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Science and mathematics instruction for emergent bilinguals through children's literature

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Language acquisition, reading comprehension, and teacher PD will be presented in this article to discuss how the three components can be helpful in supporting emergent bilinguals (EBs). Using children's literature in mathematics classes could improve the performance of (EB) students. The most current research suggests students who engage more with language through meaningful experiences like stories have greater retention for the material they are learning while they also see the English language in action. The more interaction and exposure to the language may increase EBs performance in the class subjects of English Language Arts and Reading. One of the best ways to engage emergent bilingual students with science and mathematics while supporting language acquisition is the use of children's literature to teach science, technology, engineering, art, and math (STEAM) concepts. The elements of a story help students learn the structure of English usage in everyday speech while giving them solid STEAM concepts they can more easily understand through the story. This strategy also allows the teacher to scaffold for EB students using the story as a building block. By selecting and pairing effective EB strategies with children's STEAM literature, there may be an increase in student performance overall.

KEYWORDS

emergent bilingual, STEAM, language acquisition, effective teacher training, scaffolding literature

Introduction

As our world becomes more globally integrated, teachers are seeing an increase in the number of emergent bilingual students. In the state of Texas, there are approximately 1,269,408 EB students in classrooms, accounting for 23.1% of the student population (Texas Education Agency [TEA], 2024). Teachers do not receive much relevant support or training related to supporting students' fluency and literacy skills in a second language such as English. Due to standardized testing, expectations continue to rise alongside budget cuts and growing class sizes. Thus, a 6th grade in Texas faces several challenges regarding how it can meet the academic needs of all students, including EBs while also under so much pressure from high-stakes testing. Using literature in the classroom may be one way to support these students' language acquisition while they continue to learn grade level science and math. The usefulness of science, technology, engineering, art, and math (STEAM) concepts instruction on emergent bilingual students through children's literature is a topic worth discussing in the modern classroom.

Students who engage with stories are experiencing authentic language experiences. Literature offers the opportunity for multimodal learning to greater language acquisition by

students (de Araujo et al., 2018). Emergent bilingual students have underperformed compared to their monolingual English-speaking peers according to the National Assessment of Educational Progress (NAEP) on the reading and math performance from years 2007–2017 (Ortiz et al., 2022). In this article, EBs and English learners (ELs) are used interchangeably. As Ortiz et al. (2022) infer, this gap in performance between English learners (ELs) and non-ELs is due to lack of educational equity. In other words, access to appropriate resources such as personnel, curricula and instruction that are tailored to meet the academic and individual needs of EBs, and therefore improve student achievement levels (2022). There needs to be a greater understanding among educators (e.g., administrators, teachers, paraprofessionals) in PK-12 schools, in terms of how scholars such as Cummins (1979, 1980) explain the processes on how EB students acquire social language known as basic interpersonal skills (BICS), and academic language known as cognitive academic language proficiency (CALP) in a second language (L2).

Before teachers are released to the classroom, they go through systems of preparation based on their location such as field-based experiences, and clinical training. Many teachers receive some training on how to work with EBs. If we expect teachers to provide adequate support to EB students and help them develop literacy and language development skills, they need access to quality on-going PD training to keep up with the latest research. "More coursework and site-based practice seem necessary for new teachers to develop facility with interactional scaffolds and multifaceted instructional scaffolds, such as providing clear and explicit instructions or integrating related scaffolds throughout a lesson to build student independence" (Schall-Leckrone, 2018, p. 34). If we expect students to acquire language skills, we need to train teachers on how to support them. Therefore, by providing additional professional learning opportunities (e.g., best teaching practices, innovative and hands-on learning activities, research-based PD, multimodal learning, etc.) we can force a major shift in the field related to bilingual and ESL education to better support EB students.

Review of literature

There have been extensive studies done on emergent bilingual students trying to answer similar questions. Why are EB students underperforming in the classroom? What teaching strategies work best for Emergent Bilinguals? Researchers have spent immense amounts of time developing methods to help support EB students following them on their educational journeys and tracking the effectiveness of the education system (de Araujo et al., 2018; Dixon et al., 2012; Han, 2011). Across the country there are several factors that keep EB students from performing at the same level as their peers. Those factors include historically understaffed schools, lack of funding resources, lack of knowledge base related to second language acquisition and lack of effective professional development (research-based) for teachers. One example of how teachers may be able to close the achievement gap for EBs is through integration of arts and other content areas through a STEAM approach (Corrigan et al., 2022; Hughes et al., 2022). To support emergent bilingual students, we can explore the effectiveness of using literature in STEAM classes to improve language acquisition and reading comprehension when coupled with properly training teaching staff in supporting EBs by using literature.

Language acquisition

Language acquisition is a complex process. According to the National Assessment of Educational Progress (NAEP) Reports, English Learners have consistently shown lower academic performance in areas such as Reading and Mathematics in comparison to non-English learners (U.S. Department of Education, 2023). Reasons for this lower performance can be related to inadequate resources, lack of quality teacher training, and curriculum and instruction that does not align to academic needs of EBs (Ortiz et al., 2022). In addition, lower performance can also be tied to educators not understanding language acquisition research (e.g., theories, variety of longitudinal data, etc.) and the importance of developing cognitive and linguistic skills in first language (L1) so that those foundational language skills can be transferred to second language, contributing to higher levels of academic success (Cummins, 1980). In Han (2011) study, the author concluded that Latino children to be least advantaged and more likely along with Asia children to attend public schools with high levels of socioeconomically disadvantaged students, as well as less school support and physical resources.

While we do assume some level of monolingualism in the classroom, that is because only about 1/5th of US children are bilingual (Byers-Heinlein et al., 2019). According to National Center for Education Statistics (2024), in the year 2021, ELs made up a national average of 10.6% or 5.3 million of the student population across the country. This number in Texas is more than double, where EBs account for 23.1% of the total student population (Texas Education Agency [TEA], 2024). This paper focuses on how we can better serve all students, including monolingual and Emergent Bilinguals in an English-only Science and/or Math classroom that uses children's literature to teach STEAM concepts. Schools are pushing to have more literacy inclusion in STEAM classrooms, so these are examples of how to support EB students. This article does not argue against using multiple languages in the classroom, it just offers a component that can be included in which teachers should be trained to use.

One idea in which teachers can bridge the achievement gap is to incorporate classroom activities, in the areas of language and literacy, in meaningful ways through multimodalities of learning. Dixon et al. (2012) identified multimodal communication, mathematics and languages proficiency, and the professional development necessary for teachers to effectively implement resources for their students. This article finds the similarities between studies focusing on EB students who are struggling in math and what solutions are found to be effective in the classroom.

Students require multimodality and opportunities for multiple literacies to be practiced within one lesson. For EB students that require extra support in these settings, a well-crafted lesson can provide a variety of opportunities to learn language skills and new concepts. As an example, a student learning a new concept needs to hear the word, see the word, a picture, a definition, and see it used in an example with proper guidance from the teacher. By scaffolding and guiding the students learning of new concepts and words, they can over time become more independent as they progress through the Zone of Proximal Development (ZPD), as constructed by well-known

scholar Vygotsky and Cole, 1978. ZPD is applicable to all students, regardless of language including for EBs, as they are introduced to new concepts through multiple modalities of activities.

Using this multimodality approach to learning, we can then extend this to the effectiveness of using literature in the classroom to support EB students. Lessons based around literature create a space for teachers to provide these learning experiences. By using literature in the classroom, the content and book provide the opportunity to include multiple learning types in a single lesson, scaffolding information, and building up to greater understanding of STEAM concepts. Books provide meaningful opportunities to experience language; they provide pictures, story, and the opportunity to create assignments which align with the content, providing additional scaffolding for EB students. When lessons are coupled with clear goals for students, they will connect what they are learning with the element of story (Lamberg and Andrews, 2011).

Gillanders and Soltero-González (2019) identify the importance of language acquisition for EB students, something which children's literature provides. They also talk about symbol and pattern recognition, a requirement of the sciences for students to be able to solve complex multi-step problems in their classes. This supports the importance of word and symbol recognition for EB students in science and mathematics classes. EB students write and think in specific ways that vary from their monolingual peers. Teachers need to support their language acquisition.

STEAM has its own language. Each subject has content specific language and concepts students must learn to effectively understand the larger material and preform necessary tasks like solving a math problem or recording numbers in a scientific table. When we keep in mind that we are using language acquisition strategies for students learning these new words and symbols, educators can apply that same principle throughout the lesson to support EB students. The same way a student learns the purpose of the division symbol to create an equation, an EB student is learning the concept, relevance of the word and how it connects parts of the sentence. "Many students were able to reference background knowledge from previous science lessons or other learning experiences, use gestures, or leverage their peers and teachers to aid in communicating their ideas" (Haverly et al., 2021, p. 24). Communication is multimodal, as students acquire language skills when working with peers. Finding and discussing solutions lends itself to STEAM and builds on high order thinking skills.

To expand and explain the significance of this process in the classroom, imagine how a teacher would incorporate a children's math book in this situation. The book serves multiple purposes that support all learners but unique benefits to the EB student in which skill acquisition can be multifaceted. First the book provides the opportunity for a student to learn the flow of language. Within the book there is the use of story, which provides context for unfamiliar words and helps illustrate the concept being taught, helping even students who have less exposure to practice in the language which impacts literacy skills. Finally, content specific words and strategies are being highlighted in the story, helping students understand the language of the book. The next phase of the book is the use of strategies to help students obtain mastery of the skill presented and the opportunity for scaffolding, an effective strategy to support EB students when implemented correctly (Smit et al., 2013). Teachers can scaffold skills by leading up to the writing assignment by first having students discuss their solutions, a strategy which also provides additional support to EBs. Both book selections showcase core components of STEAM. *Iggy Peck Architect* is an example of the combinations of science (physics) and art through the study of architecture while providing a story which children can engage with. *One Grain of Rice* uses a story to explain a math concept which can be intimidating with clear pictures for students to make connections with language and numbers.

As an example of scaffolding through a children's math book, let us look at a hypothetical lesson based around *One Grain of Rice* (Demi, 1997). The book teaches students 6th grade and up the foundational information surrounding exponents. The teacher can 'even the playing ground' for student by building background knowledge. Math based vocabulary is new to all students and can be introduced alongside examples for students in both English and other languages. The teacher will then read the book allowing students to view accurate mathematical visuals, occasionally stopping to have students make predictions. After the end of the book manipulatives to represent rice can be handed out as students visualize the effect of exponents. This allows students to familiarize themselves with the concept while working with students around them. The teacher can now facilitate discussion in the classroom by asking students to identify patterns they noticed in the rice. After these steps student can move onto individual practice and compare answers in their groups. Lesson plan (STEM Literature, 2024) found at https://www.tamucc.edu/education/departments/cils/stem-literature/.

By incorporating a story when teaching math, teachers are better able to support EB students understanding of material. They are acquiring new vocabulary and using these new terms when practicing with manipulatives. Books can be paired with manipulatives to allow for greater peer to peer collaboration encouraging conversation and language practice.

Reading comprehension

de Araujo et al. (2018) compiled and synthesized 75 articles about emergent bilingual students to identify solutions to mathematics and literacy issues faced by EB students in the classroom. They found a large disparity between EB and monolingual students. To bridge this gap, teachers need to have effective strategies to support their EB students. There are a variety of strategies that help increase the performance of EB students, but the most important component is variety, through differentiated instruction. EB students need to be exposed to the English language to become fluent, so it makes sense to support their learning.

Reading comprehension is a complex process which requires the reader to not only understand the individual words they are reading, but then combine the words to create greater understanding; then remember those concepts and combine them to make an overall understanding of a story or concept. This is a complex process. When you read, you process each letter individually and assign it a sound. This can be the first hurdle for an EB student. The only way to improve is through practice. To understand and process information in STEAM classes, EB students need to understand English to master new concepts and skills.

Incorporating reading and literature will help increase practice and therefore understanding of language. The more language skills an EB student acquires, the more rigorous work they can

take on. True understanding comes from discussion and stories provide a clear subject of discussion for students to make connections.

Fine and Furtak (2020) outline specific effective strategies for supporting EB students learning science skills. Incorporating their strategies and going a step further by applying to a lesson with a science concept being taught through a book. As previous researchers have mentioned, multimodal learning is highly effective for EB students. They require exposure to language across all subjects to master new concepts while building their language skills.

Students come to us with various levels of literacy and language skills; it just may not be in the English language. We should anticipate how to support these learners. "Since language is learned in context, it is often the case that DLLs have different vocabularies in each language" (Gillanders and Soltero-González, 2019, p. 34). This can be viewed as an advantage. Just like monolinguals are learning content specific vocabulary, EBs are learning language specific vocabulary and content specific vocabulary as well. This applies well in STEAM settings. Each of these subjects has content specific vocabulary which was created to explain a specific concept. If introduced through story, these concepts are ingrained in EB students' vocabularies with the specific STEAM content.

Iggy Peck Architect (Beaty and Roberts, 2022) is another example of using children's literature with the corresponding lesson plan for its use for reading comprehension by exposing 6th–8th grade students a variety of engineering terminology. Teachers can easily scaffold more complex concepts of physics and engineering by incorporating this book. The teacher begins by introducing unfamiliar vocabulary needed to understand the book like types of forces and energy. After reviewing vocabulary, the teacher will present the book helping them visualize the concepts through the clear and engaging illustrations. Finally, students will review the new concepts covered in the book and expand them through teacher led instructions. After students have reviewed terminology and visualized these terms in action, they are ready for a hands-on portion where they plan then build a bridge based on Iggy's solution in the book. This lesson format based around a children's book lends itself to scaffolding and built in EB supports. At each step, all students are supported regardless of level of language acquisition.

By using this book teachers can easily support EB learners with a variety of strategies (e.g., sheltered instruction, scaffolding, critical thinking, and hands-on activities) which lend themselves to the lesson format. This level of scaffolding supports reading comprehension as student read through the book but also when they make predictions and practice vocabulary. By having students build a bridge similar to the one in the book. Lesson plan (STEM Literature, 2024) found at https://www.tamucc.edu/education/departments/cils/stem-literature/.

Teacher – professional development

Teachers need to have effective professional development and instruction on the support of EB students and the strategies that are effective in supporting their academic needs (Dixon et al., 2012; Horst et al., 2019; Schall-Leckrone, 2018; Smit et al., 2013). We know students need to practice skills to master them; reading being one of those foundational skills for understanding language and developing reading comprehension is necessary to master other subjects.

Even inexperienced teachers can be trained on how best to support EB students (Schall-Leckrone, 2018). Like students, teachers need clear instruction on how to incorporate new instructional material and perform new class activities. Instruction is provided to students so they can be successful and in turn teachers should do the same when new research shows the effectiveness of new strategies. We cannot expect to see results in our students without providing them with well supported teachers.

To help teach our EB students, teachers should be taught to use a variety of scaffolding techniques (Schall-Leckrone, 2018). It is important to remember teachers need feedback that shows them the correct way to perform tasks. They are human, an in that they need to have opportunities to grow without feeling targeted. Effective administration should give feedback in a way that that is productive and highlights good examples while giving teachers the chance to practice the skills they need to practice (Smit et al., 2013).

Teachers need to be taught how to effectively use their resources. Continuing the case for the importance of including literature teachers need to be taught to approach read aloud portions of their lessons with productivity in mind. What seems obvious to more experienced teachers in ELRA subjects might not come naturally to a well-intentioned Science, Art, or Math teacher. Fostering high-quality interactions lead to confident students who are building their understanding of material and language. This is crucial for all students, including EB students. Teachers must be taught to prepare quality lessons to have effective instruction (Horst et al., 2019).

Teachers need to be trained effectively in teaching strategies if we expect to see them in the classroom. We know math manipulatives increase student understanding; they are a great scaffolding tool which is necessary for all students (Larson and Rumsey, 2018). Teaching has become more data driven and teachers need to understand how to use that data to scaffold effectively. Teachers are content experts, but a content expert cannot teach without training. "Designed scaffolds encompass the plans teachers make in advance to build on students' prior knowledge and develop targeted language skills" (Schall-Leckrone, 2018, p. 34). If we do not coach teachers how to do this effectively, we are setting them up for failure and frustration alongside those feelings in their students.

Discussion

While conducting research for this literature review, I have concluded that using literature is an effective tool to help support emergent bilinguals. However, literature should be paired with other effective strategies (e.g., sheltered instruction, scaffolding, critical thinking, hands-on activities) to properly support students. By centering lessons around STEAM literature, teachers can more easily engage students with new concepts in an approachable way. The true purpose of using literature specifically for emergent bilinguals is the variety of built in scaffolding a book

provides leading to multimodal learning and therefore increased comprehension without hindering other students. When EB students underperform, it is often due to a complex combination of factors that are not easily resolved. However, instead of focusing on these insurmountable challenges, efforts should be directed toward actionable teaching strategies that support the learning process in the classroom. Teachers need to be provided with additional PD, that is research-based on how to better support EB students through engaging lessons. These students need additional exposure to language, and we should support teachers by encouraging them to use literature in the classroom and provide guidance when they introduce these new strategies.

To provide an explanation of the significance of the information presented here it must be understood that EB students deserve instructional approaches that can be tailored to their academic needs. They continuously underperform compared to their monolingual peers but there is a way to bridge that gap and including content literature in STEAM classrooms may be a significant part of the solution for many of these children. Administrators should push for professional development that favors more reading in the classroom focusing on teachers acquiring new skills, not learning a new product. Districts should consider moving away from strict "scope and sequence" schedules to support teachers who are interested in harvesting their own data from assignments so they can craft meaningful scaffolded assignments based around a book. Skill building is complex and requires careful planning and learning how to plan that way does not come naturally to most people. We have the research, we have the data, now we need to implement it properly.

Implications and conclusion

So, what should we do with this information as educators? The takeaway should be to integrate more opportunities for EB students to practice reading in authentic ways. Children's literature provides the opportunity to do that in a classroom that are not English Language Arts and Reading (ELAR). By supporting these students there is an overall net benefit to all students as new content should be taught through authentic experiences to increase retention of new concepts and seeing language used authentically as important for all students.

Bring these strategies to the classroom is the next step. STEAM teachers should be shown how to effective incorporate literature into their classrooms at the benefit of EB students. While this article has focused on how these strategies are especially effective for EB students the usefulness extends to all students. Content should be approachable and engaging. Books center and theme instruction, providing opportunities for scaffolded, multimodal learning which, in turn, improves content understanding. These strategies greatly benefit teachers, and the biggest hurdle is most secondary education teachers do not have the training and experience to implement these strategies if they know these options exist at all.

Research that focuses on EB students is emerging with new long-term studies in recent years. We are going to see a variety of new research coming out focusing on these students as their population size continues to increase in the United States. The information now is important but limited. It will be important to revisit this topic and add to current strategies we know to work with new research to provide comprehensive support to EB students.

Overall, EB students are overlooked, and the strategies pushed to teachers are not often backed by research (Dixon, et al., 2012, p. 5). There are a multitude of strategies which are proven to work (de Araujo et al., 2018). Strategies which are developed by researchers who have implemented them in classrooms to test their effectiveness are often completely free as demonstrated by resources like *The Science Assessment for Emergent Bilingual Learners Checklist* (Fine and Furtak, 2020) or *Joyful Learning with Stories: Making the Most of Read Alouds* (Horst et al., 2019). Painstakingly crafted questions are already there for educators to implement, they just need to know they exist and access them. We have the knowledge that incorporating literature works, we have the strategies, the only things missing is the implementation. The longer that last step takes the more our EB students will continue to needlessly struggle.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

AM: Writing – original draft, Writing – review & editing. FB: Conceptualization, Supervision, Writing – review & editing. DJ: Formal analysis, Resources, Writing – review & editing. CT-D: Investigation, Resources, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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