to its full advantage with its possibilities for interactions, demonstrations, and hands-on activities. Some topics may lend themselves to immersive experiences outside the classroom such as on field trips. Fourthly, effective learning requires feedback. ESL students require feedback in a multitude of areas including pronunciation and communication, accuracy of knowledge, accuracy of skills and thought process. Teachers are encouraged to continually check for understanding and effectively communicate expectations to the student. Lastly, learning is not necessarily an outcome of teaching. Learning style for example, may greatly affect whether or not a student absorbs the lesson being taught or if they would do better with a different mode of teaching. ESL students in particular, bring with them unique learning styles that must be addressed. For further information on the learning styles preferences of ESL students, which are beyond the scope of this paper, see Reid (1987).

Integrating Science Instruction with Language Instruction

Science in particular is thought to be well suited for language minority students (Curtain & Pesola, 1988; Ovando & Collier, 1985). Science, like language, is best
learned not as a set of facts to be memorized, but through immersive experience with the subject matter. Using an inquiry-based approach can facilitate the learning of science while providing diverse opportunities for language acquisition (Kessler & Quinn, 1987). A challenge for students learning English as a second language is that they may be required to abandon previously acquired knowledge. This is a complex process and may happen only superficially even after formal science teaching (Fathman, Quinn & Kessler, 1992). While this may be true for science education in general, students who are not fluent in English likely have a larger breadth of previous knowledge that may be incongruent with the Canadian science curriculum.

Much research has been conducted on how to successfully incorporate language and science learning. The remainder of this paper attempts to provide an overview of some strategies considered to be the most appropriate for elementary science teachers working with language minority students. Elementary school is a crucial time that sets the foundation for further academic learning. Students that are not properly equipped with the necessary language tools will fall behind their peers as school becomes more competitive. Similarly, students without the proper content knowledge (in the case of diluting subject matter in favor of language learning) will miss out on the richness and opportunity (both academically and career wise) that a complete science education has to offer. While many of the strategies discussed will also apply to native English speakers, they are particularly relevant to ESL students.

Using Language Teaching Techniques in Presenting Science Concepts

ESL students are consistently faced with the dual task of learning the language of a subject (vocabulary, means of communicating within that subject) as well as its content
(theoretical concepts and ideas) (Laplante, 1997). With limited hours in a school day, teaching science while simultaneously teaching language skills is both practical and enriching. Teachers can employ language related teaching strategies and methods during science instruction to achieve this goal. In addition, teachers may gain time for science instruction by using some of the time typically allocated for language arts to teach the language of science (Laplante, 1997). It is beneficial to see science as a language (Lemke, 1990). “Talking science means observing, describing, comparing, classifying, analyzing, discussing, hypothesizing, theorizing, questioning, challenging, arguing, designing experiments, following procedures, judging, evaluating, deciding, concluding, generalizing, reporting... in and through the language of science” (Lemke, 1990, p.1). In other words, to flourish in science, students must be able to extend their knowledge of concepts beyond basic vocabulary and be able to engage in, and manipulate the appropriate discourse. This academic discourse is distinct from proficiency with social language, which ESL students may already possess (Burkhart & Sheppard, 1995). Academic discourse requires specific instruction followed by practice and appropriate feedback. Teaching the expression of language from a scientific viewpoint can take many forms. Lab reports for example follow specific formats that may not be obvious or familiar to students who may be used to expressing ideas in more informal ways.

**Modifying the Language and Adapting Materials**

When exploring science related themes, new words (such as “food chain”) or familiar words used in unfamiliar ways (such as “energy”) need to be addressed. Science is very heavy in terminology. Students new to a language may be overwhelmed or confused by the use of too much unfamiliar jargon. No more than about 10 to 15 new
words should be introduced per lesson for this very reason (Fathman, Quinn & Kessler, 1992). Using real objects, pictures, visuals and hands on experiments is also helpful in creating a connection between a new word and a concept. This builds upon the learning principle that learning moves from the concrete to the abstract (American Association for the Advancement of Science, 1989). It would be difficult for students to understand the meanings of words such as “magnetic pole” or “chemical properties” for example, before they have had some hands on experiments where these concepts come into play. Re-introducing key words in different contexts, and guiding students in their use of these words during scientific investigation, helps to reinforce learning (Fathman, Quinn & Kessler, 1992). An ESL teacher may find it useful to label class objects relevant to lessons and highlight key terms within their dialogue (through repetition or emphasis) and text (through bolding or italics).

Teachers can also make science texts and written materials more comprehensible by providing sociocultural knowledge where students might not share a common background (Fathman, Quinn & Kessler, 1992). Texts written for English students assume previous knowledge that may not be familiar to someone of a different culture. English learners for example may have never seen or used a nutcracker or a seesaw. By making the special effort to bring in or provide visuals of such objects, teachers can eliminate some of the cultural barriers that impede language learning.

Adjusting the language of written materials depends on the proficiency of the student. It is often helpful to summarize the text first, using short simple sentences, pausing or paraphrasing where necessary and using repetition for emphasis (Fathman, Quinn & Kessler, 1992). Assessment materials should be adjusted accordingly.
lessons have been modified and simplified, tests and assignments should reflect such changes so learning can be appropriately assessed. The task is not to dilute the material, but to use extra precaution and effort to clarify, guide and provide effective feedback. As Rutherford and Ahlgren (1990) suggest, it is better to concentrate on quality over quantity.

_Making Science Meaningful_

Culture is an important issue in ESL classrooms. In talking to ESL teachers currently working in the Dufferin Peel School Board, adjusting to cultural barriers beyond language is one of the most difficult yet important tasks a second language teacher must face (Mrs. Aquino, Mrs. Pospieszynski, Mrs. Falcone, personal communication, March 2, 2007). Children bring with them a diverse array of experiences and ideas from their native cultures. When exploring science, they should be encouraged to share their personal experiences during class discussion (Mrs. Pospieszynski, personal communication, March 2, 2007). For example, in discussing nutrition, children might talk about the different kinds of food available in their native countries, why different foods might be available in different countries, and how this affects people’s diets. These types of discussions help to establish what the children might already know as well as misconceptions they might be harboring. The AAAS (1989) recognizes the influence of prior knowledge on learning. They emphasize that learners construct meaning by relating new information to concepts they already know. Furthermore, learning a new language requires restructuring within the brain (Cook, 1989). When a new word or concept is learned, new neural connections begin to form and are strengthened by further learning. When a previous idea is corrected or changed, new parameters must be set and prior
connections may be discarded. Even if children’s beliefs are not necessarily contrary to those promoted and accepted by Western science, the cultural lenses through which minority language learners see the world should be identified as they still act as filters through which meaning is constructed (Laplante, 1997). These beliefs can also influence students’ reactions to new learning situations and their attitudes to science in general (Atwater, 1994; Lemke, 1990).

Adopting a culturally sensitive approach to science should touch upon different levels of pedagogy. Teachers are encouraged to regress from the prevalent Eurocentric/androcentric perspective of teaching in favor of a “culturally affirming perspective” (Barba, 1995, p. 53-69). In other words, teachers should be sensitive in their choices of printed materials, instructional language, mode of interaction, and use of role models and cultural objects (Barba, 1995, p. 13-17). Scientific discoveries for example, made in South America or Africa are often ignored, while role models of male European ancestry are presented (Laplante, 1997). Additionally, teachers might allow students to discuss some complex ideas in their native tongue to promote better understanding (Ovando & Collier, 1985). This is possible when students in the class share a common background or upon the availability of peer tutors (Mrs. Falcone, personal communication, March 2, 2007). Students should then relate their understanding back to the teacher in English to allow for feedback. Small group activities that combine children of unique backgrounds is also a beneficial teaching tool. Students have the common ground of being in a new educational situation yet may bring different skills both in language and content which creates a scaffolding type learning situation. Communicating in groups provides an immersive experience where children can learn
from one another, practice language, and share the process of scientific discovery. Teachers who make the effort to include objects, contexts, environments and inspiration from a cultural perspective show consideration and respect for children’s home language and culture.

Extending science outside the classroom is another way to make science more meaningful to students. Choosing topics and activities that have personal importance to students (where possible) as well as taking learning beyond the classroom with field trips or guest speakers for example, adds diversity and richness to their education (Fathman, Quinn & Kessler, 1992). As discussed above in this paper, presenting information in different contexts helps to solidify understanding. While such strategies are particularly helpful for ESL students, class activities that broaden students’ horizons, and provide a source of inspiration and connection to the real world, are beneficial to native English speakers as well.

**Teacher and Student Collaboration**

Students across Ontario are placed in a particular ESL program depending on their location (school board), the availability of resources at their school and their personal needs. Second language programs can thus take many forms. Some children may learn English and science from the same teacher. Others attend a separate class for English instruction. In this case, to truly integrate science and language learning, collaboration between teachers is necessary. Teachers may want to share strategies (for example, science teachers learning how to enhance language skills), as well as plan together so that topics and vocabulary covered between the two classes may be previewed in one class and supported in the other (Fathman, Quinn & Kessler, 1992).
Cooperative learning between students is another effective technique for integrating language with science learning. The science classroom provides an excellent atmosphere to develop social behaviors needed to find solutions, foster curiosity and use language as a tool to communicate meanings and solutions. Many ESL teachers already face the task of instructing children of differing language proficiencies at the same time (Mrs. Pospieszynski, personal communication, March 2, 2007). However this challenge can actually work as an advantage. Grouping students of varying abilities is particularly helpful for ESL students who may have the cognitive ability to complete the tasks, yet may be limited in demonstrating their understanding in English (Laplante, 1997).

**Conclusion**

In the spirit of an integrative program, the preceding paper attempts to provide a bridge between learning principles and teaching strategy. These strategies provide a theoretical framework from which science teaching can be improved. These strategies work well in unison as they connect to one another and overlap at the different levels of pedagogy. ESL students are a unique, heterogeneous, and growing group. Teaching science effectively to second language learners brings with it many challenges that can be addressed through creativity and tactfulness on the part of educators. Not only do such strategies enhance the learning experience of language learners in a very cost/time effective fashion, they also enrich the learning experience of their native English peers.

Science provides many opportunities to grow in language proficiency. Lessons can be tailored to the cognitive and verbal ability of the student through simple modifications. Adjustments can be made accordingly as students progress through the curriculum. Thus, doing science in an immersive setting, with collaborative interactions,
has a huge payoff for learning language. The benefit to students will be carried with
them throughout their academic career and help to provide a strong foundation for later
learning. On an affective level, this approach helps to preserve a sense of wonder, joy,
excitement and curiosity (Hart, 1987) setting the stage for lifelong learning.

With an ever-growing population in need of ESL services, it is even more
important to ensure these students are properly equipped for the future and not left
behind. Finding innovative solutions such as integrative programming will help to ensure
quality education in an education system that is not allocating its’ primary resources to
these students.
References


