Science Education and ESL Students

by Heather Allen and Soonhye Park

The number of students who learn English as a second language (ESL) in U.S. schools has grown significantly in the past decade. This segment of the student population increased by 56% between the 1994–95 and 2004–05 school years (NCLR 2007). As the ESL student population increases, many science teachers struggle to tailor instructional materials, resources, and teaching strategies to facilitate ESL student learning. With this issue in mind, we examine the challenges ESL students experience in learning science and provide a lesson plan and assessment with which we attempted to overcome the obstacles ESL students face in the science classroom. We then summarize teaching strategies effective for ESL students’ science learning based on research findings and our own teaching experiences.
Student challenges

The language used by many ESL students is conversational English, while science classes require fluency in academic English. Carrier (2005) notes, “Academic language can be confusing when first encountered [by ESL students] because of terms that sound similar to conversational English, but have different meanings. This cognitive academic language proficiency (CALP) takes five to seven years to fully develop.” The discrepancy many teachers see in the performance of their ESL students in written English versus spoken English skills may be due to the two- to three-year gap in the acquisition of academic English versus spoken English (e.g., if a student has been in the United States for eight years, his or her academic English will be at about five- or six-year proficiency). This causes great difficulty in testing. Some students are not able to translate the terminology used on science tests into language they are familiar with. This gap in proficiency between conversational and academic English can explain the duality sometimes seen with ESL students, who may be able to converse with great success but have a difficult time interpreting written examination questions.

In addition, many students may not have the proficiency in reading skills to comprehend the material they read in science. Avalos and her colleagues (2007) have investigated reading levels in ESL/ELL (English language learner) children and discovered “the key to determining readiness appears to be the student’s reading level in the first language, indicating the importance of L1 [first language] literacy assessment to guide L2 [second language] instruction.” If students are struggling readers in their primary language, they are not able to grasp a second language as easily as proficient first-language readers. Lack of understanding in a second language can be impeded by the same struggles seen in primary-language learners. Teachers can determine the reading level of students in their first language in several ways. Using ESL/ELL teachers, foreign-language teachers in the school, or community members would all be options in determining a student’s primary-language proficiency.

Home life can also impact ESL students; lack of English use in the home slows progress in new language acquisition (Su 2006). Personal pride can also impede learning. O’Loughlin and Haynes (2008) point out that when asked, ESL students will claim to understand, even if they do not. In order to avoid looking ignorant, ESL students will sacrifice understanding for saving face. We can be sensitive to personal pride by allowing students multiple opportunities to demonstrate their learning; offering options such as posters, movies, collages, or artistic projects in addition to traditional paperwork for classes allows students without great English skills to showcase their individual understanding of a topic. Translation of instruction into multiple languages also enhances the understanding levels of students.

All of these factors play a part in the discrepancy between ESL students’ performance and the performance of non-ESL students. Without the proper foundations, tests, exams, quizzes, and even worksheets provide an additional source of stress and challenge for ESL students.

Sample lesson

How can teachers tailor their science instruction to accommodate ESL students’ special learning difficulties and needs? This question was one that we strived to answer with the following sample lesson when we taught a life science lesson to a group of sixth-grade ESL students. This sample group consisted of all non-native English speakers, of multiple abilities. There were approximately 20 students in the class, with a few students who were very proficient in English and others who struggled. This lesson was developed by altering the general lesson for all students in grade 6 to meet the unique needs of this special group of students. The few changes from the original lesson were intended to simplify directions and enhance understanding. These changes could be used with a group of native English speakers, as well, and the results should be the same. This lesson could be used with all students in sixth grade.

Our focus for this lesson was diversity in nature. The lesson addresses the content standards described in the National Science Education Standards for form and function, specifically the life sciences standard level 5–8 for diversity and adaptations of organisms (NRC 1996). Students came to the classroom with handheld translators, so they were provided typed versions of the activity and given time to translate any unfamiliar terms. If students do not have handheld translators, additional time should be given for peer translation or translation by aides or available ESL/ELL teachers. The activity, about bird beaks in nature, was described to students before it was carried out, and the steps were demonstrated for the class. Students working in groups progressed through the activity described in Activity Worksheet 1. Students were allowed to use
ACTIVITY WORKSHEET 1: Which beak is best?

Safety note: Do not consume any food during this activity.

Imagine you are a bird. You are going about your daily search for food when you find a huge area where lots of food has been spilled. Many other birds have also seen this large pile of food. You quickly fly down to eat as much as you can. When you reach the bottom, four other birds are eating the food, as well. You try to get as much as you can.

At your table, you will find a bowl of food, utensils, and a plastic bag. You will use your utensils to place the food in your bag. Choose one utensil and predict how much of each food type you will be able to eat. When the time starts, you will have 20 seconds to eat as much of each type of food as you can. The foods will be eaten one at a time. Which beak is best to eat food on the ground?

<table>
<thead>
<tr>
<th>Beak type</th>
<th>Tweezers</th>
<th>Toothpick</th>
<th>Spoon</th>
<th>Straw</th>
<th>Clothespin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food type</td>
<td>Predict (P)</td>
<td>Observe (O)</td>
<td>P</td>
<td>O</td>
<td>P</td>
</tr>
<tr>
<td>Worms</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>(elbow pasta)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shrimp</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(rice)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Squid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(rocks)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(marshmallows)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seeds</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(popcorn seeds)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Honey</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(juice)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Based on the data in your chart, answer the following questions:

1. Which type of bird beak (utensil) ate the most in total?
2. Which type of bird beak ate the most worms?
3. Which type of bird beak ate the most shrimp?
4. Which type of bird beak ate the most honey?
5. Which type of bird beak ate the most meat?
6. Which type of bird beak ate the most seeds?
7. Which type of bird beak ate the most squid?
8. Which beak worked best to help a bird eat only one type of food? What would make this a good thing? What would make this a bad thing?
9. Why do you think birds have beaks that do not look the same?
### ACTIVITY WORKSHEET 2: Which beak is specialized?

**Safety note:** Do not consume any food during this activity.

Imagine again that you are a bird. The next day, you are flying around, and you see food in a small jar and decide to try to eat it.

At your table, you have lids for your bowls. We will do the trials again, but you must go through the top of the lid to get your food. There is already a hole in the top of the lid for you to “eat” through. Do not add additional holes or increase the size of the hole. Make new predictions for each food.

Which beak is best to eat food in a small jar?

<table>
<thead>
<tr>
<th>Beak type</th>
<th>Tweezers</th>
<th>Toothpick</th>
<th>Spoon</th>
<th>Straw</th>
<th>Clothespin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Food type</strong></td>
<td>Predict (P)</td>
<td>Observe (O)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worms (elbow pasta)</td>
<td>P</td>
<td>O</td>
<td>P</td>
<td>O</td>
<td>P</td>
</tr>
<tr>
<td>Shrimp (rice)</td>
<td>P</td>
<td>O</td>
<td>P</td>
<td>O</td>
<td>P</td>
</tr>
<tr>
<td>Squid (rocks)</td>
<td>P</td>
<td>O</td>
<td>P</td>
<td>O</td>
<td>P</td>
</tr>
<tr>
<td>Meat (marshmallows)</td>
<td>P</td>
<td>O</td>
<td>P</td>
<td>O</td>
<td>P</td>
</tr>
<tr>
<td>Seeds (popcorn seeds)</td>
<td>P</td>
<td>O</td>
<td>P</td>
<td>O</td>
<td>P</td>
</tr>
<tr>
<td>Honey (juice)</td>
<td>P</td>
<td>O</td>
<td>P</td>
<td>O</td>
<td>P</td>
</tr>
</tbody>
</table>

1. How were your results not the same as the first trial?
2. Did your beak shape help you get food? Why or why not?
3. If the top of the lid were smaller in size, would you still get to eat?
4. All students at the tables were birds, but your beaks did not look the same—why?

their native language when answering questions or presenting ideas if they needed, and their responses were interpreted by other students more comfortable with English. If peer translators were not available, students could show responses as lists or pictures, or use the English they do know to communicate.

Students should work in groups of five at a table. Have all students choose one type of “beak” (utensils such as tweezers, toothpicks, spoons, straws, or clothespins), hold it in one hand, and place their other hand behind their back. Place a “stomach” (plastic bag) in front of each student. Place one type of food (elbow pasta, rice, rocks, marshmallows, popcorn seeds, or juice) in a small bowl (either paper or Styrofoam bowls that can be used and disposed of are best) at each group’s table and instruct students that, at your signal, they must compete for as much of that food as they can eat with their beaks. The amount of food in each bowl is up to the teacher, but should be consistent among all of the groups. We had the bowls about 1/3 to ½ full.) Give the signal and then allow each group 20 seconds to “eat.” After 20 seconds, give the signal to stop. Have students measure how much of the food they ate and record their measurement in their worksheets. Repeat
the procedure for each type of food available. The juice should be the last material tested as the others are removed from the bag to be counted. Students use their utensils as best as they can with the juice. The point is that some beaks are very specialized. The straw should do the best, with the spoon also getting some juice. A second set of materials should be on hand for the second activity so that fresh materials are available.

For students’ safety, they were instructed not to play with tweezers, toothpicks, and clothespins (e.g., poking neighbors or themselves with the tools). They were also asked not to eat the marshmallows, rice, pasta, popcorn seeds, or juice. Rather than discuss diversity ahead of time, students had direct experience with it through the activity, seeing for themselves which food types they were able to eat and which ones they could not.

After the first activity, there was discussion on which type of beak worked best for the various foods and why. There was also a brainstorming discussion of different food types from those tested in the activity and which beak type would work best for those foods. We discussed which types of beak would work for different foods such as ants, honey, fish, and thistle seeds; which types of birds eat these foods; and the type of beak they have.

In the second stage of the activity, students used a constructed lid for the bowls as described in Activity Worksheet 2. The lids can be preconstructed and attached to a new set of bowls or just taped on to the bowls used in the previous activity. Students should try to fit their “beaks” through a hole in the lid; some will fit, while others do not. Students should be instructed not to make the hole bigger. This is another way to demonstrate differentiation of beaks with differing food sources. The result should be that the “birds” will get less material out of the bowl than they did when it was an open source of food.

After the second activity, the connection between adaptation and diversity was made through a discussion that included niches of bird species in an area and the types of food they eat. One clear example was with the straw, which most easily relates to a hummingbird beak. Hummingbirds eat nectar and have an extremely specialized beak. Hummingbirds are found where there are many flowers, but not in the middle of a lake where eagles and hawks find their food. Eagles and hawks have different beaks than a hummingbird because they have a different food source. We also proposed some scenarios such as drought, the loss of a food source, or the reduction in the size of the food (mostly for the larger beaks that were not specialized) to students and asked them what would happen to the bird populations under each of these circumstances. We discussed eating habits of birds (e.g., the birds that ate meat probably did not eat nectar). Specialization became a focus at that point, and students were successful in identifying beaks that would not be involved with certain food types and would not be in competition. The discussion of bird beak shapes added to the lesson, because students were starting to make conclusions about where in a large area they would most likely find different types of birds. For example, if looking for hummingbirds, the shoreline of a lake would not be a good place to find them, but it would be a good place to look for eagles, hawks, and other birds that eat fish.

When looking at the original lesson with an eye toward ELS students, we simplified the language to make the words easily translatable. Sometimes substituting less academic language can make a significant difference in the understanding of students, for example, using a phrase such as “Tell me what is not the same...” instead of “Differentiate between...” We used pictures of the birds as well as their names in English so that ESL students who are familiar with what the bird looks like will learn the English words for the bird species. There was also more discussion in the ESL lesson than in the regular lesson.

**Assessment**

To assess students’ understanding of the concepts of diversity and adaptation, they were asked to sort out a variety of birds by their beak shapes from photographs of different birds. Students were then asked to draw the place where they think each group of birds could survive best, such as a lakeshore with a meadow and forest nearby, and write a short paragraph that explains why. All of the bird species we discussed would have their own area of habitation and food sources. The discussion that resulted from the drawings and paragraphs involved food types and locations and the reasons that in one area you may see several different types of birds and their associated adaptations that allow them to eat specific types of food. The pictures were chosen based on students’ native countries and birds native to our area and included pelicans, cranes, vultures, eagles, hawks, finches, hummingbirds, robins, and woodpeckers. Using birds students may not have seen in their native country allowed us to de-
termine if they were still able to correctly categorize the birds as belonging to a specific beak group. If a student’s drawing and written response were neither clear nor understandable, we met with the student and discussed the drawing and paragraphs to assess understanding. We met with all students to maintain an environment of equity.

Assessment of ESL students does not need to mirror that of students for whom English is the native language. Although the same concepts should be tested, as noted by O’Loughlin and Haynes (2008), “Students with limited English need to be graded on whether or not they are making a sincere attempt to understand the content material at their current level of English language ability.” Knowing the English comprehension level of each student is a key component for the teacher in determining which assessment style to use with ESL students. (The assessment for native English speakers included a matching activity and an essay question that assessed their understanding of the concept.) Collaboration with ESL instructors may also provide additional details as to appropriate assessment techniques to use for individual students. Our analysis of students’ responses to the assessment indicated that most students developed an informed understanding of the relationship between animal diversity and adaptation. We identified four aspects of the lesson playing a critical role in the success with ESL students. Those strategies are listed below.

**Instructional strategies for ESL students**

The four instructional strategies that appeared to be effective to support ESL students’ science learning were (1) use of a worksheet that employs simpler language in a sentence frame, (2) use of pictorial materials, (3) use of peer interpreters, and (4) altered assessment tools such as drawings and individual interviews. These approaches are consistent with instructional strategies that research supports for ESL student learning (see Figure 1).

Because conversational English is the first acquired, the use of peer interpreters can be useful (Medina-Jerez et al. 2007; O’Loughlin and Haynes 2008). Pairing students of diverse ability can be a useful strategy for ESL students. Students may be more comfortable asking a peer for clarification in their native language than the teacher. This peer should have greater English skills and preferably have already acquired proficiency in academic English. The peer interpreter can be used

**FIGURE 1** Strategies for use with ESL students

- Peer interpreters (Medina-Jerez et al. 2007; O’Loughlin and Haynes 2008)
- Altered assessment tools such as student portfolios, performance tasks, drawings, journals, or books made by students (Armon and Morris 2008; Aschbacher, Li, and Hammon 2008; Avalos et al. 2007; Flynn 2008; Glynn and Muth 2008; Medina-Jerez et al. 2007; Siegel, Wissehr, and Halverson 2008; Varelas et al. 2008)
- Use of pictorial materials (O’Loughlin and Haynes 2008)
- Paperwork (worksheets, etc.) translated into the native languages or books currently printed in both English and other languages (O’Loughlin and Haynes 2008; Schon 2008)
- Cooperation with ESL teachers (Davison 2006; Medina-Jerez et al. 2007)
- Posted goals for all students for each unit of study (Davison 2006)
- Allowing ESL students to audiotape classes for translation at a later time (O’Loughlin and Haynes 2008)
- Use of sentence frame worksheets to enhance correct grammatical usage of science terms and model correct technique (Armon and Morris 2008; Carrier 2005)
- Use of vocabulary posters to increase understanding of science terms (Davison 2006)
- Use of simpler language for science concepts, but not simpler concepts (O’Loughlin and Haynes 2008; Siegel, Wissehr, and Halverson 2008)
as a source of information by both teacher and student in that the teacher may ask the peer interpreter if the other student understands the material being covered or if the student needs additional instruction.

Use of pictorial materials also assists in understanding by ESL students (O’Loughlin and Haynes 2008). The use of pictures replaces some of the technical terminology used by science teachers. Diagrams of procedures or materials to be used along with text instructions enable understanding by ESL students of varying abilities.

Cooperation with ESL teachers is also critical in making appropriate accommodations for ESL students. Partnership with ESL instructors will provide science teachers with a better understanding of their students, as can partnerships with teachers in other instructional areas (Davison 2006; Medina-Jerez et al. 2007). The ESL teacher can offer insight into the level of science understanding held by students in both classes. Each student is unique and may have individual needs for additional instruction. When science teachers work cooperatively with ESL instructors, students can benefit by having additional opportunities to practice terminology used in the science classroom, as well as having a resource for translation of unfamiliar terms or vocabulary they are struggling with in the classroom. ESL teachers can provide suggestions as to assessment tools that are appropriate for each student’s English speaking and writing ability.

For schools without separate ESL classrooms, accommodations for ESL students can be done in many ways. Discussion of needs with foreign-language teachers in the school district and developing relationships with parents, community members, and advocacy groups provide a source of information and interpretation for ESL students.

Conclusion
As teachers, we are faced with many challenges in the classroom, but not all of them have to be daunting. By keeping in mind the obstacles faced by our ESL students and focusing on how we can help them effectively learn science, we can overcome the language barrier. Partnering with ESL teachers in the school can be a great way to generate new ideas for accommodating and assessing this unique group of students. Although students are learning English through their classes, they are also learning content. Keeping these dual goals in mind, we can give our students knowledge that will last their lifetimes.

References

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