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Interactive, Conceptual Word Walls: Transforming Content Vocabulary Instruction one Word at a Time

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Abstract

Research shows a strong relationship between student word knowledge and academic achievement. This research study explores the use of interactive, conceptual word walls to support science learning in an ethnically diverse, high-poverty middle school in a large southern state. Unit test scores of 115 sixth grade students were collected and analyzed in order to test whether the percentage of students passing, and the mean test score among students, significantly varied on the basis of whether interactive, conceptual word walls were utilized. Both were found to be significant. Linear regression determined the effects of word walls on the basis of three demographic variables. On the basis of this analysis, the percentage of students passing is expected to increase by 25% and the mean test scores is predicted to increase by 12.56 points when interactive, conceptual word walls are utilized. Qualitative methods were used to analyze student and teacher perceptions. A good, better, best word wall rubric that was used to guide word wall construction and teacher reflection is also presented. Interactive, conceptual word walls are presented as a viable teaching strategy that positively impacts both unit test means and the total number of students passing science tests.

Keywords: Science achievement, vocabulary instruction, English language learners, low socio-economic status

1. Introduction

The United States is experiencing a profound demographic shift and the ethnic and racial composition of the nation’s public classrooms reflect these changes. During the past 20 years, the proportion of White students enrolled in public schools declined from 68% to 55% while the proportion of Hispanic students doubled from 11% to 22%. During this same period, the number of African-American students increased, but their share of enrollment decreased from 17% to 16%. The enrollment of Hispanic students in public schools surpassed African-American enrollment for the first time in 2002 and remained higher through 2008. The National Center for Educational Statistics (2012) expects the Hispanic population to grow at a faster rate than most other races/ethnicities. In 2025, about 21 percent of the U.S. population is expected to be of Hispanic ethnicity. This shift in classroom composition mirrors an increase in school-age students who speak English as a second language. The number of kindergarten – twelfth grade students who speak a language other than English at home tripled between 1980 and 2009, resulting in 11.2 million or 21% of all public school students being classified as language minority. The majority of these students report Spanish as their first language. Examination of the ethnic and racial demographic distribution in public schools reveals that large percentages of Hispanic (46%) and African-American (34%) students attend high-poverty public schools where more than 75% of the students are eligible for free or reduced-price lunch. (National Center for Educational Statistics, 2012).

Schools are under increasing pressure to meet accountability requirements and show growth in student achievement across tested content areas. Texas began testing science achievement in the 8th grade in 2004. The State of Texas Assessments of Academic Readiness (STAAR®), is administered to 8th grade students every April. Longitudinal analysis of statewide 8th grade science test scores reveal that English language learners and economically disadvantaged students consistently post scores that are considerably below the state average. These students are at substantial risk for falling and staying behind in science.

The number of students classified as English language learners (ELL's) is growing. In fact, ELL's 'are the fastest growing group of students in the US' (Stoddart, Bravo, Solis, Steven, & Vega de Jesus, 2009). Cummins (1996) proposed that ELL's receive instruction that is contextually rich and cognitively demanding. Contextually rich instruction builds basic language comprehension through the use of photographs, pictures, illustrations, diagrams, and experiences. Researchers found that the science achievement of ELL's improved when inquiry science was supported by contextually rich instruction (Lee & Luykx, 2006). Husty and Jackson (2008) reported that English language learners achieved a deeper understanding of science and enhanced vocabulary development in science when they were guided through inquiry-based, multisensory explorations that repeatedly exposed them to words and definitions in context. In fact, scores on high-stakes tests increased, across all student groups, when teachers used interactive word walls and provided opportunities for students to encounter and use science vocabulary in authentic and engaging ways (Jackson, Tripp, & Cox, 2011).

Research shows a strong relationship between student word knowledge and academic achievement. Words are the foundation of knowledge. They are powerful tools used to express ideas, communicate with others, access prior knowledge, and learn about new concepts. As a result, building academic content vocabulary is an important part of science instruction. With the numbers of ELL's in USA classrooms increasing, science educators must look for and use instructional strategies that enhance and support language acquisition.

'Researchers agree that teachers need to provide structured opportunities for students to encounter and use new words in authentic and engaging ways' (David, 2010). Robust vocabulary instruction involves 'directly explaining the meaning of words along with thought-provoking, playful, and interactive follow-up' (Beck, McKeown, & Kucan, 2002, p. 2). Graves (2006) proposed that a balanced approach to vocabulary instruction includes rich and varied language experiences for students, as well as explicit instruction addressing a limited number of well-chosen words. In addition, Stahl and Fairbanks (1986) suggested that effective vocabulary programs provide multiple exposures to words that have been introduced in meaningful context and involve students in processing the meanings of the words.

Many middle school classrooms have word walls displaying vocabulary students have learned in class. Word walls serve as visual scaffolds and are a common classroom tool used to support reading and language arts instruction. To support vocabulary development in science, Husty and Jackson (2008) created interactive word walls that resemble semantic maps (Masters, Mori, & Mori, 1993). Semantic maps are graphic organizers that help students identify important ideas and how those ideas fit together. They visually showcase relationships and may also be referred to as a web or concept map. An interactive, conceptual word wall organizes vocabulary and provides visual aids that illustrate word meanings in order to deepen understanding. These word walls usually include a visual representation of the word and a vocabulary label to accompany it. Vocabulary definitions are optional (Jackson & Narvaez, 2013). This article describes the results of our efforts to support ELL's in science by implementing interactive, conceptual science word walls in an ethnically diverse, high-poverty middle school in central Texas.

2. Research Purpose and Questions

Closing achievement gaps and improving science learning outcomes for all students are educational priorities. The pressing need to help language learners succeed in science prompted the following research questions: Would the use of interactive, conceptual word walls impact the science achievement of middle school students on unit tests? Would the use of interactive, conceptual word walls impact the science achievement of middle school English Language Learners on unit tests? To test these questions we developed a professional development initiative that taught middle school science teachers how to use a good, better, best interactive word wall rubric to guide the planning and construction of interactive, conceptual word walls. Then, we challenged teachers to plan and build interactive, conceptual word walls to support upcoming units. Finally, we compared 115 sixth grade students test scores on units that incorporated interactive word walls to the test scores of units that did not use this instructional strategy. We also compared the passing rate and mean test scores of students classified as ELL, Special education (SPED) and 504 to see if interactive word walls affected the unit test scores of unique student populations. This research study was conducted at an ethnically diverse, high-poverty, public middle school located in central Texas.

2.1 Professional Development Initiative

The professional development initiative included one whole day session and six campus visits. The morning of the whole day meeting introduced grade-level teams at Gordon Middle School (a pseudonym) to interactive, conceptual word walls. Teachers were given photos of sample science word walls and they were asked to sort them into three categories: good, better, and best. They were encouraged to generate criteria to support their sorting choices. They discussed their sorting criteria and developed a rubric that delineated the differences between good, better and best word walls. During the afternoon teachers worked to purposefully plan word walls for upcoming science units. They reviewed state science standards and their district science scope and sequence in order to identify and target vocabulary for unit word walls. They made lists of content specific vocabulary, vocabulary that the students should already know and vocabulary that would be essential in future grades. When the lists were complete, teachers matched each vocabulary word with a visual support or if the visual aides could be student created, they scheduled time for students to work on the visual supports in class or planned to assign them as homework. This provided for a mix of student generated and teacher prepared word wall elements. Teachers also looked for important semantic connections that should be highlighted to support understanding. Then they designed and sketched the word walls. The interactive, conceptual word walls, including both teacher and student generated materials, were then constructed during instruction (Jackson & Narvaez, 2013). Six follow-up campus visits occurred after the full day professional development. These bi-monthly visits took place during the 45-minute team planning periods. This gave teachers opportunities to ask clarifying questions regarding the use of word walls and share thoughts and concerns. Finally, test scores of units that were supported by word walls and units that were not support by word walls were collected and analyzed.

2.2 Good, Better and Best Science Word Walls

Traditional word walls are simply lists of words that are aligned with current instruction and posted in a classroom. This is a good beginning. Jackson and Narvaez (2013) found that teaching potential of word walls increases when student-generated material and visual supports including black-line pictures and/or cartoons are arranged to illustrate relationships between words and concepts in order to organize learning. The most effective word walls include photographs or the actual item (realia) as well as explicit connections between concepts. Teachers may also chose to include visual artifacts from inquiry based science activities to help students remember the activities and to connect labs with scientific concepts. This process supports deeper understanding of science because it provides opportunities for students to interact with the objects on display. We live in a visual society. Most students' everyday lives reflect the dominance of images. As a result, students have a lot of practice making meaning from information presented as images. Therefore, student participation in creating and maintaining word walls is crucial. Students can supply the items, create the labels, and suggest relevant connections. Table 1 contains the word wall rubric that was generated by teachers and subsequently used to guide word wall construction. It outlines the criteria needed to transform a good, traditional, word wall, a list of words, into a powerful interactive, conceptual teaching tool that involves students and supports learning (Jackson & Narvaez, 2013; Jackson, Tripp, & Cox, 2011).

Table 1. Interactive, conceptual word wall rubric

GOOD	BETTER	BEST
Academic vocabulary is posted	Academic vocabulary is posted	Academic vocabulary is posted
Aligned with current instruction	Aligned with current instruction	Aligned with current instruction
Words are visible from a distance	Words are visible from a distance	Words are visible from a distance
	Words are arranged to illustrate relationships and organize learning	Words are arranged to illustrate relationships and organize learning
	May contain student generated material	Contains student generated material
	Visual supports are black-line pictures or cartoons.	Visual supports are color pictures, photographs or the actual item (realia).

2.3 Purposeful Planning

'While standards-based curriculum and instruction were called for and conceptualized by national reform efforts (AAAS, 1993; NRC, 1996), standards must be operationalized at the state, district, school, and classroom levels' (Bianchini & Kelly, 2003). The Texas Essential Knowledge and Skills (TEKS) comprise the official curriculum in Texas public schools. To facilitate standards-based instruction, Texas school districts developed unique curriculum frameworks and pacing guides that they required their teachers to use to plan and pace instruction. These efforts typically begin with the 'development of aligned curricula—what will be taught, followed by cultivating pacing guides that specified when particular content and skills would be covered' (Protheroe, 2008, p. 38). Produced in-house by district personnel who may not fully understand the TEKS and the content being tested, the quality and rigor of these documents vary from district to district. As a result, classroom teachers shoulder the burden of translating these state standards into situated practice (Bianchini & Kelly, 2003). Wallace, Blasé, Fixsen, and Naoom (2008) stated that positive outcomes in education are the product of effective innovations and effective implementation efforts, concluding that teachers are the critical piece of the standards-movement puzzle because teachers' actions and words deliver the intervention. Thus, teachers are the key players in standards-based educational systems.

Teachers are most likely to improve student learning when they address specific learning outcomes in their planning (Schmoker, 1996). Purposeful planning provides teachers with opportunities to plan instructional activities that focus on the standards with fidelity while heeding district guidelines. It also provides time for teachers to understand the content vertically, answering the questions of what has been taught, what needs to be taught, and what will be taught in future grades. Furthermore, this time can be used to help teachers understand content connections and big ideas. Finally, it provides structure that encourages teachers to identify essential academic vocabulary and plan how they will connect targeted words during instruction.

The professional development initiative focused on alignment of instruction with the TEKS and identifying key content vocabulary underpinned all professional development activities. Grade-level teams were given vertically aligned copies of the sixth grade, seventh grade and eight grade science TEKS and instructed to use this primary source document to plan instruction. Teachers were taught to look closely at the rigor of the TEKS verbs, science content, and science process skills in order to understand the rigor and intent of the standard. They were also encouraged to look at the vertical alignment of concepts. As the TEKS became the primary planning tool, the district-prepared curriculum and pacing documents moved into supporting roles.

Once teachers understand the big picture, they are ready to build the wall with their students. Many teachers plan and structure instruction around the construction of the word wall. They strategically introduce new terminology while connecting the words to previously established terms during instruction. Some teachers build sections of the wall from scratch with each class while other teachers prefer to build the wall with their first period and then reference it throughout the day. Most teachers make efforts to include student-generated artifacts on their walls. Wall space and the room arrangement often determine the configuration and placement of word walls. They may be arranged on cupboard doors (Figure 1), on classroom walls (Figure 2), or hung from the ceiling using wire and string (Figure 3). Maximum instructional potential and efficiency is achieved when word wall construction is aligned with lessons. As s result, walls are usually built across many days and finished as a unit nears completion (Jackson, Tripp, & Cox, 2011).

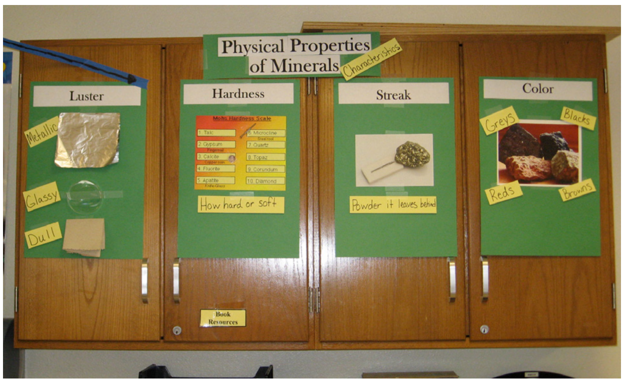

Figure 1. Word wall on cupboard doors

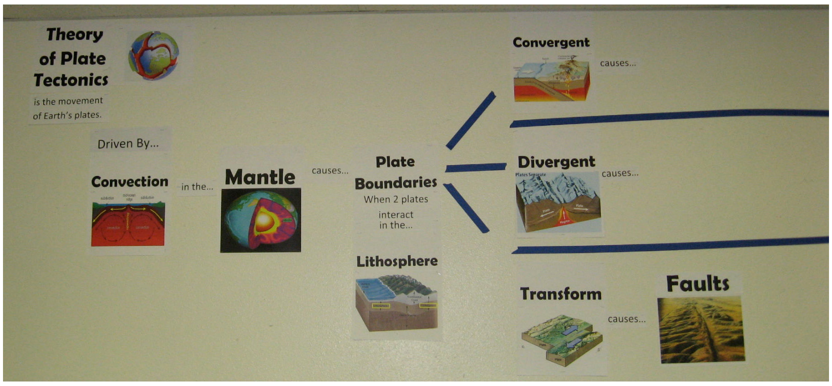

Figure 2. Word wall on classroom wall

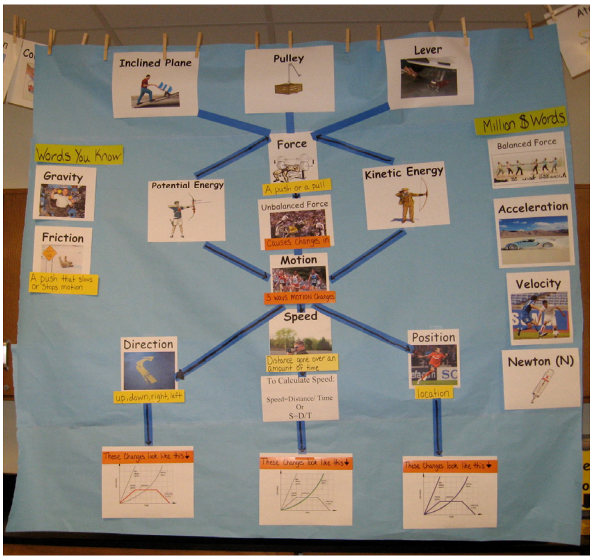

Figure 3. Hanging word wall

3. Research Setting

Our research project was driven by concerns about the low science achievement at Gordon Middle School. Additionally, we were concerned with the underachievement of ELLs and economically disadvantaged students. Gordon Middle School has a history of being rated Academically Acceptable by the Texas Academic Excellence Indicator System (AEIS) due to low scores on the eighth grade science Texas Assessment of Knowledge and Skills (TAKS) test which was replaced by the State of Texas Assessments of Academic Readiness (STAAR) test in 2011. The Academic Excellence Indicator System (AEIS) uses three indicators (TAKS/STAAR test scores, dropout rate, completion rate) to determine the accountability rating of schools in Texas and there are four rating categories: exemplary, recognized, academically acceptable, and academically unacceptable. The AEIS indicator system for middle schools is based primarily upon the performance of all students and of subgroups of students on the Texas Assessment of Academic Skills (TAKS/STAAR) content tests. Science

TAKS/STAAR scores are an important AEIS matrix and frequently determine a schools rating. To improve its AEIS ratings, Gordon Middle School needed to show growth in student achievement while closing achievement gaps in science.

3.1 Gordon Middle School

A sixth, seventh, and eighth grade campus, Gordon Middle School is part of a large school district that encompasses high-tech manufacturing and urban retail centers, suburban neighborhoods, and farm and ranch land. Serving 45,000 students, this district has a diverse ethnic base. 75 years old, Gordon Middle School has a history of serving ethnically diverse, economically disadvantaged, and at-risk children. The TAKS/STAAR test is the chief metric used to gage the academic success of students enrolled at Gordon Middle School and ensuring achievement for all students was the first strategic goal of the campus improvement plan. A focus objective of this goal included accelerating TAKS/STAAR gains for economically disadvantaged, African American, and Hispanic students to reduce existing achievement gaps. Table 2 contains a four-year enrollment history and ethnic distribution data for Gordon Middle School, collected by the Texas Education Agency (TEA, 2011) to determine the AEIS school ratings. Both Texas Education Agency and No Child Left Behind Act (2002) refer to students who are not fluent in English as Limited English Proficient (LEP) students; however, in practice, ELL is more common. The Texas Education Agency (TEA, 2011) describes an LEP/ELL student as a student whose primary language is other than English and whose English language skills are such that the student has difficulty performing ordinary class work in English. The Texas Education Agency (TEA) created The Texas English Language Proficiency Assessment System (TELPAS) to assess the progress that limited English proficient (LEP) students make in learning the English language. Students enter and exit LEP/ELL programs based on their TELPAS scores. The Texas LEP/ELL population includes over 120 languages. However, 91% of the ELL's in Texas schools are Spanish speakers and they represent 17% of the total student population (TEA, 2011). Membership in ethnic groups was self-reported by the students during school registration.

Table 2. Gordon Middle School enrollment history and ethnic distribution

School year	All	African American	Hispanic	White	Native American	Asian Pacific Islander	Economically disadvantaged	Limited English Proficient (LEP)	At-risk
2008-09	687	14.3%	54.6%	28.1%	0.4%	2.6%	63.2%	16.6%	58.1%
2009-10	668	13.8%	54.2%	27.7%	0.4%	3.9%	65.7%	15.7%	50.6%
2010-11	701	16.1%	52.9%	25%	0	2.9%	69.2%	13.4%	44.2%
2011-12	724	15.6%	55%	24%	0.6%	2.2%	68%	14.8%	43%

Table 3 compares the state, district, and Gordon Middle School percent of students passing the 8th-grade science assessment: the TAKS test. A TAKS score of 70 or better is considered passing. The percentage of Gordon students passing the test is consistently below the state and the district averages. Furthermore, English language learners (LEP/ELL) regularly score below the 70% passing rate. STAAR scores are not referenced in this article because 2012 was a pilot year and STAAR and TAKS scores are not analogous.

Table 3. Percent passing eighth grade state science assessment scores compared to state and district

Year	State Avg	District Avg	Gordon Avg	African American	Hispanic	White	Native American	Asian Pacific Islander	Eco Dis	LEP
2008-09	73%	84%	62%	55%	55%	81%	*	*	53%	19%
2009-10	78%	90%	77%	75%	70%	91%	*	*	68%	47%
2010-11	79%	89%	75%	51%	75%	82%	*	*	73%	45%

Note. * indicates fewer than 30 test takers, so the subgroup was not evaluated separately.

4. Method

4.1 Timeline

This research study was implemented at a grade six, seven and eight, ethnically diverse, high-poverty middle school during the 2010-2011 school year. The participating teachers, Sophia Bradshaw and Claire Lawrence (both pseudonyms), received interactive, conceptual word wall training during a district sponsored professional development session held on October 19, 2010. Ms. Bradshaw began using interactive, conceptual word walls during November of 2010 and Ms. Lawrence started to use them in January 2011. All quantitative data utilized in this study originated in Ms. Bradshaw's sixth grade class. Table 4 shows the implementation timeline of the intervention.

Table 4. 6th grade interactive, conceptual word wall implementation schedule

	Unit 2.1 Energy Transformation	Unit 2.2 Earth's Energy Resources	Unit 3.1 Force & Motion	Unit 4.1 Structure of Earth	Unit 4.2 Plate Tectonics	Unit 5.1 Classification	Unit 5.2 Ecosystems
Word Wall	Traditional	Traditional	Interactive Conceptual	Interactive Conceptual	Interactive Conceptual	Interactive Conceptual	Interactive Conceptual
Date	2nd 6-weeks	2nd & 3rd 6-weeks	3rd 6-weeks	4th 6-weeks	4th 6-weeks	5th 6-weeks	5th 6-weeks

Because the professional development initiative was implemented after the beginning of the school year, two units were taught with traditional word walls (see Figure 4) and five units were taught using interactive, conceptual word walls (see Figures 1, 2, or 3).

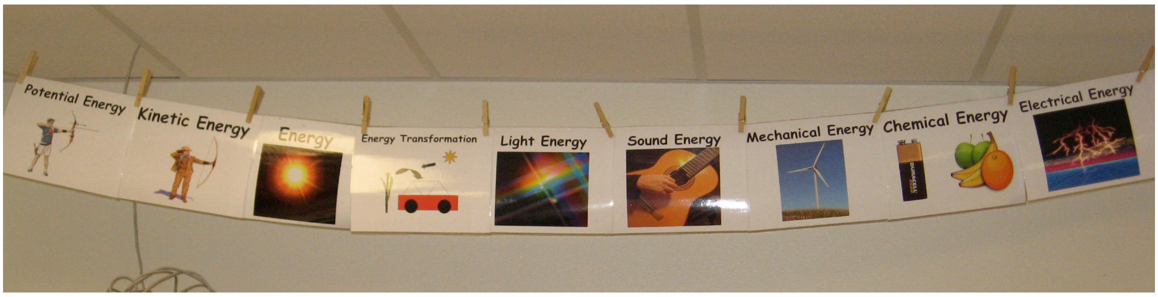

Figure 4. Traditional word wall

4.2 Classroom Demographics

Ms. Bradshaw and Ms. Lawrence have both been teachers for six years. They have exclusively taught science and have had LEP/ELL students in their classrooms every year. Ms. Lawrence is bilingual and received LEP/ELL training when she began her teaching career in Miami, Florida. Ms. Bradshaw has taught in Texas her entire career and is not bilingual. Both teachers had five years experience using traditional word walls to support instruction. This intervention provided them with their first opportunity to plan and use interactive, multi-sensory word walls.

Table 5 provides a snapshot of Ms. Bradshaw's sixth grade science classroom. It contains the number of students assigned to each class as well as the demographics of each period. Every period included students who were learning English as a second language. Three periods included special education students and two periods included students who were designated as 504. The school district assigned the student labels used in this study. English language learners (ELLs) are students whose first language is not English and who have been determined to lack proficiency in English reading, writing, and speaking through a series of language proficiency tests (TELPAS) and a review by the Language Proficiency Assessment Committee (LPAC). The LPAC is comprised of the English as a second language (ESL) teacher, a classroom teacher, school administrators, and a parent representative. Students who qualify for services under Special Education or 504 are first identified through the Response to Intervention (RTI) process. After identification, both Special Education and 504 students must meet eligibility requirements to receive services. Special Education determinations are made through diagnostic evaluations administered by a qualified speech/language pathologist, educational diagnostician, and a licensed specialist in school psychology. To qualify as 504, the student must have a physical or mental impairment that substantially limits one or more major life activities, have a record of such an impairment, or be regarded as having such an impairment.

Table 5. Participating 6th grade classroom demographics

	Total number of students	Limited English proficient (LEP)	Special education	504
1st period	24	58%	8%	*
2nd period	24	13%	16%	8%
6th period	21	14%	*	9%
7th period	23	17%	30%	*
8th period	23	9%	*	*

Note. * indicates zero students met this classification.

4.3 Data Collection and Analysis

Multiple data sources were utilized during this research study. Unit test scores from 115 sixth grade students assigned to Ms. Bradshaw were collected and analyzed using independent-samples t-tests in order to test whether the percentage of students passing, and the mean test score among students, significantly varied on the basis of whether interactive, conceptual word walls were utilized. Linear regression analyzes were conducted to determine whether using interactive, conceptual word walls helped specific student populations: LEP/ELL students, special education students, 504 students. A convenience sample of students enrolled in Ms. Bradshaw's first and second class periods were asked to describe how interactive word walls supported their science learning. Qualitative methods were used to analyze their written responses. Naturalistic inquiry methods (Lincoln & Guba, 1985) were used to analyze written responses. Three raters coded the data. The first rater analyzed, coded, and categorized the data by emergent themes. A second rater cross-checked codes and themes to ensure the reliability of the data. When there was a disagreement in coding a third rater was consulted and an agreement was reached to resolve the issue

The data analysis results section of this paper includes lists of emergent themes and supporting quotes. Finally, Ms. Bradshaw, a sixth grade science teacher and Ms. Lawrence, an eighth grade science teacher described their efforts to implement interactive, conceptual word walls. A synthesis of their experiences has also been included. Photographs of their interactive, multi-sensory unit word walls and corresponding unit tests were also collected.

5. Data Analysis and Results

5.1 Independent-Samples t-tests

Initially, independent-samples t-tests were conducted in order to test whether the percentage of students passing (see Table 6), and the mean test score among students (see Table 7), significantly varied on the basis of whether interactive, conceptual word wall were utilized. There results are summarized in Table 8.

Table 6. Percent of students passing and type of word wall used to support instruction

	Unit 2.1 Energy Transformations	Unit 2.2 Earth's Energy Resources	Unit 3.1 Force & Motion	Unit 4.1 Structure of Earth	Unit 4.2 Plate Tectonics	Unit 5.1 Classification	Unit 5.2 Ecosystems
Word Wall	Traditional	Traditional	Interactive Conceptual	Interactive Conceptual	Interactive Conceptual	Interactive Conceptual	Interactive Conceptual
1st Period	25%	25%	58%	75%	79%	46%	96%
2nd Period	62%	29%	38%	67%	79%	54%	96%
6th Period	48%	33%	57%	71%	76%	43%	81%
7th Period	26%	30%	26%	52%	39%	56%	91%
8th Period	65%	35%	35%	74%	61%	57%	78%

Table 7. Mean test scores and type of word wall used to support instruction

	Unit 2.1 Energy Transformations	Unit 2.2 Earth's Energy Resources	Unit 3.1 Force & Motion	Unit 4.1 Structure of Earth	Unit 4.2 Plate Tectonics	Unit 5.1 Classification	Unit 5.2 Ecosystems
Word Wall	Traditional	Traditional	Interactive Conceptual	Interactive Conceptual	Interactive Conceptual	Interactive Conceptual	Interactive Conceptual
1st Period	69%	56%	74%	77%	83%	70%	90%
2nd Period	72%	59%	70%	76%	80%	70%	86%
6th Period	71%	54%	69%	76%	83%	69%	82%
7th Period	60%	55%	60%	70%	68%	70%	82%
8th Period	75%	59%	73%	75%	81%	74%	81%

First, in regard to the percentage of students passing, 37.91% of students in total had passing scores when traditional classroom word walls were used, while this value increases very substantially to a total of 63.43% students passing in cases where interactive, conceptual word walls were used. The mean difference in the percentage of students passing was found to be statistically significant, $t(33) = -3.73$, $p < .001$.

Next, in regard to the average test score found, in cases where classroom word walls were traditional, the average test score was found to be 63.00. This average increased substantially to 75.56 in cases where interactive, conceptual word walls were utilized. This mean increase in test scores was also found to be statistically significant, $t(33) = -4.67$, $p < .001$.

Table 8. Summary of independent-samples t-Tests

Variable/Group	N	Mean	SD	t (df)
Percent Passing				
No Word Walls	10	37.91%	15.21%	-3.73*** (33)
Word Walls	25	63.43%	19.33%	
Mean Test Score				
No Word Walls	10	63.00	7.89	-4.67*** (33)
Word Walls	25	75.56	6.90	

Notes: *p<.05, **p<.01, ***p<.001.

5.2 Linear Regression Analyzes

Two linear regression analyzes were conducted in which the percentage of students passing and test scores were predicted from whether interactive, conceptual word walls were utilized, the percentage of LEP/ELL students, the percentage of SPED students, and the percentage of 504 students. The purpose of these analyzes was to determine whether using interactive, conceptual word walls helped specific student populations. Regressions including only these four predictor variables were run in order to initially determine whether interactive, conceptual word walls, and these demographics, were found to be significant. If both interactive, conceptual word walls and any of the demographic variables were found to significantly predict either the percentage of students passing, or mean test score, then interaction effects were analyzed in order to determine whether the benefit of the use of word walls significantly changed on the basis of these three demographic variables.

Table 9 presents the results of the initial linear regression analysis conducted on the percentage of students passing. As shown, while the demographic variables were not found to be significant predictors of the percentage of students passing, the use of interactive, conceptual word walls was found to be significant. On the basis of this analysis, the percentage of students passing is expected to increase by 25.5% in cases where interactive, conceptual word walls are utilized. The overall model was found to be significant on the basis of the significant F-statistic presented in the notes of the table. Additionally, this model had an R-squared value of .3406, which indicates that 34.06% of the variation in the percentage of students passing is explained by these predictor variables; namely, the use of interactive, conceptual word walls. As none of the demographic variables were found to be significant, no additional analysis was conducted focusing on interaction effects.

Table 9. Linear regression of the percentage of students passing

Variable	Coefficient
Word Walls	.255**
Percent LEP/ELL	.001
Percent SPED	-.003
Percent 504	.006

Notes: *p<.05, **p<.01, ***p<.001; N = 35; $F(4, 30) = 3.87$, $p < .05$; R2 = .3406.

Next, Table 10 presented below, presents the results of the initial linear regression analysis conducted on mean test score. Similar to the previous analysis, the use of interactive, conceptual word walls was found to be a significant predictor, while none of the demographic variables were found to be significant. In regard to interactive, conceptual word walls, this analysis found that the use of interactive, conceptual word walls led to a predicted increase in mean test score of 12.560 points. Additionally, the overall model was found to be significant, on the basis of the significant F-statistic presented in the notes of the table. Also, this model had a high R-squared value of .4688, which indicates that the independent variables included in this model (specifically, the use of interactive, conceptual word walls), was found to explain 46.88% of the variation in mean test score. Similarly to the previous analysis, interaction effects were not analyzed as none of the demographic variables were found to be significant predictors of mean test score. These results, in relation to both models, indicate that the effect of interactive, conceptual word walls on the percentage of students passing as well as test scores do not substantially vary on the basis of these three demographic variables.

Table 10. Linear regression of the mean test score

Variable	Coefficient
Word Walls	12.560***
Percent LEP/ELL	.046
Percent SPED	-.193
Percent 504	.079

Notes: *$p<.05$, **$p<.01$, ***$p<.001$; N = 35; $F(4, 30) = 6.62$, $p < .001$; $R^2 = .4688$.

Running a post-hoc power analysis, using a medium effect size f2 of .15, an alpha of .05, a total sample size of 35, and four predictors, the actual power in regard to R2 deviation from zero was .358, which is low. Using a large effect size of .35, actual power was .739, which was reasonably high. Power was higher when focusing on the significance of a single regression coefficient. Again conducting post-hoc power analyzes, with a two-tailed test, with a medium effect size of .15, an alpha of .05, a sample size of 35, and four predictors, power was .602. With a large effect size of .35, power was increased to .923. These results indicate that power was acceptably high in the case of a large effect size.

5.3 Student Perceptions of Word Walls

A convenience sample of sixth grade students enrolled in Ms. Bradshaw's first and second class periods (48 students) were asked to describe how interactive word walls supported their science learning. Forty-one students participated (85% return rate) and their perceptions are described in the following section. Their responses reveal that an overwhelming majority of students believe that the interactive, conceptual word walls helped them. Their responses to the open-ended question were reviewed, coded and sorted by emergent theme (see Table 11).

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Table 11. Student perspectives regarding impact of interactive, concept word walls on science learning (n=41)

Common Theme	Number of Responses
Helped me understand or learn vocabulary and definitions	19
Helped me remember	17
Used as a reference during classroom activities	12
Valued visual supports	10
Valued organization	8

5.4 Impact on Science Learning

When describing the impact interactive, conceptual word walls had on their learning, 19 students reported that the word walls helped them understand or learn vocabulary and definitions. One student wrote, 'the word wall helped me learn and understand the meaning of some words'. Another student valued the 'basic, very accurate definitions'. Several stated that the word walls helped them 'learn vocabulary' before they forgot it. Seventeen students used the word wall to help them remember the meaning of words. The word wall 'helped me because whenever I forget I could just look back and it gave me good information'. Additionally, it 'helps remind us of what we have learned' and 'since it is always up there I always remember'. Twelve students reported using the word wall as a reference during classroom activities. 'It helped me understand the meaning and know stuff that I need to know for a test or on a worksheet'. And, 'the word wall helps me because if I'm not sure of something I look there'. Ten students valued the visual supports included on the word walls. The 'word wall helps a lot because it can be a reference and I learn from seeing stuff so the pictures really help' and 'the word wall helps me by giving me a visual understanding'. Finally, eight students indicated that the way the words were organized on the word wall was important. 'I like the word wall because it helps me remember which order [the words] go in and the definition'. 'They helped me with picture definitions and the order that they go in helped me a lot'. And, 'it helps me see what other things that word is related to'.

5.5 Teachers Perspectives: Selecting the Words and Building the Wall

Ms. Bradshaw, a sixth grade science teacher and Ms. Lawrence an eighth grade science teacher described their experiences implementing interactive, conceptual word walls. Both agreed that organizing the word wall display was the most time consuming part of the process. Interactive word walls require planning. Because they build schema for individual terms through the use of images and manipulatives while showcasing connections between terms in a unit or lesson, both teachers needed to organize the information themselves before they could present it to and involve their students. Choosing terms for the word wall was not easy. First, they reviewed the essential content vocabulary and verbs included in the Texas Essential Knowledge and Skills (TEKS) for middle school science. Then they studied the vertical alignment of content vocabulary set forth in their district science curriculum. Finally, they identified common terms included in student expectations, science process skills, words students might know or have used in a different context, and words that they thought might challenge English language learners. For example, they included brief definitions and many connecting words like 'is made up of,' 'occurs in the,' and 'states that'. The next step required paring selected words with pictures. They tried to use the actual item or photographs instead of clip art or drawings whenever possible. They emphasized that pictures included on the word wall 'do not need to be elaborate'. Their purpose is to help students make quick and easy visual connections to vocabulary. Words and pictures or realia were then arranged on sheets of paper. Once essential vocabulary and phrases were identified and matched with pictures or realia, they sketched a concept map to organize content and connect the vocabulary. Completed sketches became blueprints for the actual word walls. This process organized information within a unit, just as a graphic organizer would. Additionally, the classroom word wall then became a unit organizer that students could easily reference to help them organize content and support vocabulary development as the unit progressed.

5.6 Teachers Perspectives: Challenges

The most challenging part of the word wall process was finding time to plan and sketch the concept map and locate appropriate photographs to go with the words. It was difficult finding unique and distinctive pictures to represent every term. For example, while 'speed' and 'velocity' were be differentiated by finding a way to visually acknowledge that velocity includes direction, coming up with a simple picture for 'acceleration' that distinguishes it from those of 'speed' and 'velocity' was difficult. Also, making the word wall interactive for students was logistically difficult. One teacher used Velcro® tape to move words on and off the word wall with each class as she progressed through the school day. Deciding when and how to rotate word walls was also challenging. Wall space was a factor in the study science classrooms making it difficult to display multiple word walls simultaneously. Finally, certain science topics were easier to work with than others. However, given these challenges Ms. Bradshaw and Ms. Lawrence believe it was well worth the effort and they made time to plan and implement interactive, multisensory science word walls. They discovered that defining terms does not deepen understanding if students cannot see and understand the unifying connections between concepts.

5.7 Limitations

The sample size is a potential limitation of this study. Future studies could include a larger sample size in order to increase statistical power. Additionally, this study did not include pre-test measures, therefore it was not possible to determine whether or not significant differences existed between groups of students before word walls (traditional or multi-sensory, interactive) were utilized. Future studies could utilize pre-test measures as controls in order to account for any initial differences which may exist between groups of students. Student responses were anonymous and as a result the researchers were unable to distinguish the open-ended responses of students labeled as ELL's, special education, 504, or any combination of the above labels from other students. It would be interesting to survey these student populations to determine their perceptions regarding the usefulness of interactive word walls. Finally, student learning from other sources could be a potential limitation of this study.

6. Conclusion

Public schools in America are challenged by the changing demographics of classrooms and the rapidly increasing numbers of students who speak English as a second language. Many teachers struggle to meet the needs of linguistically diverse students and actively seek research-based strategies that may be used to enhance vocabulary instruction. The present research suggests that using interactive, conceptual word walls may contribute to student achievement in science. Interactive, conceptual word walls support dynamic vocabulary instruction while providing an overview of each lesson, and upon completion, an overview of the unit as well. Teachers who implemented these word walls found that they made organizing unit instruction easier and focused planning meetings. The planning process that teachers engaged in prior to word wall construction appears to help them understand the content and the connections among the concepts better. This increased understanding may have positively impacted instruction. Additionally, Ms. Bradshaw saw significant gains in her sixth grade students mean scores and the number of students passing the summative tests of units that had accompanying interactive word walls. Furthermore, students reported that these word walls helped them see connections between and among terms, recall connections, and learn vocabulary. Moreover, students became more self-sufficient during activities and labs; finding information they needed by looking at the word wall.

Despite the significant increase on actual unit test mean scores and the number of students passing unit tests and the prediction that future test scores and the number of students passing would increase, the data did not significantly vary on the basis of three demographic variables. Quantitative data analyzes suggested that LEP/ELL's, SPED and 504 students were not helped differentially by interactive, multi-sensory word walls. However, qualitative data analysis revealed that all students valued having access to the word walls and used them as a reference when completing classroom assignments and for remembering content from one day to the next. Students' acknowledged that they benefited from visual, concrete displays of science content arranged in logical sequences. Interactive, multi-sensory word walls are a reliable resource that students may reference in their efforts to apply English vocabulary when participating in or listening to classroom discourse, as well as when asked to read or write about science content.

The results of this study contribute to the research by reporting that interactive, multi-sensory word walls may support improved science achievement and increase students' ability to effectively apply the language of science in classroom and testing situations. Additionally, when teachers are given time to purposefully review content standards, organize instruction, and plan word walls their understanding might be strengthened. Interactive, multi-sensory word walls might support differentiation because they visually display vocabulary definitions and showcase connections between concepts. They also provide effective lesson planning structures for teachers and are a viable teaching strategy that benefits most students.

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