# Project ACCESS: High School Student Learning of Academic Vocabulary in the Rio Grande Valley

Angela M. Chapman
University of Texas Rio Grande Valley

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**Abstract**

Academic language can be a major obstacle to students' learning in science and math. For English Language Learners this challenge can be even greater. One reason this challenge prevails is the persistent deficit perspective towards students whose native language (L1) is Spanish. One way to address this issue is to leverage students' knowledge of Spanish and personal culture to develop a deeper understanding of academic vocabulary in high school math and science courses. Project ACCESS (Acquisition of Curricular Content for Exceptional Success in STEM) seeks to challenge the assumptions and biases toward students in the Rio Grande Valley (RGV) who have been marginalized in their STEM classes and are underrepresented in STEM. Specifically, Project ACCESS is (1) creating a consortium to examine P-16 STEM education practices in the RGV and (2) developing, implementing, and testing the use of multiple vocabulary strategies (MVS) in high school math and science classrooms. Results from this three-year study indicate that (1) MVS are effective in helping high school students learn math and science vocabulary and (2) Spanish/English bilingual students learn science when making explicit connections to Spanish and academic vocabulary. Last, efforts to address STEM education issues in the RGV are well underway. Research findings, progress toward STEM education consortium efforts, and next steps are discussed.

The National Assessment of Educational Progress (NAEP) highlights science achievement disparities in the United States (NCES, 2016). The disparities are evident when the data is disaggregated based on socioeconomic status (SES), ethnicity, and first language (ELL) as summarized in Table 1. The data raise important questions about how we are educating K–12 students in science and math, and more importantly ensuring they are prepared for postsecondary education. Similar trends are observed by State of Texas Assessments of Academic Readiness

(STAAR) Biology performance measures. For example, in fall 2018 54% of high school students did not meet the state standards (Texas Education Agency, 2018). When disaggregated based on English Language Learner (ELL) status, special education status, or students identified at-risk the disparity widens. For example, 64% of ELLs, 74% of students with special needs, and 59% of at-risk students did not meet state standards on the fall 2018 STAAR Biology exam and will require academic intervention. Similarly, 58% of students with special needs and 32% of ELL students did not meet state standards on the fall 2018 STAAR Algebra I exam (Texas Education Agency, 2018b).

**Table 1**
Mean scores on the 2015 12th grade Science NAEP

| Variable | Mean Science Score | Mean Mathematics Score |
|---|---|---|
| All Students (public & private) | 150 | 153 |
| Students designated low SES | 134* | 137* |
| *Students designated as ELL* | *108** | *119** |
| *Students reporting as Hispanic* | *136** | *139** |
| Students reporting as White | 160* | 160* |

Scale: 0–300. *Significantly different from all students mean score with p<0.05.

There is an body of literature that focuses on improving academic success of all K–12 students as a way to broaden participation of underrepresented groups in science, technology, engineering, and mathematics (STEM) careers. For example, the literature attributes low retention in undergraduate freshman courses such as General Chemistry, Algebra I, or General Biology to inadequate academic preparation during high school (Harris, et al, 2004), which is often related to the teachers' pedagogical content knowledge or PCK (Van Driel, Verloop, & de Vos, 1998). There is extensive research on best practices in math and science teaching, including inquiry-based instruction (for example, see NCES, 2011). Regardless, students often resort to rote forms of learning (Drake, Lowrie, and Prewitt, 2002; Notebaert, 2016).

One of the challenges for K-12 students achieving literacy in math and science classes is the vocabulary load in science and math textbooks (Groves, 2016). Groves found that secondary science textbooks contain anywhere from three to eight Tier 3 (academic) vocabulary words per page. Many students struggle with learning academic vocabulary, which is considered foundational to literacy (Snow, 2010). Even though students need a strong academic vocabulary foundation in order to be successful in their science and math courses, the vocabulary used and how it is introduced in science classes presents challenges to students. This is particularly true for students who are English Language Learners. While ELLs have fluency in Spanish, they do not recognize their knowledge of the Spanish language as an asset in learning science. Furthermore, biases toward the use of Spanish in classrooms discourage students from speaking L1 in the classroom (Stevenson, 2015). Previous researchers have reported that ELLs better learn science when they utilize both languages (Lee, 2005). In addition, multiple vocabulary strategies, including those that help students connect Spanish to science vocabulary, improve learning and attitudes toward science (Chapman, et al. 2017).

The are two overarching objectives of this project. The first objective is to address the successes and challenges in P-16 STEM education for the Rio Grande Valley through the development of a STEM Education Consortium. This group is made up of stakeholders from P-12 RGV school districts (administrators, teachers, and students) and UTRGV faculty from

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[1] Tier 1 vocabulary are high frequency everyday words. Tier 2 vocabulary are medium frequency words typically used in classrooms, but not necessarily discipline or subject specific. Tier 3 vocabulary are low frequency words that are discipline or subject specific.

varied disciplines, including science education, bilingual education, special education, early child and elementary education, biology, chemistry, physics, and engineering. Second, the research objective is to develop and test science and math curricula that are embedded with multiple vocabulary strategies with high school students in the Rio Grande Valley. The research question guiding this study is: What is the effect of MVS on students in high school Algebra II, Biology, Anatomy, Physics, and Chemistry? How does MVS affect student learning? How does MVS affect student perceptions and attitudes toward language, science, and mathematics?

## Methods

**Study Participants and Design.** Thirteen high school teachers (biology, anatomy, chemistry, physics, and algebra) and their students were recruited from public schools in the Rio Grande Valley with 98% of students identified as Hispanic (n=1,348).

Working professional development sessions were made up of discipline-specific faculty, preservice secondary teachers, a science education faculty member, and high school teachers. During these sessions, units of instruction and key vocabulary were identified, and multiple vocabulary strategies were developed. **Table 2** summarizes the lessons taught by discipline.

| Course | Lesson(s) |
|---|---|
| Algebra | Quadratic Functions<br>Exponents and Exponential Functions |
| Anatomy and Physiology | Cardiovascular System<br>Muscular System<br>Skeletal System |
| *Biology* | Mendelian Genetics<br>Biochemistry<br>Macromolecules |
| *Chemistry* | Chemical Reactions |
| Physics | Sound Waves |

High school classes were randomly assigned to either a treatment group (MVS + inquiry-based instruction) or control group (inquiry-based instruction). Control groups received inquiry-based instruction, while treatment groups received multiple vocabulary strategies in addition to regular instruction. These strategies included morpheme analysis (MA), etymology/ word origins (E), meaning association (A), visuals (V), first language translation (L1), first language association (L1A) and personal/cultural relevance (R) were taught at the beginning of the unit. The vocabulary and strategies were reinforced in treatment groups throughout the remainder of the lesson, with a minimum target of 10 repetitions (Hu, 2013). It is important to note that most teachers, including those recruited in this study, utilize word walls and repetition based strategies (i.e. – flash cards) to support vocabulary acquisition. A goal of MVS is to support student learning through deeper understanding of vocabulary and content.

The PI or an undergraduate research assistant taught the lessons in all treatment classes. This approach allowed students to learn while the classroom teacher observed how the MVS were taught. The teacher completed an observation protocol (Appendix A) which was used to document the type and frequency of vocabulary strategies used. Students in all groups (control and treatment) completed an assessment before and after the intervention.

An Anatomy and Physiology teacher's students were administered the Picture Vocabulary subset of the Woodcock-Muñoz Language Survey-Revised English and Spanish versions (WMLS-R; Woodcock, Muñoz-Sandoval, Ruef, & Alvarado, 2005). Because it can take up 45 minutes to administer the WMLS to one student, we focused on collecting data from a subset. In this case, we selected Anatomy & Physiology because the subject matter has one of the highest frequency of L1 and L1A strategies because of Latin root words and cognates. The greatest treatment effects were observed with Anatomy & Physiology. This data allowed a calculation of language abilities in English and in Spanish, with age-corrected norms (M = 100, SD =15). To better understand how Spanish influenced their learning of academic vocabulary, students from these classes were interviewed at the end of the lessons. Focus groups of two to four students were interviewed to investigate their perception of language fluency (Spanish and English) as well as their perceptions of the role of Spanish in learning academic vocabulary. A semi-structured interview protocol was employed.

**Data Collection and Analysis.** Quantitative data were collected from pre/post assessments and classroom observations. All students were given written assessments at the beginning and end of the units. The assessment included a vocabulary strategy questionnaire to determine which strategies students were using to answer questions. An example is provided in **Figure**

Pulmonary is related to the
a. lungs.
b. heart.
c. blood.
d. liver.

Strategies used: ______________________________

Refer to the list of strategies provided and choose the best option that describes how you answered this question. There can be more than one option. Choose all that apply. Write the letter(s) of the alphabet in the space provided.

A. I know the word already.
B. I know of a similar word in Spanish.
C. I know the origin of this word.
D. I associated the meaning of this word to a word that I know in Spanish.
E. I broke the word into its prefix, suffix and root.
F. I related it to a personal experience.
G. I guessed the answer
H. Others (Please specify.) _________________

An observation instrument was created to demonstrate fidelity of implementation between control and treatment groups, and to facilitate classroom teacher learning of MVS. The teacher observed the teaching of high school students and recorded every time a different vocabulary acquisition strategy (morpheme, visuals, L1, L1 association, meaning association, etc.) was used. The teacher was taught how to use the instrument, used the instrument while the principal investigator (PI) was teaching, and then debriefed after the lessons were taught.

Quantitative data from pre- and post-assessments were first analyzed by comparing gain scores between control and treatment groups using independent samples t-tests, then confirmed using a 2 (group) x 2 (test score) repeated measures analysis of variance (ANOVA) with pre- and post-test scores as the repeated measure (Creswell, 2013). In addition, the frequencies of MVS from the observation instruments were used to demonstrate fidelity of implementation. Qualitative data from student interviews were transcribed and coded for emerging themes using predefined categories to determine the extent to which students connected L1 to learning academic vocabulary (Patton, 2002).

## Findings

**Objective 1: Student learning and attitudes toward science and math.** Students in the treatment group were provided with multiple vocabulary strategies during the lesson. For example, during the Algebra II lesson on quadratic functions, students learned the meaning of the word quadratic using etymology, L1, and L1 association. A student version of the worksheet (appendix B) was provided and students were first asked to translate “Recinto cuadrado en el que tienen lugar los encuentros de boxeo” to English. The questions were all directed to help students understand the meaning of the word quadratic equation, one in which the highest exponent is squared. This term was chosen in part because it may be a false cognate (Lubliner & Hiebert, 2011) as students often confuse the term quadratic (squared) with the term quadrangle or quad meaning four. This can lead to a choosing a common distractor on standardized tests in which students choose an answer that has an exponent to the 4th power because they associate quadratic with four.

Based on the observation protocols, the most common MVS teachers utilized in control groups were visuals (i.e., diagrams) and morpheme analysis. The treatment groups showed higher use of all MVS for all subjects (algebra, biology, chemistry, anatomy, physics). This is important, as it helps to establish fidelity of implementation in the research project.

Table 3 shows the gain scores (post – pre) by group (control or treatment) and subject (algebra I & II, biology, chemistry, physics, and all subjects). As shown in Table 3, there is a treatment effect across all subjects (Chapman & Bailey, in preparation). Thus, multiple vocabulary strategies are effective for helping students learn academic vocabulary and concepts.

The findings were varied when treatment effects were analyzed by subject (algebra I & II, biology, chemistry, physics). Algebra I, algebra II, anatomy and chemistry demonstrated significantly higher gains for students in the treatment group as compared to the control group. Significant differences were not observed in the biology and physics courses. The physics was limited to one year with one teacher due to issues with recruitment of teachers. As the sample size was small ($n=48$), nonparametric methods were utilized. Mild treatment effects ($p<0.10$) were observed. Data from the biology courses ($n=370$) were from four different teachers. To determine if teacher effects would explain the lack of significance in the biology group, the one way repeated measures ANOVA was repeated for each teacher. The findings are summarized in Table 3, and demonstrate significance for two of the four teachers (teachers 1 and 4). Based on observations during teaching of the control or comparison classes, we found that teachers 1 and 4 used MVS minimally. This was not the case for teachers 2 and 3, as we found that these teachers were using MVS (including L1 and L1a strategies) frequently.

One goal of the research was to understand if students' attitudes toward math and science were affected by the use of MVS during instruction. Previous research has shown that students with lower pre-test scores not only show greater learning gains with MVS in the nervous system but also significantly higher self-efficacy and instrinsic motivation toward science than students with higher pre-test scores (Chapman, et al, 2017). The Science (or math) Motivation Questionnaire II (SMQ-II; Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011) was administered prior to the lessons. The SMQ-II measures five components: intrinsic motivation, grade motivation, career motivation, self-determination, and self-efficacy. In this study, a ceiling effect was observed in that students reported high mean scores.

**Table 3**
Mean gain scores by subject and group

| Course | *n* | Gain scores (Post - Pre) | |
|---|---|---|---|
| | | Comparison | Treatment |
| Algebra I | 84 | 0.06% | **6.25% *** |
| Algebra II | 54 | 12.5% | **27.4% *** |
| Anatomy | 554 | 22.4% | **55.7% *** |
| Biology | 359 | 31.0% | 34.9% |
| Chemistry | 237 | 25.2% | **29.3% *** |
| Physics | 48 | 1.3% | 10.8% |
| All | 1337 | 22.6% | **38.6% *** |

*Significance observed with $p < 0.05$

**Table 4**
Mean gain biology scores by teacher and group

| Course | *n* | Gain scores (Post - Pre) | |
|---|---|---|---|
| | | Comparison | Treatment |
| Teacher 1 | 123 | 30.6% | **41.2% *** |
| Teacher 2 | 59 | 46.8% | **38.9%** |
| Teacher 3 | 114 | 35.4% | **34.4%** |
| Teacher 4 | 63 | 10% | **25.3% *** |

*Significance observed with $p < 0.05$

Sixty-six students in one of the anatomy classes were administered the WMLS Picture Vocabulary test to measure their fluency in English and Spanish. Eighteen students in this group were selected to be interviewed about their perception of language and learning anatomy, including five English monolingual students, five medium Spanish fluency students, and eight high Spanish fluency students. Four students in the English monolingual group made references to using visuals and morphemic analysis to help them learn anatomy vocabulary. For example, Julian stated, "If I'm completely not, like, aware of.... of a certain vocabulary word, I probably dissect it. And, like, I probably, like, split it into prefix and suffix". His statements indicate using morpheme analysis, a non-L1 specific strategy. All five students in the medium Spanish fluency group considered themselves to be English monolingual but reported using all multiple vocabulary strategies, including L1 (Spanish) translation and L1 association, to learn anatomy. One exchange (below) with students highlights how they are accessing Spanish to learn.

**I:** The, um, all right what about the blood supply to the heart? What are those blood vessels called?

**Karen:** The –

**Jessie:** Um.

**I:** How do you say “heart” in Spanish?

**Karen:** Corazon

**Jessie:** Corazon

**I:** So, what would the blood supply (cut off)

**Karen:** Oh, like, the coronary or, like.... something arteries.

**Jessie:** Coronary

During the interview, students struggled with remembering the correct response when asked about blood supply to the heart (coronary artery), but as soon as they were asked to translate heart to Spanish (corazon), the immediately connected it to the blood supply to the heart. Thus, they are using L1 and L1A. These findings are under submission to the International Handook of Research on Multicultural Science Education (Chapman and McHatton, 2021). Like students in the medium Spanish fluency group, students reported using a mix of L1 specific and non-L1 specific strategies to learn about the anatomy of the heart. However, students in this group made more references to Spanish translation (L1) and Spanish association (L1A) than the other two groups. Thus, students are accessing their knowledge of Spanish to better learn science. Following is a quote from Mary (a pseudonym).

“Yeah…like artery, away, like the way you guys would say “double a”… like how vientre, closer to the stomach like all those things I just remembered when I was doing the test.” She is demonstrating using three strategies, (1) a mnemonic (artery and away begin with the letter a) (2) L1 translation and (3) L1A. Vientre is Spanish for stomach and the ventricles are closer to the stomach.

**Objective 2: STEM Education Consortium.** The interdisciplinary steering committee is made up of faculty and students representing the colleges of education, engineering, and sciences as well as informal STEM educators. The conference was attended by 349 participants in year 3, 247 participants in year 2, and 141 in year 1. The theme for the 3rd year was "Be the Disruption: Towards Transformative Practices in STEM Education." As shared in the program, a fundamental goal of this conference is ensuring that all STEM educators are prepared to successfully implement best practices in STEM education, from preschool to college, for all students—and to do so with a heightened awareness of existing systemic inequities, hegemonic ideologies, and how we as educators impact student engagement, interest, and academic achievement. Conference participants are the doers, with a willingness to be introspective and have dialogue around difficult conversations about what works as well as what doesn't work and how to transform that into success for STEM learners. The conference included participants from all disciplines of P-16 STEM education, from high school students to STEM faculty (Table 5).

Presenters included STEM and STEM Education faculty from across the United States, Canada, Puerto Rico, and Mexico as well as local P-12 STEM educators, and high school students from La Joya ISD and Vanguard Academy. Presentations were diverse, including hands-on and inquiry-based practitioner workshops, critical discussions with high school students, P-16 STEM educators from all disciplines, P-16 administrators, and informal STEM educators, as well as current STEM education research. Keynote and plenary speakers discussed ways in which we disconnect ourselves from and dismantle dominant ways of generating knowledge in science education, why the "A" matters in STEM+A, and indigenizing social and political consciousness in marginalized groups through questioning and challenging dominant practices. Over the three years of this conference, feedback demonstrated the success of individual sessions and the conference as a whole. The predominant themes that emerged from attendee feedback included appreciation for the opportunity to network with STEM education faculty from around the country, the diversity of attendees (including the inclusion of high school students), and the focus on social justice in STEM education. An advisory board has been assembled that includes colleagues from UTRGV, RGV P–12 school districts, Georgia Southern University, The University of Texas San Antonio, and the University of Iowa. The steering committee will continue to expand this conference as a national and international conference, with the goal of emerging as a leader for transformative STEM education practices for diverse student populations.

## Discussion

The research on the effectiveness of MVS and the efforts toward transformative practices in STEM education are the two main objectives of Project ACCESS. In each of the following sections, a potentially transformative practice is described.

**Potentially transformative practice 1: Academic vocabulary acquisition in math and science.** The results of this study demonstrate that MVS are a way to improve learning for high school students in math and science classes. While treatment effects varied across disciplines, much of this variance can be accounted when teacher effect is examined. Two of the four biology teachers admit that they commonly use morpheme analysis and try to help students connect their native language of Spanish to learning in the classroom. Thus, linguistically responsive practices are already being used by some teachers. Changes to the research study have already begun with (1) a modification of the science and math motivation questionnaire to include statements that measure whether students use native language to learn content, and (2) modification of the interview protocol to include pre- and post-interview questions that address use of native language and other strategies in their prior courses and in the study as well as assessment questions that will better help the researchers understand students conceptual understanding of content and academic language. The SMQ-II has been modified to add Spanish language statements, for example, "I believe my knowledge of Spanish will help me learn in math or science." The modified survey was administered to high school students in order to determine validity and reliability. This data will be analyzed in summer of 2020 and submitted to School Science and Mathematics (Chapman, Bailey, forthcoming).

Regardless, by providing students with a variety of vocabulary strategies as part of classroom instruction, student learning was improved. The treatment of multiple vocabulary strategies helped to leverage the students' linguistic assets, including students whose native language is Spanish. When students in the treatment group were provided explicit strategies that included helping them utilize their first language (Spanish) or make first language associations, they made significantly greater learning gains than students who were not given the same strategies. This finding is strengthened with the interview analysis. This is critical if bilingual students and/or ELLs are to develop a deep and meaningful understanding of academic vocabulary.

These findings support previous work (Chapman, et al, 2017; Chapman and Bailey, forthcoming) and provide evidence that using strategies which access high school students' cultural capital, including language, and personal relevance, improves learning of academic vocabulary and content similar to the study by Lee et al. (2005) on science literacy achievement of culturally and linguistically diverse elementary students in urban schools.

Suriel (2014) reported that students should be encouraged to identify cognates during instruction as a way to develop conceptual understanding in science. Using MVS allows students to develop a deeper understanding of academic vocabulary and connect it to math and science concepts. In addition to the impact of learning, studies have reported that many English Language Learners do not recognize their knowledge of Spanish as an asset in classrooms or hesitate to speak Spanish in class because of the bias and deficit perspective communicated throughout their schooling experience (Stevenson, 2015). In this study, students were provided with the opportunity to make explicit connections between Spanish and learning science. This is a first step toward shifting from deficit thinking toward linguistic capital as a form of cultural capital in the science classrooms. Part of this success comes from considering the cultural and linguistic capital of bilingual students and helping them connect their Spanish language to science vocabulary. We need to continue to push the frontiers in bilingual science education from deficit to asset views of our students and value what they bring to the classroom. Even though most of the students in this area are either bilingual or English Language Learners, there is a common view that English is the “right” language and that Spanish is not.

Currently, a STEM MVS database is being developed and is composed of more than 500 key vocabulary, along with several strategies for teaching these vocabulary. This database will be finalized during the summer of 2020 and shared via UTRGV.

**Potentially transformative practice 2: Multi-tiered educative curriculum development.** The project was designed for discipline-specific STEM faculty (chemistry, biology, mathematics, physics), science education faculty, high school STEM teachers (chemistry, biology, algebra, physics), and undergraduate preservice STEM teachers to work collaboratively in order to identify challenges and develop the MVS for specific lessons that can be tested. During meetings, everyone becomes knowledgable with respect to the vocabulary, curriculum, and how to teach.

In addition, this model also has educative curricular potential. Educative curriculum materials have been offered as one way of simultaneously supporting teacher and student learning (Davis & Krajcik, 2005). This type of curriculum uses a heuristic approach to help teachers develop a deeper understanding of the content and how to teach it. In the model presented here, this becomes a professional development model for inservice teachers as either the science education facultyor undergraduate preservice teachers model the lessons in the high school classroom while the teacher observes, using an observation protocol (Appendix B). Given the current COVID-19 pandemic, I had to delay the preservice and inservice teacher interviews to better understand how this helps them to develop as a pedagogical content expert and culturally responsive teacher. Once the IRB modifications have beenapproved, the interviews will be conducted during the summer and fall of 2020.

**Potentially transformative practice 3: Shifting the culture of STEM education.** The STEM Education conference has laid a transformative foundation by creating a purposeful, inclusive environment that brings everyone involved in P-16 STEM education together. The conference created a space for educators and students to have open, honest, and critical discussions about what is happening in the classroom.

For example, discipline-specific (chemistry, biology, engineering, mathematics, physics, and nature of science) roundtable discussions were intentionally designed to include faculty from the representative discipline as well as bilingual education, special education, early childhood, STEM education, P-12 educators (early childhood, elementary, middle/high school, bilingual, special education) and high school students. Each roundtable was led by a moderator who facilitated a P-16 vertical alignment of a topic or concept specific to the discipline (i.e., Newton's

Laws in the physics discussion). This novel discussion allowed everyone to understand what children are learning in STEM from preschool to college and to challenge the assumptions that are often made about our students. One high school student asked, “Why is there so much pressure for us to memorize in our classes?” The discussion that followed allowed the teachers, faculty, administrators, and students to share their perspective, leading to a vertical alignment that helped the group highlight strengths and better understand each other’s challenges. These sessions were recorded and will be transcribed to allow for an in-depth qualitative analysis.

Another transformative aspect of this conference was the building of local scholarship, including high school students. During the second annual conference, one of the presenters stated, “As a young Assistant Professor, Ken Tobin taught me the importance of developing the local before the national or international. It is local scholarship that leads to the development of undergraduate and graduate students who eventually become good colleagues and great thinkers, and can impact the communities in which they live and work. Yes, there is a time and place for both national and international work but that should never overshadow nor replace the local. In my view of the world, this conference has underscored this belief. A great example is an invitation you extended to high school students and some of their teachers. Not only were their teachers exposed to new ways of thinking but they were also. Perhaps this is the first time they had experiences that go beyond rote memorization and the development of good test-taking skills, making their experience much more critical as they had an opportunity to think on their own.” Often educators assume they know what is best and don’t always listen to students. Part of the vision is to ensure that students have a seat at the table and a voice that is heard.

The goal is to continue pushing the frontiers of STEM education toward transformation of best practices, research, and policy by challenging assumptions about what students know and can do in STEM through critical dialogue and reflection. I am pursuing external funding from the National Science Foundation to continue the research on the use of MVS to help students learn, with an emphasis on elementary and middle school STEM classrooms. In addition, the conference will continue with financial support from vendors, registration fees, and external funding.

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## Appendix A: Graphic organizer for “quadratic function”

Word: Quadratic Function

Please translate the following: *Recinto cuadrado en el que tienen lugar los encuentros de boxeo.*

**Square** enclosure in which the boxing match takes place.

What is this a photo of?

Spanish: Cuadrilátero
English: boxing ring

What is the English term for cuadrilátero?
Quadilateral

What are the characteristics of a cuadrilátero in this photo?

- Four sides of the same length
- Four corners

A cuadrilátero/quadrilateral has how many sides? Quatro/four

To determine the area of the cuadrilátero above, you would multiple what? Length x width in this case L=W, so L^2 or **x^2**.

Be careful! A quadrilateral is a shape with four sides whose interior angles add up to $360^0$. A **cuadrilátero** or boxing ring forms the shape of a **square** whose four sides are equal in length and interior angles are the same.

Quadratic is from Latin quadrus, meaning a square and is related to quattor meaning four. It can be easy to confuse the two! The term quadratic equations came about in the 1660s to describe equations containing the square of x.

A quadratic equation is one where the highest exponent is squared (x^2).
**A quadratic function is one that involves the square of x**.

Which of the following is/are an example of a quadratic function? Explain your reasoning.

A. $y = 2x - 3$
B. $y = 2x^2 + x + 1$
C. $y = 4x^4 + 2x^2 + x + 1$

A is incorrect because its highest exponent is to the 1st power. C is incorrect because its highest exponent is to the 4th power (be careful!). **B is correct because its highest exponent is squared (to the 2nd power).**

## Appendix B: Observation Protocol

Teacher name:
Data & Day:
School:
Period:

| Strategy | Frequency | Comments |
|---|---|---|
| **Morpheme analysis** Breaks down word into prefix, suffix, root | | |
| **Visuals**—uses any visual such as a graphic organizer, diagram, color coding, etc. | | |
| **Mnemonics-** memory i.e.- PEMDAS for order of operations | | |
| **1st language (Spanish)-** introduces/taught the word in Spanish | | |
| **1st language association-** making connections to Spanish | | |
| **Meaning association-** finding substitutes making connections | | |
| **Relevance-** making everyday life connections | | |

**Table 1**
Overview of lessons and vocabulary by discipline

| Subject | Lesson Topic | Vocabulary (strategies used) | |
|---|---|---|---|
| Biology | Mendelian genetics | Alleles (E, MA, L1)<br>Genotype (E, MA)<br>Phenotype (E, MA)<br>Dominant (E, MA, L1A)<br>Recessive (E, MA, L1A) | Zygote (E, MA, L1A)<br>Heterozygous (E, MA)<br>Homozygous (E, MA)<br>Monohybrid cross (MA, L1a, R)<br>Dihybrid cross (MA, L1A, R) |
| Chemistry | Chemical Reactions | Coefficient (MA, R, E, L1)<br>Subscript (MA)<br>Synthesis Reaction (MA, L1)<br>Exothermic (MA, R)<br>Endothermic (MA, R) | Combustion Reaction (MA)<br>Decomposition Reaction (MA)<br>Replacement Reaction (MA, R)<br>Equivalent (MA, R)<br>Dehydration Synthesis (MA, R) |
| Anatomy | Cardiovascular System | Atrium (E, L1)<br>Ventricle (E, MA, L1A)<br>Interventricular (MA)<br>Atrioventricular (MA)<br>Valve (MA, L1)<br>Bicuspid/Tricuspid (MA, A, L1, L1A)<br>Mitral (L1, A) | Pulmonary (L1)<br>Aorta (E)<br>Endo/peri/myocardium (MA, A, L1A)<br>Coronary (L1, L1A)<br>Septum (E, L1, L1A)<br>Vena cava (L1, E) |
| Algebra II | Quadratic Functions | Quadratic (E, L1, A)<br>Vertex (E, MA)<br>Interval (MA, A)<br>Coefficient (MA, A) | Polynomial (E, MA, L1, L1A)<br>Exponent (MA, E, L1, L1A)<br>Graph (E, L1) |
| Physics | Sound Waves | Medium (A, R)<br>Mechanical wave (R, L1, A)<br>Transverse wave (E, MA)<br>Longitudinal wave (MA, R)<br>Crest (E)<br>Trough (E) | Period (E)<br>Amplitude (E)<br>Constructive interference (E, MA, L1)<br>Destructive interference (E, MA, L1)<br>Node (E, L1, L1A) |

E-etymology, MA-morpheme analysis, A-meaning assoc., R-personal relevance, L1/L1A– 1st language/assoc.

**Table 2**
Mean gain scores by subject and group

| Course | *n* | Gain scores (Post - Pre) | |
|---|---|---|---|
| | | Comparison | Treatment |
| Algebra II | 93 | 5.7 | 24.6*** |
| Anatomy | 162 | 32.9 | 38.9* |
| Biology | 148 | 18.0 | 26.0** |
| Chemistry | 193 | 30.3 | 34.4* |
| Physics | 84 | 23.7 | 28.2* |

Significantly higher *** - $p<0.001$, **- $p<0.01$, *-$p<0.05$

**Table 3**
Attendees at 2nd Annual RGV STEM Education Conference

| Attendee Discipline | Percentage |
|---|---|
| Doctoral Student | 1.9 |
| High School Student | 13.1 |
| Undergraduate Preservice Teacher | 30.0 |
| Elementary Educator | *10.0* |
| Secondary Educator | *7.5* |
| Higher Ed — Administrator | *1.9* |
| Higher Ed — Education | *13.8* |
| Higher Ed — STEM | *13.8* |
| K-12 Administrator | 1.9 |
| Other, including informal STEM Education | 6.3 |