Supporting ELLs in STEM

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Abstract

English Language Learners (ELLs) are underperforming in Science, Technology, Engineering, and Mathematics (STEM) classes. Based on the educational theory of constructivism, ELLs need educational experiences that build off their prior knowledge. The overarching research question of this Capstone is: How to support ELLs in STEM. ELLs are underperforming in STEM content areas in the U.S., and in service STEM teachers have had little training on how to support ELLs (Besterman et al., 2018). In addition, Latino/a individuals are underrepresented in STEM career fields (Funk & Parker, 2018). This capstone project creates opportunities for STEM teachers to learn about researched based strategies to support ELLs, and practice implementing the strategies into lessons of their own with guidance from ESOL teachers. From the PD, STEM teachers and ESOL teachers will learn the importance of supporting ELLs with research based strategies in STEM classrooms. ESOL and STEM teachers will build collaborative relationships that are meant to continue beyond the training. More research needs to be done on strategies to support ELLS in STEM and on the possible need for ESOL services in STEM classes.

Keywords: ELLs(English Language Learners), STEM(Science, Technology, Engineering, and Mathematics), Strategies, Constructivism

Chapter 1: Introduction

Problem Statement

In my teaching experiences as a special education teacher in upstate New York, I have been in many different classrooms. I have co-taught all of the core four content areas (English, social studies, math, and science) at the middle school level. Moving on from special education to focusing on ESOL (English to Speakers of Other Languages), I have noticed that ESOL students are not receiving the same level of support in STEM classes. Frequently, in the ELA classroom I have two co-teachers, one general educator and one ESOL educator. Occasionally, I have experienced co-teaching with an ESOL teacher in a social studies class. However, I have never been able to co teach with an ESOL teacher in a math or science class.

With the advent of Common Core and Next Generation Standards, math and science teachers have to incorporate a more language-based curriculum. The increase in linguistic demands in classes does not factor in additional support for general education teachers in the STEM (science, technology, engineering, and mathematics) content areas. Without support, the content area teachers are teaching a linguistically rigorous curriculum to a student population that has a growing percentage of English language learners (ELLs). Therefore in this capstone project I will be examining and presenting a professional development (PD) addressing the overarching research question: How to support ELLs in STEM.

STEM general educators need adequate support or training to be able to serve the diverse student population they teach. Vespa et al. (2020) projected that the U.S. population will continue to become increasingly more diverse. The authors point out by 2060, almost 32% of children under the age of 18 in the U.S. will be Hispanic. The percentage of Asian children in America is

expected to rise during this time as well. The growth in these two ethnicities will affect the need for all teachers to be trained to teach ELLs.

The problem of ELLs not receiving instruction tailored to their needs in STEM content area classes is evident in ELLs performance on standardized tests. Garcia et al. (2012) found that from 2005 to 2009 in the state of Arizona, ELL students are underperforming compared to non-ELL students on standardized reading and math assessments. STEM teachers need to be given training and taught strategies to implement in their classrooms to support ELLs.

Key Terms

First, I will define the terms needed to define my capstones' overarching question. The first important term I will be using in my capstone project is ELL (English Language Learner). This refers to any individual who has a first or native language other than English and is now leaning English. This term describes someone learning English because they have moved to an English speaking country or a person who is learning English as a foreign language in a non-English dominant country. Moving on to a second important acronym, ESOL (English to Speakers of Other Languages) is used to describe the teaching certification area or specialty area of working with the diverse population of ELLs with the goal of supporting English language development alongside content area learning. Another important term, STEM (Science, Technology, Engineering, and Mathematics) which refers to academic content areas. These content areas are vital to supporting growth in science and computer related careers.

Next, I am going to describe the terms needed to describe the strategies to use in STEM classrooms to support ELLs. One of the most common strategies used to support ELLs across content areas are visual aids. Visual aids are images, diagrams, videos, and other graphic media that provide students with concrete examples to connect meaning to English words. In addition,

mind mapping is a strategy that has students create a nonlinear diagram representing concepts, words or tasks. This strategy allows students to express their knowledge without the pressure of grammatically perfect sentences. The last strategy based term I am going to explain is geospatial inquiry, which is asking and answering questions about our world by analyzing data based on geographical location.

How can ELLs get the scaffolds they need in STEM classrooms? Some specific strategies can support ELLs in all content areas. For example, the use of geospatial inquiry, visual aids, and mind mapping. Kangas et al. (2019) argues geospatial inquiry leads to the most accessible and reasonable science learning for ELLs. Wright et al. (2015) makes the argument that appropriately designed visual aids can improve science learning for ELLs without watering down curriculum. Wilson et al. (2016) found mind mapping to support accurate formative assessments of ELLs. Science teacher need to be able to scaffold the curriculum to meet the needs of ELLs

Similarly, to science, researchers have found specific strategies that help to support ELLs mathematics classes. Specifically, ELLs can be supported in mathematics class by being provided notes ahead of time, culturally and linguistically responsive schema intervention, and even the simple intervention of additional wait time. Driver and Powell (2017) explain how culturally and linguistically responsive schema intervention uses students' prior knowledge to breakdown word problems in mathematics classes. Chen et al. (2019) explains how providing notes ahead of time and giving additional wait time can improve ELL students' outcomes in mathematics classrooms. Mathematics educators need to tailor their instruction to meet the needs of the growing ELL population.

STEM teachers are not prepared to teach ELLs. Besterman et al. (2018) reports that less than a quarter of STEM teachers are attending professional development to learn how to support

ELL students. This is an issue because over fifty percent of STEM teachers reported teaching ELLs. The under trained teachers are one of the many factors that lead to ELLs underperformance on standardized tests.

Teachers need professional development that targets learning specific strategies STEM teachers can bring back to their classrooms. Hansen and Richins (2015) found positive results from a short-term mentorship between an ESOL teacher and a science or math teacher. Meskill and Oliveira (2019) took an in depth look at a yearlong professional development that created a mentorship between a science teacher and an ESOL teacher. The general education teachers' opportunities to co-construct lessons with a specialist on ELLs lead to great learning.

Significance of the Problem

ELLs are not receiving support in STEM classes. STEM teachers lack training on scaffolding instruction for ELLs is affecting all of America. Funk and Parker (2018) reported that Hispanics are underrepresented in the U. S. workforce in STEM career fields. We must consider we are unsure of how many of the STEM workers' first language is or is not English. Therefore, I am assuming that students are not pursuing a career in STEM because they are struggling to learn based on a language barrier. My assumption is supported by DeKay (2018), who reports ELLs are struggling to find appropriate employment due to their low English Language proficiency. Latinos being underemployed due to language is a serious problem because now socioeconomic status and social mobility are being limited for Hispanic ELLs.

Purpose

We can start to solve the issue of ELLs not getting the support they need in STEM class by training STEM teachers to use target strategies. ESOL support in STEM classes can improve student learning. In order to mitigate the problem of ELLs not receiving tailored instruction in

STEM classes I am designing a professional development (PD) to help foster collaboration between ESOL and STEM teachers in planning instruction. The PD will include both ESOL teachers and STEM teachers. STEM content area teachers will be required to bring one or more lesson plans to each of the three PD sessions.

At the beginning of each PD session teachers will be taught two to three research based strategies to support ELLs. The second part of the PD will be breakout sessions where teachers will be working on implementing one of the strategies taught at the beginning of the session in the lesson plan they brought with them. The breakout groups will each contain at least one ESOL teacher. The ESOL teacher will be there to guide and support the STEM teachers in adapting their lesson plans. The sessions will end with a share out. One teacher from each group will briefly share how their group is scaffolding their lessons for ELLs. Teachers are encouraged to share contact information two continue to collaborate after the PD is over. The first goal of the PD is to teach STEM teachers specific strategies that can support ELLs in their classrooms. The second goal is to demonstrate how ESOL teachers and content area teachers can collaborate to create lessons with ELLs in mind.

Summary

ESOL students are not receiving the scaffolds they need to be successful while acquiring English and trying to learn content at the same time. STEM teachers need to be taught the scaffolds to use with the different levels of ELLs. We are going to provide PD to STEM and ESOL teachers. This PD will help build more collaboration on lesson planning and teach STEM teachers what kinds of strategies they should be using. This PD will help start the path toward continual collaboration between STEM and ESOL teachers. The hope is that this collaboration will continue after the PD into the next school year.

In chapter 2, I will be reviewing literature on strategies to support ELLs in STEM classrooms. This chapter will be broken down into categories based on content area. The first section will be on strategies used in mathematics classrooms. The following section will be on strategies used in science classrooms. The third and final section will be on strategies used in technology and engineering classrooms to support ELLs. The breakdown of the research on strategies is the basis of the strategies chosen for the PD.

In chapter 3 of this capstone, I will explicitly describe the PD. I will outline what strategies taught at the beginning of each session. This chapter will go into detail of how break out groups will be decided based on the population of teachers who attend the PD. The PD will take place over the summer. Teachers will be required to attend the PD in person.

Chapter 4, the final chapter, will be a conclusion of why the lack of scaffolded instruction is a serious problem in STEM classrooms. I will explain why this problem is important to solve for students, teachers, and administrators. In addition, I will provide my recommendations for further research.

Chapter 2: Literature Review

Introduction

In this chapter, I am going to examine what the literature says about my overarching research question: How can ELLs be supported in STEM. Content area teachers need have training on the research based strategies needed to support ELLs learning content alongside learning the English language. I am grouping the strategies into three categories. The first two categories are the two major content areas of Math and Science. The third category is technology and engineering content areas, I have lumped them together due to lack of research on the content areas individually around supporting ELLs. The final part of this chapter reviews technology as a set of tools to support teaching ELLs. By reviewing the research on ELLs targeted strategies by content area several strategies are shown to best serve students in the STEM content areas. In addition, I would like to point out that most strategies could be utilized in any content area when adapted to meet the content areas standards.

ELLs need to be given opportunities to construct and discover their own learning within the classroom. The strategies that will be discussed later on in this chapter are based on constructivism as a theory for education. Elliot et al. (2000) defines constructivism as a learning approach that believes learners build or create their own knowledge and reality based on the experiences of the learner. ELLs learning must be tailored to provide experiences to build on their current knowledge of the English language, their native language, and the content being taught. Marsh and Iran-Nejad (1995) explain how constructivism presents itself in the classroom, learning happens within experiences. This means learning happens based on past experiences, and new experiences become linked to past experiences forming students' current understandings.

For the purpose of this capstone, I am focusing on two major types of constructivism. Bächtold (2013) explains the difference between Piaget and Vygotskys' view on constructivism. Bächtold states the Piagets' work aligns with personal constructivism or the idea that students build new ideas and concepts off of prior knowledge and personal experiences. On the other hand, Bächtold describes Vygotskys' work as social constructivism or the idea that new knowledge is learned through social interactions. The issue with personal constructivism in science is that Piagets' view of the theory "does not explain how the construction of concepts carried out by students can lead to the models or theories constructed by scientists" (Bächtold, 2013, p. 2481). In other words, Piaget felt that students could not discover in a grade level what scientists have taken decades to learn. In constructivism, students can build their knowledge through personal experiences or social experiences. Both types of constructivism will be the basis of the reasoning of the effectiveness of strategies chosen to support ELL students in STEM (Science, Technology, Engineering, and Mathematics) classrooms. Strategies will be further supported by specific research.

ELL Focused Strategies

Many strategies in the research literature discuss work to support ELLs also tend to work across the board in other classrooms and content areas. In this section, I will review what current research says about specific strategies that support content instruction targeted on the various STEM content areas and what technological applications are available to support ELLs. I feel it is important to discuss these common strategies and technologies to help educate STEM teachers on how to support ELLs.

Mathematics

Accountable Talk. Accountable talk and the importance of conversations in the classroom is supported by several studies. The generally accepted definition of accountable talk is a community where students have discussions where peers hold one another to a standard of sharing accurate knowledge. Peer to peer and teacher to student conversations about content supports ELLs learning of the content and development of the language. Cardimona (2018) completed a study to analyze how questioning and wait affect ELLs math progress in a small group or pair with an ELL peer tutor. Cardimona recruited 8 ELLs from the same urban school and grouped students heterogeneously to create a tutor and tutee dynamic. Based on the study, Cardimona argues that collaborative dialogue supports ELLs learning mathematics. Cardimona found that guiding questions provided ELLs with a high level of support with a high level of participation. Thus, students should be taught how to ask one another guiding questions during group and partner work time in order to support each other's' learning and not just give one another the correct answers. Collaborative dialogue fits the social constructivist model and supports students constructing their knowledge from their social interactions. Students build their understandings from the interactions and verbal communication with their peers and teachers.

In fact, Chen et al. (2019) conducted a study to determine what resources a teacher can provide ELLs to support during lecture based mathematics classes. Throughout 4 consecutive semesters, Fall 2014 - Spring 2015, Chen et al. provided students will various supports during lectures. At the end of each semester, the ELLs were surveyed on the supports provided to determine the ELLs preference of supports. Chen et al. study included 48 first year university ELL students. It is important to consider how to support ELLs in note taking during direct instruction in primary, middle, and high school settings. ELLs need clear materials to look back

at throughout the learning process. In addition, Chen et al. insists on the importance and effectiveness of pausing for student discussion within math lessons. When students are given the opportunity to discuss the mathematical concepts, they are able to construct and solidify their understanding of the instruction.

Hoody et al. (2019) takes Chen et al. assertion for the need for discussion break to another level, suggesting that well designed math activities must include group work and discussion. Hoody et al. makes a point to describe how language production in math is important for language and math learning. However, Hoody et al. points out math-teaching resources rarely include activities based on peer conversations. Based on the research findings presented, it is reasonable to conclude that using accountable talk including small group and whole group discussions within mathematics classrooms will support ELL students mathematics and language development.

Culturally Responsive Mathematics. The second strategy mathematics teachers can use to support ELLs is using culturally relevant mathematical problems. In the same way the argument of using real world mathematical examples helps bring meaning to the classroom, culturally relevant mathematics instruction and problems help students to relate the content to their own experiences. By relating the content to the students prior knowledge the instructional approach aligns with the personal constructivist model beliefs that students construct their understandings based on their own experiences.

Newkirk-Turner and Johnson (2018) reviewed current research on the debate around mathematical assessments having linguistic bias and the role of a speech-language pathologist. Additionally, Newkirk-Turner and Johnson examined the results of ELLs performance on word-based math problems on mathematical assessments items. The results of Newkirk-Turner

and Johnson point to the prior research and ELLs performance on word-based test items revealing an association between linguistic and content(cultural) biases in word-based mathematical assessment items.

When a student does not understand the context of a question they are not being assessed on their math knowledge. Driver and Powell (2017) reference multiple studies showing that students learn best when word problems relate to the student's prior knowledge or schema. Driver and Powell conducted a study where they implemented culturally and linguistically responsive schema intervention (CLR-SI) specifically with targeted word problems with 3rd grade ELLs over 10 weeks. The results of Driver and Powell's study showed implementing culturally and linguistically responsive schema intervention (CLR-SI) improved ELLs word problem solving skills. Thus, it is clear that without culturally relevant mathematics instruction and word problems that the gap in performance between native English speakers and ELLs on mathematical standardized tests will persist. Mathematics teachers need to consider the word problems they choose to use within their classrooms carefully. The word problems should include familiar names, places, and things that the ELLs will be able to comprehend to ensure ELLs can focus on the mathematics concepts.

Translanguaging in Mathematics. A strategy that can support ELLs in mathematics classes is translanguaging. Willey and Morales (2020) completed a study during an afterschool program in an urban midwestern school where 99.4% of the student population was latino/a. During the study students engaged in bilingual peer and whole group conversations and interacted with a computer program bilingually. Willey and Morales assert that the communicative practice of translanguaging supports students using their full linguistic repertoire of languages in academic settings. Another interesting conclusion derived from Willey and

Morales' study is that parents are great examples of translanguaging. Parents are a wonderful resource and should be used to incorporate translanguaging inside and outside of the classroom. The use of two or more languages simultaneously can increase students' comprehension and comfortability in the classroom.

Guglielmi (2012) reviewed the results of The National Education Longitudinal Study conducted by the National Center for Education Statistics (NCES) that followed 27,000 eighth graders for 12 years. Guglielmi reviewed the data collected from students test scores, grade point average, and surveys completed by student, teachers, and parents given every 2 years for 6 years of the students schooling. Based on the data Guglielmi analyzed the multivariate data and found that a student's level of proficiency in native language in 8th grade led to the student's higher proficiency in English in later grades. Students' English proficiency affected their performance in math and science content areas. Thus, student use and practice of their L1 or native language can lead to higher achievement in STEM classes. Guglilmi's findings support the importance of cultural relevance and translanguaging by claiming that students' native language learning leads to their second language acquisition. Willey, Morales, and Guglielmi verify that supporting students' use of their native language in the classroom leads to students developing a positive personal identity and higher self-esteem. Guglielmi reported that high self-esteem did slightly influence ELL achievement in mathematics classrooms. Through using translanguaging ELLs will feel more confident and accepted in their mathematics classes. The communication practice of translanguage should be encouraged in mathematics classrooms to support ELLs learning.

ELLs have been underperforming in mathematics classes and need to be provided adequate support to mathematics instruction. Accountable talk, culturally responsive curriculum, and translanguaging should be used to support ELLs mathematics and language development.

Students need opportunities to produce language around mathematical concepts to help construct their own learning through social interaction. Students' culture and linguistic background must be used as a strategic asset. The curriculum and word problems must reflect the students' prior schema. Again, these strategies can be useful in all content areas. The research supports the use of accountable talk, culturally responsive curriculum, and translanguaging strategies specifically in mathematics in order to support the progress of ELLs learning mathematics and the English language.

Mathematics instruction of ELL students can utilize many strategies. In this section, I have described three research-based strategies that can be used to support ELLs in mathematics classes. The first strategy of accountable talk incorporates student dialogue and discussion about content. The person doing the talking is the person learning. This strategy allows students to learn the content and the English language through conversation.

The second math strategy of culturally relevant instruction is used to support students comprehension of mathematical context. ELLs underperform on word problems due to lack of vocabulary knowledge. When teachers create word problems that are relevant to students lives and culture they are more likely to have the vocabulary to be able to comprehend what the question is asking.

The last strategy discussed around mathematics instruction is translanguaging. This strategy can be used in conjunction with any content. I feel math is a perfect fit for this strategy because the class is not focused on explicit English instruction. Translanguaging is when students are given activities that help them use their L1 or native language to make connections to their L2, which in this case is English. The students' native language is an asset that students

can transfer knowledge from their native language to English. This is particularly useful at the secondary level where ELLs tend to have a solid background in their native language.

Science

A few strategies that science content area teachers should be implementing to support ELLs are sentence frames, mind mapping, visual aids, and inquiry based geospatial instruction. Science is a content area that aligns closely with constructivism. Labs and experiments provide students with opportunities to learn and build their understanding of science from experiences. Even with target experiences, ELLs need scaffolding to ensure that they are learning the science content correctly and understanding the language around the content.

Sentence Frames. A common strategy I want to mention is sentence starters or sentence frames. Sentence starters or sentence frames can support students in any content area. A sentence frame is not a cloze or a fill in the blank activity. Instead, a sentence frame provides students with key vocabulary and supporting words. According to Block (2020), sentence frames are when students are asked to complete the sentence, and each missing piece of the sentence has multiple words or phrase choices that could correctly complete the sentence. Block found sentence frames help teach science vocabulary to ELLs. However, Block found that sentence frames have little effect on ELLs performance on assessments. Many strategies can be used to support ELLs in science classrooms and beyond, including sentence frames.

Mind Mapping. Mind mapping allows ELLs to express their scientific knowledge without being held back by the language barrier. According to Wilson et al. (2016), mind mapping is an illustration or visual made to organize information. Mind mapping is a constructivist-based strategy that will allow ELLs to express their understanding and build new connections between concepts in a visual way. Wilson et al. describes how a mind map starts

with a central abstract concept in the center of the diagram with supporting ideas surrounding the main concept. The further the idea is from the abstract central idea the more concrete the idea is. In addition, Wilson et al. reports on how mind mapping requires the use of both the left and right side of the brain, and in turn leads to deeper learning. ELLs are able to use mind mapping to organize their thoughts about a scientific idea without the pressure of writing a grammatically perfect sentence in English. Wilson et al. conducted a study of students at a Middle Eastern tertiary institution and their use of mind mapping in science coursework. Wilson et al. found that teachers were able to easily assess ELLs scientific comprehension of content via mind mapping. In addition, Wilson et al. reports that mind mapping supports ELL students' learning by reducing the cognitive load and giving students the opportunity to creatively express their understandings.

Furthermore, Prabha and Aziz (2020) conducted a study to see how mind maps influences third year Malyasian students' vocabulary acquisition in English. Prabha and Aziz's results insist that mind maps help ELL students remember words, their meaning, and their spelling. Therefore, mind maps should be used in science classes to support ELLs vocabulary development.

Visual Aids. A commonly used strategy that is beneficial to supporting ELLs is visual aids or images. Science concepts can be displayed in models and diagrams to help all learners make sense of specific concepts. Wright et al. (2015) reviewed current research around visual aids and provided clear examples of what visual aids should look like in science classrooms. Specifically, Wright et al. wants teachers to know visual aids should make tasks or understanding easier for the students. Wright et al. makes the argument that appropriately designed visual aids can improve science learning for ELLs without watering down curriculum. In other words,

science instruction can be complex and abstract, and quality graphics can support student comprehension of the science content without the burden of linguistic demands.

Britsch (2012) uses previous research to advocate for teacher created images to support teaching ELLs. Moreover, Britsch claims that visuals can provide students with an experience that allows them to discover language in an active way. Bitsch explains how visuals help student's link words to meaning and their native language. In short, visual aids apply to the personal constructivism model where students build their own learning.

Greathouse and Lincoln (2008) reviewed previous research and wrote an article giving advice to science teachers serving ELLs. Greathouse and Lincoln claim that visuals alongside language focused instruction assists students in tapping into their prior knowledge and schemas. When students see an image and see the written word in the same experience students are more likely to remember what they are learning. To put it succinctly, visual aids should be used to support science instruction of ELLs.

Inquiry-based Geospatial Curriculum. Kangas et al. (2019) describes a science curriculum designed for ELLs that was built in collaboration with ninth grade science and social studies teachers. Kangas et al., Lehigh University, and the National Science Foundation created this inquiry based geospatial curriculum that provides students with learning through discovery about their current geographical location. The curriculum is available online for free (see Appendix C). Kangas et al. verifies the need for rigorous and relevant instruction for ELLs. Following the constructivist model, inquiry-based tasks are best because they give students the opportunity to discover a scientific phenomenon and build their own understanding of science. The importance of the geospatial component of the science curriculum is the way the tasks incorporate students' prior knowledge about the geophysical features around them in their current

environment. The curriculum discussed by Kangas et al. was created for an urban setting, and provides a great example of inquiry based geospatial learning. The authors argue that science teachers should be tailoring their instruction to provide ELLs with the opportunity to discover science through their community.

Technology and Engineering

A few strategies that have been found to support ELLs in learning the content areas of technology and engineering are hands-on activities, natural opportunities to talk, and explicitly taught academic language. Therefore, a gap exists and further research on targeted strategies to use in the content areas of technology and Engineering needs to be completed. Since, current research on ELLs in a technology or engineering class offered during traditional school hours is not readily available. Generally, engineering classes or after school programs can use hands-on activities and problem based learning tasks to support ELLs. Diverse learners have limited opportunities to participate in STEM activities due to lack of school funding or personal cost to families. I am going to review the findings from studies completed in programs that happen outside of traditional school hours. The themes I noticed are the importance of hands-on experiences, opportunities for natural communication, and the need for explicitly taught academic language. The lack of research further shows that ELL students do not have access to technology and engineering curriculum during their school day.

Hands-on Experiences. Hands-on experiences support ELLs in learning Engineering and technology concepts. Fiore and Cooper (2019) explain a collaborative program between a middle school for refugees and preservice teacher undergraduate students within the Maker Spaces, which are locations where groups collaborate via the Maker Movement. The Maker Movement is known for bringing groups together making or creating things. The focus of Fiore

and Cooper's collaboration is to bring STEM activities to ELL students who would normally not have access to such programs. Fiore and Cooper advocate for more educators to create collaborative groups through the Maker Movement to bring more STEM opportunities to diverse learners.

Authentic Communication. Teachers need to create natural opportunities for communication to support ELLs development of technology and engineering learning. McVee et al. (2017) followed several elementary students participating in an STEM after school program that met for 1 hour twice a week for 7 weeks. McVee et al. makes a point to show how the ELLs in the focus group of students are able to use multimodal communication to participate in the group. The hands-on activities completed in this afterschool program give ELLs the opportunity to have natural opportunities to communicate linguistically and beyond. Students are more motivated to learn the content and the English language when they are given genuine opportunities to apply the knowledge they are being taught.

Explicit Vocabulary Instruction. ELLs should have academic language explicitly taught across all content areas. Kim (2020) reported on the reflections of STEM teachers who participated in a one-year professional development training as part of a six year long federally funded program to educate STEM teachers on effective strategies to support ELLs in their classrooms. In service teachers who participated in the training created a portfolio of their understanding about ESOL based teaching. The program was intended to help support STEM teachers learn best practices for teaching ELLs, thus increasing ELLs achievement in STEM classrooms. The teachers' reflections after the study showed that teachers' mindset shifted about various topics including the importance of supporting ELLs with integrating academic language into instruction, using culturally responsive pedagogy, and implementing differentiated

instruction. These findings show the importance of not assuming students understand academic language, and STEM teachers should be explicitly teaching the academic language needed in their classrooms.

Technology as a Tool

Technology in the classroom has been increasing throughout the age of information (1970s-Present), and then the onset of the Coronavirus Pandemic in 2020 pushed any hesitant parties full-fledged into virtual learning. In this section I will be providing some examples of technology resources that teachers can use in their classrooms to support ELLs. I am going to focus on applications or apps that can be used from most modern technological devices including websites, mobile apps, computer software, and others.

Mobile Apps. Nisbet and Austin (2013) report on the importance of vocabulary instruction for ELL students and suggest the use of mobile apps in the classroom. Specifically, Nisbet and Austin recommend using dictionary and translation apps to allow students to find the meaning of unknown words independently. For example, *Dictionary.com* and *Google Translate* are websites that can support ELLs. *Dictionary.com* allows students to look up words through a search bar, and this can be even faster than searching for the word in a traditional print dictionary. *Google Translate* allows students to type a word or sentence in their native language and the program translates the word or sentence into English or any language of choice. In addition, *Google Translate* has a feature for users to hear the translated phrases spoken aloud. Another great feature by *Google* is the *Talk and Comment* Chrome Extension; this allows teachers to leave voice comments in any google format program for students to listen. This allows students to repeatedly listen to directions or feedback on their own. These apps support students by providing input verbally, which can support speech development in English. The

apps are great for allowing students to work at their own pace and help give students a way to research the meaning of a word independently. In short, teachers should have ELLs use dictionary and translation apps as resources during specific classroom assignments. However, it is important to hold students accountable to not solely rely on translation apps.

Teacher-made Videos. Seilstad (2012) researched how preteaching material to ELLs in short teacher created videos would impact learning gains. Seilstad completed this study at a university in Morocco with students taking a pre academic English writing class. Based on teacher and student reflections and on the students course grade compared to previous years the videos improved students' progress. The videos incorporated 4 major components: they were under 5 minutes, they reinforced major concepts, they were class specific, and they included incentives for completing the video prompts. Even though Seilstads study was completed with college level ELLs the short tailored videos can be beneficial for preteaching content at any level. In other words, teachers should consider using *YouTube*, *Screencastify*, *Screencastomatic*, and other similar programs that allow teachers to create videos for free. ELLs benefit from preteaching of targeted skills. Also, the videos can be a review material for students to look back at to review, complete assignments, and acquire language.

Multimodal Learning. Ezah (2020) reviewed the application 'Storyjumper,' this program allows students to make digital stories using multiple languages. Ezeh points out the importance of structuring the activities to teach multimodal literacy skills and this application does so. ELLs need to be building digital literacy skills alongside their English literacy skills. 'Storyjumper' and other digital recording programs like *Flipgrid* can be used to have ELLs produce outputs of writing and speaking. It is particularly useful to have students listening to their own speech for errors.

Learning Games. Guaqueta and Castro-Garces (2018) studied the impact on vocabulary development of two apps, *Kahoot* and *Duolingo*. *Kahoot* is an online program that allows teachers to make and search for interactive games and quizzes that allow students to compete live or asynchronously. Teachers can view students' performance on *Kahoot*s' after the *Kahoot* session is completed. *Duolingo* is a website and app that is targeted at language learning. Teachers can create a classroom on *Duolingo* and have each student register for their classroom or teachers can invite students via email to join the *Duolingo* class. After students are registered for the class, the teacher can assign targeted vocabulary lessons or have students work at their own pace through the program's traditional progression. Teachers can login and view students' progress in lessons. The study by Guaqueta and Castro-Garces tracked the vocabulary progress of 20 high school students in a rural community who used the language learning apps for 6 months. As a result of the study, students reported higher motivation to learn English after using the apps *Kahoot* and *Duolingo* to help with vocabulary development. These apps gamify learning to increase student engagement and encourage students to spend time outside of school practicing English. Both of these apps provide teachers with control over the assignments students are working on and track student progress.

Language Focused Activities. Madnani et al. (2016) insist that ELLs benefit from teacher created activities on the program *Language Muse.* This program uses natural language processing (NLP) algorithms that are structured to help ELLs learn English. Teachers are able to search within the program for text to base their activity on or they are able to upload their own texts. The program generates multiple activities for the chosen text and teachers can choose from vocabulary, grammar, or text organization focused activities. Madnani reported, after surveying 17 middle school teachers on their probability of using the generated activities in the classroom,

the majority of the teachers surveyed found the activities useful and reported they would use them in their classroom. In short, this program helps teachers embed supports for ELLs alongside an assigned text to support comprehension.

Conclusion

In this Chapter, I have reviewed the research surrounding strategies that can support ELLs in STEM content area classes and how technological tools can be used to support ELLs language development. A few mathematics strategies for ELLs are accountable talk, culturally responsive curriculum, and translanguaging. The Science strategies for ELLs are sentence frames, mind mapping, visual aids, and inquiry based geospatial instruction. Technology and Engineering ELLs based strategies are hands-on activities, natural opportunities to talk, and explicitly taught academic language. Lastly, I reviewed technological tools or applications that can help support ELLs instruction.

In the next chapter, I will explain my professional development that will mitigate the issue of ELLs not receive support in STEM classes and underperforming. Teachers will receive instruction on content area specific strategies for ELLs and a list of technological tools that can support implementing these strategies. Through collaborative groups STEM and ESOL teachers will work together to create lessons that will provide the scaffolds needed for ELLs to tackle the task of learning rigorous STEM content alongside learning the English language.

Chapter 3: Professional Development

Introduction

The professional development (PD) will mitigate the issue of ELLs not receiving support in STEM classes by informing STEM teachers about researched based strategies to support ELLs, showing teachers online technology resources to support ELLs, and by giving teachers an opportunity to collaborate on lesson planning with ESOL teachers during this summer PD. The training will focus on 6 main strategies: accountable talk, sentence frames, translanguaging, mind mapping, culturally relevant pedagogy, and visual aids. Teachers will learn about the research that supports each strategy and about online technologies that can support the implementation of these strategies. Teachers will have the opportunity to revise their own lesson plans that they brought to incorporate the strategies discussed. Furthermore, teachers will have the opportunity to collaborate with colleagues, including ESOL teachers, to determine best ways to incorporate strategies and technology into their lesson plans. The goal of the PD is for STEM teachers to leave with a set of 3 well developed lesson plans, 6 strategies, and online resources to bring back to their classrooms to support ELLs. Teachers are required to bring their computer to each session, and to watch the assigned TedTalk prior to session 3.

In each session, 2 ELL based strategies will be covered. The strategies are introduced with a driving question to get teachers thinking about their own personal experiences in the classroom. After discussing the driving question teachers will be provided examples of each strategy. Next, the research surrounding each strategy will be discussed for about 5 minutes because teachers will be more likely to use the strategies when they know the strategies work. Moving on to the next activity, teachers will spend 5 minutes adapting their lesson plans to incorporate the strategy at hand. Teachers need this independent work time to gather their

thoughts and decide how they think the strategies could best be used in the lesson they brought. Followed by the teachers working in collaborative groups with at least one ESOL teacher in each group. Teachers are given 10 minutes of collaborative time to allow time for each group member to share and ask for input on their lesson plan. The collaborative groups are necessary to give STEM teachers an opportunity to ask questions of the ESOL teacher and refine their initial ideas of how to incorporate the strategy at hand. After small group collaboration, groups will share their implementations of the strategy to the whole group. Sharing out to the whole group is important to give teachers an opportunity to learn from the whole group and be recognized for their contributions.

Learning Targets

The following two learning targets remain constant throughout all three sessions: 1. Teachers will be able to use technology in their lessons to support ELLs. 2. Teachers will be able to collaborate with their colleagues to increase support for ELLs within lessons without decreasing rigor.

Addition learning targets for each session are: Session 1: Teachers will be able to incorporate the strategies of accountable talk and sentence frames into their lessons. Session 2: Teachers will be able to incorporate the strategies of translanguaging and mind mapping into their lessons. Session 3: Teachers will be able to incorporate the strategies of culturally relevant pedagogy and visual aids into their lessons.

Session 1

The first session will begin with the instructor asking teachers to complete a fist to 5 or to hold up the number of fingers that best describes how they feel in regards to the question: How successful do you feel ELLs are in your classroom? 0 being not successful and 5 being very

successful. Then teachers are asked to write on a shared workspace, *Jamboard*: What they are hoping to gain form the PD? Teachers will be provided the presentation slides prior to the professional development. Throughout the sessions, teachers are encouraged to have the slides open on their own computer so they can easily click on the embedded links to activities. All of the 3 sessions will follow a similar format. Each session will have 2 focus strategies which teachers will learn about the supporting research, be provided with an example of the strategy, and given an opportunity to incorporate the strategies into the lesson plan each teacher brought with them.

During session 1 teachers will learn about the strategies accountable talk and sentence frames. For accountable talk, the embedded technology addressed is the website *Flipgrid*. The driving question that introduces the first strategy accountable talk has teachers make a *Flipgrid* response video to the driving question. *Flipgrid* is a website that allows teachers to make discussion threads for students to post response videos to a question. This program is a great way to have ELLs partake in a discussion because ELLs can listen to peers' responses multiple times to help with understanding, and students can listen to their own speech to check for errors. Teachers are asked to create a flipgrid post to model to them how technology can support using accountable talk in the classroom. In addition, teachers are given examples of discussion frames found in Appendix A to further model how to support ELLs in using the accountable talk strategy. Next, the teachers will hear about the studies completed by Cardimona (2018), Chen et al. (2019), and Hoody et al (2019) that support using accountable talk in mathematics classrooms. After reviewing the research around accountable talk teachers, watch a short YouTube video on academic conversations and talk moves. This video gives teachers a live classroom example of what accountable talk looks like.

Moving on to session 1 strategy 2, sentence frames, the embedded technology is the Google Chrome extension *Talk and Comment*. This technology is used to show teachers a way to support ELLs with read directions or read assignments. *Talk and Comment* is an easy way to add a voice recording to a Google based assignment. Teachers will be provided examples of sentence frames via Appendix B. Next, teachers will learn about the research of Block (2020). The research supports using sentence frames in teaching science vocabulary to ELLs. In support of teachers' understandings of how to use sentence frames to help ELLs learn vocabulary the teachers will watch a minute and 38 seconds of the YouTube video on the use of sentence frames. This video gives a clear explanation of how when properly used sentence frames can support vocabulary development of ELLs. Teachers need this clear explanation to understand the importance of creating meaningful sentence frames. Teachers will then work independently and with their group to create their own sentence frames for their lesson. Session 1 closes with a whole group reflection.

Session 2

Session 2 begins by reviewing the learning targets and agenda for the day. Strategy 3, translanguaging, is introduced with the driving question being written in Arabic, Italian, and Vietnamese on the presentation slides. Teachers must use the technology of google translate or any online translator to determine the driving question. This activity allows the teachers to see how google translate can support students and teachers can implement the strategy of translanguaging even when the teacher is monolingual. In addition, the program Language Muse is described to the teachers as a free platform that teachers can sign up for with their school email to make activities to support ELLs vocabulary development. The program also including activities focused on cognates for Spanish speakers. The research around the effectiveness of

translanguaging is conveyed to the teachers by reporting the research of Willey and Morales (2020) and Guglielmi (2012). In order to support teachers' understanding of what translanguaning is and how it can be used in the classroom, the teachers watch a short YouTube video what is translanguaging. The session then goes into work time for the teachers to practice implementing translanguaging into the lesson they brought and to collaborate with their colleagues.

Continuing on to strategy 4 during session 2, mind mapping is the next focus strategy. Examples of mind maps are provided for teachers to view from two online programs *LucidChart* and *Canva*. Both of these programs are free to use the basic membership. For additional features teachers can pay to upgrade their membership. The online mind map examples are used to show teachers how they can use the online programs to have students create their own mind maps. After reviewing the online examples and the research-supporting mind mapping the research around mind mapping will be discussed. The research of Wilson et al (2016) and Prabha, and Aziz (2020) will be used to show the effectiveness of mind mapping in science classrooms. Next, teachers will watch the YouTube video on the strategy to reinforce what mind maps are. The virtual examples and the video are used to help support the teachers' development of what mind maps are. Session 2 finishes with teachers being given a homework assignment of watching a YouTube video on culturally relevant pedagogy.

Session 3

The first focus strategy for session 3, the 5th strategy, is culturally relevant pedagogy, The TedTalk teachers had to watch prior to session 3 will set the stage for discussion on how to make STEM lessons culturally relevant. The driving question for strategy 5 has teachers input their answers into an interactive activity made with *Mentimeter.* This online program allows presenters

to engage their audience and teachers can use this technology in the same way in the classroom. Part of being culturally responsive is giving students ample opportunities to express themselves. *Mentimete*r is an online tool teachers can use to engage students. The teachers are then told about the work of Newkirk-Turner and Johnson (2018), Driver and Powell (2017), and Kangas et al. (2019) to explain the effectiveness of using culturally relevant pedagogy. Teachers are then given time to review their lesson independently and with their group to modify their lesson to make it as culturally appropriate as possible for their students.

The final strategy 6, visual aids, is introduced with a short game of guessing the picture. The first minute of a YouTube video zooming out on a picture. The video is paused at the 30-second mark to allow the teachers to guess what the image is then the next 30 seconds is played revealing the image. This is done to engage the teachers and get them thinking about how images can be used to engage all learners. Teachers are then shown two examples, one mathematics and one science, of ways to use visual aids to support ELLs in learning vocabulary. The examples are intentionally shared using the website *Wordwall.net* because this website is another technology tool teachers can use to implement the strategies being taught at the PD. After reviewing the examples, the teacher will learn about the research of Greathouse and Lincoln (2008), Britsch (2012), and Wright et al. (2015) and how this research supports the uses of visual aid to support ELLs. Next, the teachers will have independent and group time to add visual aids into their lesson plan. Additional technology resources are shared along with the links to all online programs used throughout the PD, see Appendix C. The final closing activity of the PD is for teachers to go back to the *Jamboard* from the first session. Teachers will read what they wrote they hoped to gain from the PD, and on the second slide of the *Jamboard* teachers will write what they have gained from the PD. Teachers will then be encouraged to share contact

information and to continue to collaborate with each other on lessons.

Conclusion

The PD will provide teachers with concrete examples, research evidence, and time to practice implementing 6 strategies to support ELLs in their classrooms. Each participant will walk away with 3 content specific lesson plans that have been revised and tailored to meet the needs of ELLs. Also, teachers will have practice collaborating with their peers, ESOL teachers with STEM teachers and STEM teachers with ESOL teachers. The hope is that participants will take this collaborative practice into their daily practice to keep making the best lesson possible for ELLs. In Chapter 4 I will be summarizing what I learned from this capstone project, addressing implications for teaching and learning, and advising on what more research needs to be done.

Chapter 4: Conclusion

Introduction

I began this capstone project with the goal of answering the overarching question: How to support ELLs in STEM? STEM teachers previously have not been given the training and resources to know how to support ELLs in their classrooms. The rigor of STEM classes on top of the cognitive load of learning a language can be discouraging to ELLs. In order for ELLs to be successful in STEM classes and go on to career fields in STEM, they need to be given support in the STEM classes. Teachers need to scaffold their instruction to ensure they are learning the content and English. The population of ELLs in the U.S. is going to continue to grow and the Education systems need to prepare to be able to meet their diverse needs.

Conclusions

Based on current research I was able to derive strategies that can be used by STEM teachers to support ELL in their classrooms. One intention of my capstone project was to create a resource for STEM teachers to learn about strategies they can use in their classrooms to support ELLs. In addition, I wanted to give teachers a safe and collaborative environment to ask questions and collaborate with colleagues. Through this project I have learned the importance of ESOL and STEM teachers working together to provide ELLs with scaffolded instruction. ESOL teachers bring their knowledge of language learning and STEM teachers bring their deep content knowledge to the collaborative table. Together, ESOL and STEM teachers can create powerful lessons. Both teaching fields alike deserve the opportunity to collaborate and create meaningful lessons. Through reviewing the research, I learned that one strategy alone cannot support ELLs. In addition, one strategy will not work for all students. Students need a variety of strategies and

tools to be able to be successful in learning a second language. Especially, in the setting of learning a language through a rigorous content area.

Implications for Student Learning

Vocabulary Learning

Students will benefit from the implementation of the strategies recommended in chapters 2 and 3. STEM teachers can structure activities to develop ELLs English vocabulary and content knowledge through the strategies of sentence frames, mind mapping and visual aids. I know these strategies will support ELLs because of the research results. The findings of Block (2020) support the use of sentence frames to build vocabulary. Prabha and Aziz (2020) found that mind mapping helped ELLs remember vocabulary words and their meaning. In addition, Greathouse and Lincoln (2008), Britsch (2012), and Wright et al. (2015) findings support the use of visual aids to help students learn vocabulary. Vocabulary development is one of the most important skill developments for ELLs to be able to comprehend input.

Content Learning

Students' understanding of STEM academic concepts will be promoted by the strategies of translanguaging, mind mapping, and culturally relevant pedagogy. Willey and Morales (2020) concludes that the strategy of translanguaging allows students to use their native language to help students comprehend academic content and build linguistic skills at the same time. Wilson et al.(2016) concludes that mind mapping helps students comprehension and memory of concepts. The findings of Newkirk-Turner and Johnson (2018) and Driver and Powell (2017) support the importance of using culturally relevant content within lessons to provide students with opportunities to learn about culture and focus on content concepts. The techniques that have been supporting ELLs in Technology and Engineering settings are hands-on activities, genuine

opportunities to talk, and explicitly taught academic language. The research shows how ELLs learning can be positively impacted when teachers implement the strategies recommended in chapters 2 and 3.

Technology Competency

The students will also gain technological competency when teachers use the various technology resources outlined in chapter 3. Exposure to resources like Flipgrid and Kahoot can help students learn content and become more familiar with online platforms. For students to be prepared for college and career environments students need to be comfortable using various forms of technology. By introducing teachers to new technological resources to use with students will in turn result in students using technology more often. Experiences using technology will add to student schemas around technology.

Implications for Teaching

Resources

Teachers will benefit from knowing a clear set of strategies with examples of how to implement strategies into their lesson plans to support ELLs in STEM classes. STEM teachers will now have a set of strategies to look back at to use in their future lessons. ESOL teachers can recommend these strategies to STEM teachers when they are consulting on lesson ideas. Administrators can provide and guide their staff to learning more about the needs of ELL students and the resources avaliable to support ELLs.

Additionally, ESOL and STEM teachers learn of the benefits of online technology resources to help in implementing the strategies to support ELLs. In a post Covid-19 Pandemic world, everyone must be technology literate. Online resources designed for teachers are on the rise and it can be frustrating sifting through trying to determine which ones work best. Appendix

C provides a list of online technology resources teachers can use that have already been vetted by other teachers.

Collaboration

Teachers will collaborate with colleagues to create meaningful learning for ELLs. Hansen and Richins (2015) saw the positive results from a short term mentorship between an ESOL teacher and a science or math teacher. Furthermore, Meskill and Oliveira (2019) looked at a year-long professional development that created a mentorship between a science teacher and an ESOL teacher that led to STEM teachers reporting they felt more effective teaching ELLs. Collaboration between STEM and ESOL teachers helps create the best lessons for ELLs. STEM teachers should find more success in their lessons when they implement researched based strategies for ELLs and get input from ESOL teachers. ESOL teachers gain the knowledge of the importance of supporting ELLs in STEM classes. The data shows ELLs are underrepresented in STEM careers (Funk & Parker, 2018). ESOL teachers know that advocating for ELLs is a part of their job description. Thus, knowing ELLs are not being successful in STEM I believe ESOL teachers will step in to support teachers and students the best they can.

Recommendations

ESOL Training

Current STEM teachers should receive training and day to day guidance on how to serve the ELLs in their classrooms. ESOL push in services should be allocated to all content areas. When an ELL leaves English class their need for linguistic support leaves with them. State policy and administrators need to support ESOL staff being assigned to push into STEM classes. At the very least, STEM teachers should have scheduled sessions within their ESOL teacher for indirect consultation on lesson planning. In technology and engineering content area classrooms,

ELLs have limited access to these classes and are not receiving the support they need. Content area teachers need more training on how to meet the needs of ELLs using researched based best practices.

Technology Training

Differentiating instruction for ELLs can be overwhelming for a STEM content area teacher who does not generally receive direct support from an ESOL teacher. However, technology programs and applications can help teachers create engaging and effective lessons for ELLs. Programs like translation apps and Duolingo can help teachers to use translanguaging in their classrooms even if they do not speak the students' native language. Furthermore, visual aids can be embedded in Kahoot and StoryJumper activities to support ELLs. Teachers need more training on technology to use in their classrooms along with training on strategies that best support ELLs in STEM content areas.

Research

Research needs to continue to determine more effective strategies to support ELLs in STEM content areas. Especially, the content areas of Technology and Engineering which has little research on effective strategies to support ELLs. I would like to see a study done comparing student outcomes in STEM between a class who receives direct ESOL support from an ESOL teacher compared to a class who receives indirect ESOL support from an ESOL teacher. This study would need to take into account the students current command of the English language. Students at the entering level may need the direct support, versus transitioning students may be better served with indirect ESOL support. I think the results from this type of study could change policy around ESOL service allocations at the state and federal level.

Final Thoughts

Ultimately, curriculum and assessments need to be designed to incorporate student linguistic and cultural backgrounds. Driver and Powell (2017) report that current tests used in the U.S. to assess mathematical abilities are linked with cultural and linguistic bias, and ELLs perform lower on standardized tests than native English speakers. This needs to be addressed. Teachers, administrators, and policy makers need to advocate and bring about change to support ELLs in the STEM. STEM teachers deserve training on what strategies support ELLs, and when needed have an ESOL co-teacher in the classroom with them. In order to continue to mitigate the issue of ELLs underperforming in STEM, general education teachers need opportunities to collaborate with ESOL teachers at PD's and during school hours. STEM teachers should reach out and ask for the support they need. On the other hand, ESOL teachers should reach out and offer support. Change takes time, but teachers can start to support ELLs now by using strategies that are known to work.

STEM content areas are known to have abstract and complex concepts associated with them. Thus, the struggle ELLs experience to learn STEM contents alongside the task of learning English. In mathematics, some strategies that can support ELLs are using accountable talk, culturally relevant instruction, and translanguaging. Moving on to science, strategies that can help ELLs are sentence frames, mind mapping, visual aids, and inquiry based geospatial instruction. Engineering and technology content areas should use hands-on activities, natural opportunities to talk, and explicitly taught academic language. Teachers should use technology applications to help support implementing these strategies in STEM content areas. All of these strategies and technological tools use the principles from the theory of constructivism and create experience for students to derive meaning.

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Appendix A
Accountable Talk: Discussion Frames Examples

Reasoning

I agree with ____ because ___.

I disagree with ___ because ___.

Clarifying Questions

Can you say that again?

What do you mean by___?

How do you know?

Adding on

I like what you said about ___, and I want to add___.

I agree with ___, but I also think ___.

Revising

After listening to ___, now I think___.

I have changed my mind because___.

Appendix B
Sentence Frames Examples

Science Vocabulary Words: cells, abiotic, biotic, prokaryotic, and eukaryotic

Cells are _____ that make up _____.

_____ is abiotic because_____.

_____ is biotic because_____.

_____ is a prokaryotic cell because it_____.

_____ is a eukaryotic cell because it _____.

Math Vocabulary Words: equation, expression, variable, coefficient, and like terms

Equations are made up of _____ and have _____.

Expressions are made up of _____ and do not have_____.

A variable is a _____ that is used to represent_____.

A coefficient is a _____ in a mathematical term that is found _____ the variable.

You can tell two terms are like terms when _____.

Appendix C
Technology Links

Accountable Talk

Flipgrid https://auth.flipgrid.com/

Example Join Code: 038d620d and Guest Password: Ells2021

Talk and Comment Chrome Extension

Translanguaging

Google Translate https://translate.google.com/

Storyjumper https://www.storyjumper.com/

Online Dictionaries

https://kids.wordsmyth.net/we/

https://www.oxfordlearnersdictionaries.com/us/

https://learnersdictionary.com/

https://www.dictionary.com/

https://www.merriam-webster.com/

Mind Mapping

Canva https://www.canva.com/

Example 1

LucidChart https://www.lucidchart.com/

Example 2

Culturally Relevant Pedagogy

Mentimeter https://www.mentimeter.com/

Example

Screencastify Chrome Extension

Screencast-o-matic Chrome Extension

National Science Foundation geospatial curriculum: https://eli.lehigh.edu/sesi

Visual Aids

Wordwall https://wordwall.net/

Science Example

Math Example

Picture Dictionary https://kidspicturedictionary.com/

Video Dictionary http://www.vidtionary.com/

Google Images https://www.google.com/imghp?hl=en

Kahoot https://create.kahoot.it/login

Other Resources

Poll Everywhere https://www.polleverywhere.com/

Duolingo- https://schools.duolingo.com/