STEM Strategies for English Language Learners (ELL) with Disabilities

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ABSTRACT

STEM strategies for English Language Learner (ELL) students with disabilities include learning centers, instructional games, and techniques to develop conversational language, academic language, scaffolding, concrete materials, and visual learning. Teachers can use these techniques to provide best practices in math and science instruction integrated with modifications for teaching ELL students with disabilities. These strategies utilize technology as well as the science, math, and problem solving of engineering to improve the education of English learners.

Keywords: cultural diversity, special education, educational technologies, English Language Learners, STEM strategies.

Mathematics Teaching Strategies for ELL Students with Disabilities

Developing Conversational Language in the Mathematics Classroom

Conversational language is an essential learning component in the mathematics and science classroom. "Conversational language" is sometimes referred to as "everyday language", "natural language", or "social communication". It is often the first type of language acquired by second language learners (Cummins, 2000 [2]). Teachers of English learners are now realizing the importance of conversational language, especially in the mathematics and science classroom (Harrell & Jordan, 2004 [11]).

Developing Academic Language

Mathematics and science are academic disciplines that contain a language that includes specialized words and phrases related to content, procedures, and expressions (Echevarria, Vogt, & Short, 2004 [4]). Cummins' (2000) [2] Cognitive Academic Language Proficiency (CALP) is the "abstract language abilities required for academic work. In order for ELL students with learning disabilities to be successful, they must experience multiple exposures to new terms through meaningful activities (Lielenberg B. & Wong Fillmore, 2005 [16]).

Scaffolding Provides Support for Mathematics, Science, and Language Learning

Vygotsky (1978) [27] emphasized the importance for a child's learning to be guided thoughtfully by a knowledgeable adult or capable peer. This type of guidance is often called "scaffolding" (Wood, Bruner, & Ross, 1976 [28]). Echevarria, Vogt, and Short (2004) [4] point out that three types of scaffolding are especially important for English learners: verbal scaffolding, procedural scaffolding, and instructional scaffolding.

Concrete Materials

Students need to actively use concrete materials as they investigate new mathematical ideas and concepts. The goal of all instruction should be to help students develop mathematical and scientific proficiency and understanding that can be applied in new and varied situations (NCTM, 2000 and National Research Council, 2001 [19]). Concrete materials are important to vocabulary and language development, which is particularly beneficial for English learners. Words are easier to remember when they can be associated with something to touch (Garrison & Mora, 2005 [6]).

Visual Learning

Visual learning provides organizational representations as a regular component of instruction. Visual learning strategies are especially important for English learners as they support understanding and communicating about ideas and processes. Diagrams, charts, and tables can be used to organize new information and cue memory. Gerlic and Jausovec (1999) [8] found a correlation between increased activity in the brain and the creation of nonlinguistic representations. Helping students discuss visual tools can enable students to more deeply understand and to recall information

(Levine, 2002 [15]). Ability to visualize a situation, to generate mental pictures promotes learning (Hembree, 1992; Shigematsu & Sowder, 1994; and Mendieta, 2005 [9]). Student created representations provide insight into students' understanding and level of generalization (Smith, 2003 [26]). English learners' gestures may also provide important information on students' reasoning and level of knowledge (Domingues, 2005 [3]).

Science Strategies for ELL Students with Disabilities

Today's science teachers must be prepared to teach students whose first language is not English. The Institute of Education Sciences of the United States Department of Education defines English language learners (ELL) as: students with a primary language other than English who have a limited range of speaking, reading, writing, and listening skills in English. Individuals who (1) were not born in the United States or whose native language is a language other than English; or (2) come from environments where a language other than English is dominant; or (3) are American Indians and Alaskan Natives and who come from environments where a language other than English has had a significant impact on their level of English proficiency; and who, by reason thereof, have sufficient difficulty speaking, reading, writing, or understanding the English language. (IES, 2007 [12]).

Herr (2007) [10] maintains that science vocabularies are complex and can be difficult even for native English speakers to learn. ELL teachers should understand that a student's difficulty in learning English should not be confused with an inability to think scientifically. ELL teachers should also be aware that some of the methods that are useful for English language learners are effective for designing instruction for other students as well. In instruction, try a variety of methods to see which is most effect for your teaching style and students. Speak slowly, distinctly, and write down key terms so students can see them and connect them to the spoken word.

Anyone who has recently learned a foreign language, and then traveled to a country where the language is spoken, has probably found that it is difficult to understand natives because they seem to talk fast. What is normal speed to the native speaker can be extremely fast to a language learner or to a student with a hearing impairment Herr (2007) [10].

STEM Content and Technology

Herr (2007) [10] suggests the following strategies for teaching ELL students, and these are especially effective with STEM content.

Closed Captioning: When showing videos, Turn on the closed captioning so students can see what narrators and actors are saying. This helps ELL students to correlate written and spoken English, and models spelling and sentence construction. Closed captioning also helps the hearing impaired student.

Manual Video Control: Science videos often introduce new terms and concepts that can be challenging even for native speakers to remember. Herr (2007) [10] suggests that teachers pause the video to discuss key concepts and use the bookmark and video clip features to return to precise sequences for review. Use the step-frame, slow motion, and replay features as needed.

E Books, E Readers: ELL students with disabilities can use the "read aloud" feature to hear the book and also see the printed words. In addition, students can even make their own E Books.

Mobile Learning Tools (M-Learning): Students can use digital tools to consume and mobile learn. These technology tools include tablets, iPads, and Smart Phones that allow students to study anywhere at any time. M-Learning utilizes visual and audio learning experiences in many languages. ELL students with disabilities can learn to design and create their own learning materials and experiences such as puzzles, flash cards, games, and flow charts. Through technology, ELL students with disabilities can become engaged, constructivist learners, and this type of learning lends itself especially well to STEM content.

Assistive technology: Utilize devices such as screen readers, magnifying devices, large display calculators, and large, high contrast keyboards to provide supplemental aids for English language learner students with disabilities. These devices are equipped with slight alterations to make the process of using them easier for individuals with disabilities.

Interactive Technology programs and software: Use interactive software and online sources to provide engaging opportunities to access language. Online picture dictionaries, interactive games, and software, such as Rosetta Stone assist in the language acquisition process.

Teaching STEM through Effective Practices for ELL Students with Disabilities

Emphasize visual literacy: Visual literacy, the ability to evaluate, apply, and/or create conceptual visual representation, is relatively independent of language. Math and music are regarded as universal languages, i.e., can be read regardless of one's primary language. For example, an American musician can play a score drafted by a German composer. Also, regardless of linguistic background or nationality people around the globe can interpret mathematical equations and musical scores. Science and math students can also interpret pictures and symbols, and with minimal linguistic skills, can interpret charts and graphs. Herr (2007) [10] suggests that vector diagrams, scientific diagrams, pictorial riddles, photographic analysis, movie analysis, and map development and analysis, are a few of the activities and methods that can be utilized to facilitate visual literacy.

Graphic Organizers: Graphic organizers communicate concepts with minimal use of spoken or written language, as well as introduce and assess concepts in a manner that assists meaningful learning. Such diagrams or maps that show relationships facilitate integration of new and familiar ideas. Graphic organizers require minimal language. They include Conceptual grids, Venn diagrams, flow charts, mind maps, and concept maps, as well as, scatter and line graphs, column and bar charts, pie and area graphs, and high-low, combination and log plots.

Group projects & Cooperative Learning: These activities provide opportunities for students to discuss, write, and present ideas in a manner that facilitates understanding and retention.

Partner English Learners with Strong English Speakers: Teachers are aware that the best way to learn something is to teach it. Partner English learners with strong English speakers and both students will benefit from their interaction.

Think/Pair/Share: English language learners like to share their ideas using their new language with their peers. The think/pair/share strategy provides students with opportunities to practice English by explaining science concepts.

Encourage Participation: Requiring English language learners to speak in front of class may cause great anxiety. Encourage students to express themselves, but do not force them to the front of the class prematurely.

Road map to science: English language learners benefit greatly from a "road map" that shows where they are in the science curriculum. Provide students with a copy of your lectures and discussions. This helps ELL students to know where they are, and where they are going.

Scaffolding: Relate to prior knowledge to the students' background knowledge of science concepts. Use pre-assessments to discover what your students already know about a given topic and design lessons accordingly.

Science Laboratory: Hands-on activities provide an excellent learning environment for English language learners.

Demonstrate and Model Laboratory Activities: Provide clear, procedural steps. Use a pre-lab demonstration to present procedures clearly using flow charts, pictures, and outlines. Demonstrate procedures prior to doing the activity to ensure that English language learners can see the procedures before engaging in an activity.

Pictorial Guide: Similar to international symbols pictorial guides provide a visual reference to glassware and other materials used in experiments and activities. Review safety symbols and post them in the room and in the lab handout.

Journaling: Effective writing requires practice. Require English language learners to keep science journals to record lecture notes, new terms, and new concepts.

Science reading comprehension activities: Cloze and jigsaw are effective methods for developing and assessing reading comprehension. They can be used for formative and summative assessments of language and science learning.

Wait time: English language learners must translate terms and simultaneously formulate an explanation. Provide wait-time sufficient for the majority to develop an answer before calling on any individual.

Analogies: Analogies are an effective method of relating new concepts to previously learned concepts.

ELL Vocabulary: Language-based science games such as Science Bing and crossword puzzles reinforce vocabulary and concepts and require minimal spoken language.

Picture glossary: Pictorial flash cards with a picture of the science concept on one side while the term (in the language to be learned) is on the reverse. This method helps students to correlate concepts directly with words and eliminates the need for translation.

Root words: Teach the Greek and Latin prefixes, suffixes, and roots. Approximately 50% of all words in English have Latin roots that are shared with Spanish, French, Portuguese, and Italian. Knowledge of scientific root words will facilitate an understanding of the vocabulary of a variety of languages, particularly English.

Word wall: Post new vocabulary terms on the wall in an organized, grouped according to their level of organization and/or relationships, e.g., cell, tissue, organ, etc. (Herr, 2007 [10]).

Children with Hearing Impairments

In continuing the discussion on the overall importance of integrating STEM strategies in the education of English Language Learner (ELL) students with disabilities, this section will provide a detailed model of using STEM strategies within a specific disability category of students with Hearing Impairments. In this instance, it is important to note that the ELL students discussed may have a native language other than English that also includes American or Spanish Sign Language.

The specialist teacher responsible for the ELL student with a hearing impairment needs to not only be familiar with the STEM strategies but also ELL education and the appropriate sign language (American or Spanish). The presence of a teacher and an assistant in the classroom is effective, especially when at least one of the instructors is a person with a hearing impairment. This is due to the differing cognitive processes between hearing and deaf individuals. An instructor that has a hearing impairment will better empathize with the student's needs and relate to his or her cognitive processes.

For example, a specialist teacher working with children with hearing impairments knows that a child develops his/her cognitive process using visual-spatial processing. For a child with a hearing impairment, the ideas about "the world"", one's self" and "the other" are based on the sum of all forms of human perception, except for the audition. The strategies should accommodate the different cognitive processing with all the richness and uniqueness it implies.

The Framework

Globally, there is a trend of children who are deaf being born into families where both parents do not have a hearing impairment. For instance, in the United States, more than 90% of children who are deaf are born to parents without hearing impairments. Likewise, in Spain, 95% of children who are deaf are born into families where both parents are hearing. In both cases, parents frequently make decisions having little knowledge of the deaf culture or politics. Given this, it is the policy of the educational system to accept the responsibility described in the United Nations and UNESCO proposal for the 21st century, "mobilizing for education: so that every child, boy or girl, has access to quality education as a fundamental human right and as a prerequisite for human development" (UNESCO, 2014 [24]).

As the educational system accepts this responsibility, the education of ELL students with hearing impairments, the

educational community may provide a different, cognitive way of communicating through the concept of 'total communication' (C.E.C. [1]). Total communication is the use of sign, speech, and digital language combined to create complete access to language in all forms of communication used. This establishes a collaborative process between ITC (Information technologies and communication) and the educational system to overcome the barrier in communication, across all languages, rather than allowing it to rule the life of the child. Currently, ITC has significantly influenced families of individuals with a hearing impairment, because the language is thoroughly integrated and visual literacy is emphasized.

Utilizing Technology

Cochlear Implant: A continual development in technologies for individuals who are deaf is the use of the cochlear implant. As a surgically implanted device, choosing a cochlear implant is a difficult and potentially life-altering decision for the future of a child who is deaf. Each case is individually studied, with all possibilities taken into serious consideration. In fact, according to a recent paper presented by the University of Miami, technology has created a stir within the deaf activist community, both positively and negatively. As stated in the paper, "[cochlear] implants are getting cleverer . . ." (Listen up, 2013 [17]). They have even begun developing technology that allows a cochlear to be wired directly into the brainstem. Thus, technology, such as this, provides opportunities for certain individuals who are deaf to gain the use of their auditory senses.

Material Resources: In the technological world, children with hearing impairments find their own virtual learning space like any other child. Currently, more than 30% of youth access information on Internet forums, such as *YouTube,* rather than watching television. This suggests a need to match the popularity of a technologically updated personal world, with that of an educational one. Consequently, specialist teachers should learn to use newer technologies to improve the linguistic and non-linguistic communication of their student population. By utilizing newer forms of technology, specialist teachers can scaffold a student's education while providing supports for mathematics, science, and language learning.

In addition to utilizing newer technological tools, inclusive programs and material resources can offer efficient ways for the integration of new STEM strategies to aid in the cognitive process. Through a combined system of sign language and literacy, the child can improve on his/her use of conversational and academic language. This occurs through educational and social interactions with specialized staff and peers. Coupling these interactions with resource programs available, such as online interactive games, provides engaging opportunities for the English language learner with a hearing impairment to maximize his/her language acquisition potential.

Captioning: Captioning offers a textual synthesis of the contents of spoken language in a digital format. The audiovisual subtitles have to be specially designed for people with a hearing impairment by adapting the displayed text according to age and condition. By offering a visual-spatial mode of communication, this technological strategy can assist an ELL child with a hearing impairment to improve his/her reading skills and, indirectly, their writing skills, through exposure and practice. This strategy is incomplete, and the most complete communication strategy for an ELL child with a hearing impairment is using the audiovisual subtitles, with the inclusion of an interpreter of Sign Language on the TV screen. This provides the ability to scaffold learning for the student, by eliminating aids as the child develops language proficiency. Here, the three integrated systems of sign, speech, and technology are present for maximum effect.

University Programs

Enlaces: The Center for Computing and Communication for Building Knowledge at the University of Chile (C5) for 'Enlaces', created a study that focuses on good teaching practices, with the use of information and communication technologies integrated into the classroom. The activity is designed to develop grammatical, reading, and writing skills in the English language. Classes take place in the traditional classroom, combined with sessions in a computer lab designed specifically for learning the English language. The software and technology used allows personal work with differentiated activities, by distinguishing groups of children and then orienting tasks to the personal progress of each student. One of their projects is oriented to teach the Chilean deaf population through specific programs in computer system. They also offer a proposal about Media Education for students and their families (Enlaces, 2014 [5]).

Translation Statistical System: Voice Sign Language for the Deaf / Sistema de Traducción Estadística de Voz a Lengua de Signos para Personas Sordas: B. Gallo, R. San-Segundo, J.M. Lucas, R. Barra, L.F. D'Haro and F. Fernández are all members of the Speak Technology Group at the University Politechnic of Madrid. They work on the development of several experiments for creating a system for speech translation from the Spanish Oral Language to Spanish Sign Language (Gallo, 2008 [6]). The development of software such as this can have a huge impact on the education, interaction, and communication advancements of ELL students, with hearing impairments.

Continuing Education and Employment

Deaf TEC: In the United States, there is an institution whose research, learning and teaching actions are very useful for the professional development of people with hearing impairments. DeafTEC (award DUE-1104229) is a National Science Foundation-Funded Center of Excellence. Their website focuses on deaf and hard-of-hearing students, rather than on a technical discipline. In using DeafTEC,

> "Employers can learn how best to hire deaf and hard-of-hearing workers and successfully integrate them into the technician workforce. DeafTEC offers training in best practices for high school teachers and community college faculty for improving access to learning for deaf and hard-of-hearing students. DeafTEC provides resources for high schools and community colleges that educate deaf and hard-of-hearing students in STEM-related programs. Students and their parents can find information on STEM technician careers developed specifically for deaf and hard-of-hearing individuals" (R.I.T., 2014 [21]).

By recognizing that there is a continued education basis and workforce need to support ELL students with hearing impairments, specifically in the STEM field, relevant evidence is established for using these strategies in the classroom.

Conclusion

In sum, utilizing the above presented STEM strategies for English language learner students with hearing impairments is

just one example of how these strategies can be integrated into the education of English Language Learners with disabilities. With the continued advancement of technology and engineering, many new supports, aids, services, and software are bringing newfound platforms for education. It is important to keep these advancements in mind, especially when teaching science and mathematics. STEM content and technology can blend together to establish a classroom filled with a plethora of accommodative strategies that maximize the potential for a student's success.

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