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Promoting Tangible, Cultural, and Cognitive Access to STEAM Identity Through Literacy-Based-Picture Book Biographies

Joan Boulware[a], Eula Monroe[b]
[a]Middle Tennessee State University, [b]Western Kentucky

Dr. Beverly Joan Boulware is a Professor of Literacy Education at Middle Tennessee State University. Her teaching expertise includes courses in reading, writing, assessment, research, and children's literature. She conducts research in the effectiveness of strategic interventions to enable early and elementary learners to build comprehension of print materials.

Dr. Eula Ewing Monroe is Professor Emerita of Mathematics Education at Western Kentucky University and Brigham Young University. Among the topics she studies are literacy-STEAM relationships (including the role of picture book biographies), vocabulary in mathematics, and the development of basic facts among young children. She is interested in the translation of research in these areas into classroom practice.

Abstract

Learning and innovation skills such as creativity, critical thinking and problem solving, communication, and collaboration can be fostered through learning about STEAM role models. Using selected picture book biographies, teachers can help their elementary students visualize the experiences of these individuals as they developed and refined ideas or products that addressed needs. The nature of picture book biographies, the unique vocabulary of each STEAM content area, and the use of language arts strategies can promote access and equity as students examine issues and challenges faced by previous generations. They can question and begin to form their own STEAM identities as they consider the contributions they can make during their lifetime.

Keywords: STEAM education, equity and access, picture book biographies, literacy strategies, role models

Introduction

The concept of STEAM (science, technology, engineering, the arts, and mathematics), a recent and exciting innovation in curricular thinking (Piro, 2010; Sharapan, 2012), is fluid and evolving, and has a role in literacy instruction through the use of STEAM picture book biographies. Not unexpectedly, the roles and emphases the arts can and should have alongside or within the STEM subjects of science, technology, engineering, and mathematics remain a matter of considerable discussion and debate. Nevertheless, it is widely viewed that each of the arts—

visual and graphic arts, the language arts (subsumed within a broad definition of literacy, including disciplinary literacy), music, etc.—holds the potential to contribute to creative aspects of discovery and invention as students develop and hone foundational skills needed for innovative thinking and problem solving.

Learning and innovation skills such as creativity, critical thinking and problem solving, communication, and collaboration (Partnership for 21st Century Skills, 2009) can be developed through STEAM-based literacy using language arts curriculum tasks. These skills empower students, over time, to develop possibilities not yet envisioned for solving problems for themselves and for the larger world around them.

STEAM picture book biographies provide positive motivation for aspiring STEAM-interested elementary learners of varying age levels who see the people represented in the biographies as role models. Role models may also be others who have gone before them, recognized the challenges their generations have faced, made connections to available resources, solved problems, and created innovative designs that addressed issues pertinent to their lives. (Gladstone & Cimpian, 2021.)

The genre of the picture book biography, consisting of limited text and mostly pictures, has its roots in previous decades. Particularly in STEAM subjects, it is growing in appeal and is becoming a favorite among elementary children (MSRI, 2003). Alongside the increasing presence of STEAM education in schools, the availability of recently produced picture book biographies of STEAM role models from many eras of history makes their use a natural choice in instruction. These biographies can provide contexts for developing STEAM concepts and literacy tools while helping students develop their own potential identities as they explore the lives of individuals in STEAM-related careers (Gladstone & Cimpian, 2021; Young et al., 2021). Picture book biographies often pique students' interest while addressing issues of access to learning about careers that initially may seem distant from their everyday lives and their own aspirations.

Picture book biographies may be shared in a variety of contexts for multiple purposes and are not necessarily age- or level-dependent for learners. However, this article is addressed to elementary teachers, a teacher group broadly prepared with a cross-section of skills for working with young students to equip them for future, yet-unknown challenges, and to teacher educators who collaborate with elementary teachers. Picture book biographies can provide an especially meaningful context in which teachers can mobilize their own STEAM knowledge base and their diverse experiences in planning and implementing lessons to foster literacy within and across the STEAM disciplines.

Picture Book Biographies Access Points

The lives of a wide range of individuals, so interestingly shared in well-written picture book biographies, can encourage learners to envision themselves in STEAM-related careers by supporting three kinds of access: *tangible* access, *cultural* access, and *cognitive* access (Saldutti, 2019). Knowledge of these access points enables teachers to design and implement equitable

solutions to a range of literacy needs in their classrooms, including awareness of the kinds of literacy tools needed in different STEAM disciplines.

Tangible Access

Tangible access to learning opportunities such as doing experiments, constructing models and drawings, and involvement in other carefully designed STEAM tasks can activate connections that emphasize how human endeavors have met needs and affected people groups. Such authentic content-related experiences are foundational to developing STEAM skills and practices (Saldutti, 2019). At the same time, a well-written picture book biography read aloud by the teacher, or in the hands of a reader, can provide an authentic, near-tangible experience as the learner identifies with the primary character, and in doing so, with that character's career choice.

Cultural Access

One's sense of self, or identity—situated, at least in part, within perceived bounds and expectations of culture—has been found to be integral in decisions regarding participation in STEAM, thus deeply affecting career goal choices (e.g., National Council of Teachers of Mathematics [NCTM], 2020). Teachers influence their students in developing and expanding their identities, including their identities as learners and doers of STEAM, by planning and enacting lessons situated within their students' background and knowledge base. At the same time, teachers can choose picture book biographies that feature individuals from a wide variety of backgrounds and interests in the STEAM professions. In that way, students can explore literacy experiences that offer the promise of empowering them to think of themselves as active contributors to the betterment of society, either through STEAM-related fields or other careers. The genre of picture book biography offers a repertoire of choices for examining a wide range of human endeavors, and thus the likelihood that students can discover exciting options they may not otherwise have considered.

Cognitive Access

As important as both tangible and cultural access are to learning STEAM content and practices, students must also develop skills and strategies essential for them to gain cognitive access to development in the STEAM disciplines. Often foundational understandings in one discipline support cognitive access to another. For example, content in the traditional STEM subjects typically builds on or utilizes mathematical understanding; and the arts bring with them, perhaps not so obviously, the need for mathematical understanding as well as opportunities for its development. However, nowhere across STEAM instruction do we find this interplay among disciplines more obvious than in the need for the language arts: "speaking/listening, reading/writing, and viewing/representing" (Malloy et al., 2019, p. 7), which are essential to accessing, developing, and expressing STEAM ideas. Often in ways specific to the discipline, the language arts not only support the development of content and literacy, but, while doing so, support their own development as well (Houseal et al., 2016).

Well-written picture book biographies often provide rich contexts for developing a range of literacy strategies that support comprehension of STEAM concepts. These strategies may be

specific to the discipline, but often more general strategies are needed within the context and content of the STEAM ideas addressed in picture book biographies. Such strategies may involve sequencing ideas, identifying details, making inferences from print-based evidence, and engaging in reasoning scenarios that provide opportunities for learners to recognize and interpret patterns prevalent in the content under study (Buehl, 2017).

Teachers will also need to address other aspects of literacy while using picture book biographies. The vocabulary specific to the context and content of a selection, as in other targeted text materials (Flanigan et al., 2012; May et al., 2019), has a major influence on cognitive access to concepts. Learners can be given opportunities to participate in meaningful collaboration with peers that involves verbal interactions and writing activities in which students record their ideas and configure them as needed to communicate an emerging idea or invention they may desire to introduce into the culture. Elementary teachers can actively engage their students in literacy tasks that may require them to build charts or graphs and generalize ideas that enable them to develop vocabulary and meanings specific to the discipline, promoting comprehension of online or print materials (Monroe et al., 2018).

Selecting Picture Book Biographies for STEAM Instruction

STEAM picture book biographies are typically about individuals who thought beyond the boundaries of the traditional notions of their generation. Their paths varied, but STEAM biographical characters are among those who were able to impact their present circumstances and contribute to a STEAM profession, and, in many cases, to the culture as a whole. These biographies provide current readers opportunities to examine identities of people who contributed to an idea, invention, or innovation.

Teachers can work with their students to analyze selected picture book biographies for qualities of creativity and problem solving that enabled the STEAM role models to develop their interests as well as their identities. Among the growing number of titles available for examination, the special achievements of the biographical characters featured may help children recognize that, contrary to some perspectives, STEAM is done by and with real people who do interesting and exciting things with their lives (Columba et al., 2005).

The following subheadings pose several important considerations when selecting picture book biographies for STEAM instruction. Overall, the discussion extends the work of May et al. (2019), who identified several common characteristics of well-written picture books when considering their use in music instruction, and Young et al. (2021), who described the use of picture book biographies in mathematics instruction. It also is situated in the authors' previous work with STEAM instruction using picture book biographies (e.g., Boulware & Monroe, 2021, 2023).

Length/Scheduling Considerations

The picture book biography is usually 32-40 pages in length and can fit readily into a classroom schedule. This format encourages their use as read-alouds in connection with the STEAM concepts being taught. However, teachers may choose to use picture book biographies as a part of their

overall literacy instruction. A specific selection may fit equally well in either place, according to the teacher's instructional goals.

Format

Picture book biographies are typically written in a story format, which is often more accessible and engaging, especially for younger learners, than are many other text materials. Teachers can use these stories to appeal to the STEAM interests of their students, connect them with the biographical characters featured, and enhance their access to the STEAM topic under study.

Context

Picture book biographies are often situated within places, people groups, or time periods different from those of many students within a specific classroom, yet the characters and the context may be accessible, and can be culturally enlarging, to a wide range of students at various age levels. Teacher use of a specific book will vary according to age and knowledge base of the students as well as goals for instruction, including the specific STEAM ideas under study.

Art and Graphics

In well-designed picture books, the art and the words interactively communicate the content. Other graphics, when included, serve as teaching tools to develop the content of the discipline and allow for meaningful discussion.

Range of Choices

Across STEAM content, a wide range of picture book biographies is emerging for classroom use. When teachers select and use books that honor diversity and address the biographical characters' interests and individual differences or unique needs equitably, student access to the STEAM disciplines is likely to increase.

Back Matter

A section usually known as back matter is included in many picture book biographies. This section often provides additional content-related information as well as other information that expands understanding of the book character's life, including contributions to STEAM.

Access/Equity

As teachers address the considerations discussed under the previous subheadings in making book selections, they all coalesce when anticipating the kinds of access the specific book selection may support with the students in their classrooms. Tangible, cultural, and cognitive access to STEAM can be supported through giving students opportunities to learn about individuals who have made notable achievements in STEAM-related careers. Selected picture book biographies of such individuals, past and present, who exemplify qualities of creativity in problem solving can be shared by teachers in their classrooms. Literacy experiences with STEAM biographies

can both inspire and empower students to develop their own visions of how to make the world a better place, either through a STEAM-related field or through other worthwhile choices.

Sample Picture Book Biographies, With Accompanying Goals and Literacy Tasks

The considerations noted in the previous section guided the selection of the five picture book biographies used as samples. Teachers can access picture book biographies, either through a hard copy or, in many cases, as an online posting of a read-aloud of the selection. Although hard copies provide for more flexible use, online postings often provide engaging renditions of the stories and may include supplemental materials that can be used to deepen students' understanding of the STEAM field under study.

Each book selected provides teachers rich contexts through which they can engage their students in numerous age-appropriate tasks to help them access STEAM content. The context of the book characters' lives impacted their opportunities, experiences, and often their dreams and visions for themselves. Real-world situations described in the texts often point to issues of equity and factors that affected tangible, cultural, and cognitive access for that individual. Sample tasks allow students to participate in critical thinking, problem solving, and reasoning while engaging in meaningful communication and collaboration with peers. The tasks provided are designed to spark the thinking of teachers regarding the ways they themselves might use picture book biographies in supporting literacy needs of their students for engaging productively in learning STEAM content and processes in their classrooms.

Bardoe, C. (2018) *Nothing stopped Sophie: The story of unshakable mathematician Sophie Germain.* Illustrated by B. McClintock. New York: Little, Brown and Company.

Book summary:

Sophie Germain had an indomitable spirit and an approach to life that embodied perseverance in the face of many odds. Even when Sophie was a little girl, her parents did not want her to do mathematics—females in her culture were allowed to play the piano and other pursuits, but it was "unseemly" for them to do mathematics. Both the author and illustrator delightfully present Sophie, who persevered in solving problems that led to advances in engineering and in pure mathematics. Her foundational work with modeling the mathematics of vibrations allowed for the later design and construction of structures such as the Eiffel Tower, modern skyscrapers, and long-span bridges.

STEAM goal:

To support the development of students' perseverance in problem solving, a primary goal of school mathematics (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010), is applicable also in other STEAM disciplines.

Literacy task:

Present the book to students as a read-aloud experience. Later, read the book again orally, asking students to think about Sophie's perseverance. The title, *Nothing Stopped Sophie*, will lend itself well to helping students understand this trait. After discussion, ask each student to write two or three words or short phrases that describe or provide examples of Sophie's perseverance. Using your favorite Word Art or Word Cloud program (see, for example, https://wordart.com/), enter the students' responses, including all repetitions.

Display the word cloud and clarify that the size of the words and phrases is related to their frequency. Ask students to think about important ways Sophie demonstrated perseverance in mathematics. Is there anything they can learn from Sophie about why it is important to persevere in mathematics and in other STEAM-related fields? As a class or as individuals, guide the students to decide on a way they can focus on developing and extending their perseverance in STEAM content and help them develop individual or group plans for doing so.

Biebow, N. (2019). *The crayon man: The true story of the invention of Crayola Crayons.* Illustrated by S. Salerno. HMH Book for Young Readers.

Book summary:

The year 1903 must have been exciting for Edwin Binney, who spent his days running a company that sold carbon black pigment for everything black—from shoe polish to rubber car tires. In that year, he developed the original Crayola spectrum of eight coloring crayons!

Although he earned his living in black, he loved color, and he had an inventive mind. His wife, a former schoolteacher, told him of the inadequate quality of crayons at that time (besides being unpleasant and lumpy, some were poisonous) and challenged him to invent better, cheaper ones. After many tries and with much experimentation and the help of many people, Binney developed the crayon that still rules the market today.

STEAM goal:

To focus students on the processes an inventor might use in creating or improving a product.

Literacy task:

In pairs or small groups, students are to create a storyboard based on the book. The storyboard is to document in words and pictures the process Mr. Binney engaged in to invent Crayola Crayons. Students are to create and label the storyboard sections and put them together sequentially.

Make sure students note Mrs. Binney's part in helping her husband define and introduce the word *Crayola* into the culture. They also should consider the marketing and distribution of Crayola Crayons that involved his friend Harold at the World's Fair in 1904.

Diehn, A. (2019). *Computer decoder: Dorothy Vaughan, computer scientist.* Illustrated by K. Mazeika. Nomad Press.

Book summary:

Dorothy Vaughan, born in 1910, was gifted even as a child at solving problems. After graduating from college, she became a mathematics teacher. One day she saw an ad on a bulletin board for a position as a human computer at the Langley Memorial Aeronautical Laboratory (the predecessor to NASA). Although she was hired for the position, she experienced discrimination as a female in the workplace. As an African American, she also dealt with segregation issues. Despite the challenges, her gifts as a mathematician were recognized and she was promoted to a supervisory position, where she led a team of people in acquiring the knowledge needed to develop programming skills. She is remembered as an author of computer codes that are foundational to the technological society that exists today.

STEAM goal:

To help students begin to envision themselves in STEAM occupations and to understand the kinds of preparation needed for them.

Literacy task:

Dorothy Vaughan's life changed when she responded to a bulletin board ad for a mathematics position. Students can learn about STEAM jobs available today by creating written advertisements for job openings.

Working in pairs, students are to prepare interview questions for someone who works in a STEAM occupation in which they are interested. Then they are to conduct the interview, taking notes and/or recording as they interview. They are to use the information they gathered to construct a realistic advertisement of a hypothetical job opening in that occupation. Make sure students document in their ad the preparation and skills needed to perform the job effectively.

Griffith, E. (2021). *Secrets of the sea: The story of Jeanne Power, revolutionary marine scientist.* Illustrated by J. Stone. Clarion Books.

Book summary:

Jeanne Power, born in 1794, was a 19th-century problem solver. She is remembered as the designer of aquariums so she could study marine animals in their natural habitats. As a young woman, she moved to Paris to learn the trade of drawing patterns and making clothes. Her work as a seamstress became sought after to the extent that she was commissioned to draw a pattern for the wedding gown of an Italian princess. After marrying in 1818, she and her husband moved to Sicily, where she observed, drew, and studied both land and sea animals. The skills she had acquired as a dressmaker helped her draw images designed to scale for fish tanks made of transparent glass that sea creatures could inhabit. The scientific community credits her today for inventing the aquarium and for solving the mystery of how the paper nautilus creates its own shell.

STEAM goal:

To promote student awareness of the pervasiveness and roles of patterns in everyday life.

Literacy task:

Jeanne Powers was an expert at creating patterns and then producing a product from the written pattern she created. There are many kinds of patterns, and they appear everywhere! Some are repeating patterns; others grow or shrink, with regularity in the way they change.

Assign students to pairs or small groups. Ask each group to create a pattern, either a repeated pattern or a growing or shrinking pattern (They might use music, movement, numbers, shapes, claps, objects, seasons, time intervals, etc.). Then they are to devise a way to represent their pattern on paper and label whether it is a repeating, growing, or shrinking pattern and/or "perform" their pattern for peers and ask them to label it.

Now, back to Jeanne's dressmaking patterns: In what ways could the patterns Jeanne created for dressmaking be repeated? How might she have adapted them to become growing or shrinking patterns? Children who have learned about equal ratios might design a pattern for their own glass fish tank, referring to the drawings in the book. In planning for its completed size, they will need to consider the space needed for the aquatic life it will be designed to hold.

Parsons, K. (2021). ***Saving the day: Garrett Morgan's life-changing invention of the traffic signal*****. Illustrated by R. Christie. Little, Brown and Company.**

Book summary:

Garrett Morgan, a Black inventor, was born in 1877 as the seventh of eleven children. His parents recognized early in his life that he had a gift for thinking in innovative ways. Although his parents were not wealthy, they sent their son from rural Kentucky to the city (Cincinnati, Ohio) where he could study with a tutor and work toward his dream to become an inventor. Garrett studied during the day and after hours experimented with the tools he had available to create products and fix objects. He is credited for inventing the zig-zag attachment for sewing machines and a mask that provided protection for soldiers and firefighters. However, he is best known for the idea and invention of a three-way traffic signal.

As a Black American, he promoted equal rights for all. He gave much of his wealth from his inventions to traditionally Black colleges and universities.

STEAM goal:

To engage students in reading and interpreting graphic representations of technical information.

Literacy task:

Garrett Morgan looked around himself and viewed things that could be made better in the culture and environment in which he lived. One was the traffic signal. Before his development of a three-way traffic signal, patented in 1923, traffic signals were only two-way: "stop" and "go." Referring to Morgan's accident as related in the book and incorporating children's knowledge of safety at traffic signals, discuss why a three-way signal was a major improvement. Then project the drawings from Morgan's patent application, included in the book as the last page of back matter (n. p.). They are technical in nature, but with careful examination, students can make some important observations.

After reviewing what they observe from the drawings, have them use a Venn diagram to compare Morgan's three-way signal of about one hundred years ago with current three-way signals. The following questions may prompt children's thinking.

> What materials were used to build the signals then? Now?
> What were the power sources then? Now?
> What would happen if that source of power became unavailable?
> Do the signals accomplish the same—or different—purposes?
> What were traffic signals called then, and what are they usually called now?

Summary

Elementary teachers can create many opportunities to inspire and help their students envision themselves as capable of STEAM learning and as agents for positive change through STEAM fields. Teachers manage learning environments and instruction that employ the language arts: "speaking/listening, reading/writing and viewing/representing" (Malloy et al., 2019, p. 7) to promote tangible, cultural, and cognitive access to the development of student identities as STEAM learners. Introducing students to picture book biographies that present a diversity of STEAM contributions by highlighting the accomplishments and struggles of the characters is a promising practice.

The characters (and potential role models) responded to the contexts and challenges of their time periods and circumstances by producing innovative ideas or products to address needs. They engaged in problem solving to find solutions and to produce change. The contribution each STEAM biographical character made enriched the lives of not only their generation but generations to come. The STEAM characters presented in picture book biographies serve not as examples to be copied, but as inspirations for students of today in developing their own identities as meaningful contributors to society, whether in the STEAM fields or in another field of their choice (Gladstone & Cimpian, 2021).

References

Boulware, B. J., & Monroe, E. E. (2021, October 15). *The many colors of STEAM: The Crayola Man and other picture book biographies* [Conference presentation]. Organization of Teacher Educators in Literacy of the International Literacy Association. Online.

Boulware, B. J., & Monroe, E. E. (2023, October 13). Developing STEAM identity through picture book biographies using language arts strategies [Conference presentation]. Organization of Teacher Educators in Literacy of the International Literacy Association. Online.

Buehl, D. (2017). Teaching comprehension of complex disciplinary texts. In D. Buehl, *Developing readers in the academic disciplines (2nd ed.)* (pp. 29-73). Stenhouse Publishers.

Columba, L., Kim, C., & Moe, A. (2005). *The power of picture books in teaching math, science, and social studies. PreK – 8*. Holcomb Hathaway.

Flanigan, K., Templeton, S., & Hayes, L. (2012). What's in a word? Using content vocabulary to generate growth in general academic vocabulary knowledge. *Journal of Adolescent and Adult Literacy, 56*(2), 132– 140. https://doi.org/10.1002/JAAL.00114

Gladstone, J. R., & Cimpian, A. (2021). Which role models are effective for which students? A systematic review and four recommendations for maximizing the effectiveness of role models in STEM. *International Journal of STEM Education, 8*(1), 59. https://stemeducationjournal.springeropen.com/articles/10.1186/s40594-021-00315-x

Houseal, A., Gillis, V., Helmsing, M., & Hutchison, L. (2016). Disciplinary literacy through the lens of the Next Generation Science Standards. *Journal of Adolescent and Adult Literacy, 59*(4), 377– 384. https://doi.org/10.1002/jaal.497

Malloy, J. A., Marinak, B. A., & Gambrell, L. B. (2019). Evidence-based best practices for developing literate communities. In L. M. Morrow & L. B. Gambrell (Eds.) *Best practices in literacy instruction* (6th ed. pp. 3-25). Guilford Press.

May, B., Milner, A., & Young, T. (2019). Biography breaks in the music classroom. *General Music Today, 32*(2), 37-43. https://journals.sagepub.com/doi/full/10.1177/1048371318814910

Monroe, E., Young, T, Fuentes, D., & Dial, A. (Eds). (2018). *Deeping students' understanding of mathematics through children's literature.* National Council of Teachers of Mathematics.

MSRI/Simons Laufer Mathematical Sciences Institute (SLMath). (2023). *Mathical Book Prize.* https://www.mathicalbooks.org/

National Council of Teachers of Mathematics. (2020). *Catalyzing change in early childhood and elementary mathematics: Initiating critical conversations*. NCTM.

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common core state standards for mathematics.* http://www.corestandards.org/Math/

Partnership for 21st Century Skills. (2009). *P21 framework definition*. https://files.eric.ed.gov/fulltext/ED519462.pdf

Piro, J. (2010). Going from STEM to STEAM: The arts have a role in America's future, too. *Education Week, 29*(24), 28-29. http://www.ischoolcampus.com/wp-content/uploads/2010/03/Going-From-STEM-to-STEAM.pdf

Saldutti, C. (2019). Equity and representation in STEM: Giving students functional access to 21st-century STEM literacies. *Literacy Today*, *36*(6), 8-9. http://viewer.zmags.com/services/DownloadPDF?publicationID=017d30e7&selectedPages=all&pubVersion=77&print=true

Sharapan, H. (2012). From STEM to STEAM: How early childhood educators can apply Fred Rogers' approach, *Young Children, 67*(1), 25-33. https://www.proquest.com/openview/faea64e6647f6d1d292b909f63fba7e2/1?cbl=27755&pqorigsite=gscholar&parentSessionId=A8b5Sa53PuVjpVcIiEzg%2F9k95Q3oZQTCrlKKl1vp%2FoU%3D

WordArt. (2009-2023). https://wordart.com/

Young, T. A., Monroe, E. E., & Roth McDuffie, A. (2021). Picture book biographies read-alouds and Standards for Mathematical Practice. *The Reading Teacher, 75*(2), 135-146. https://doi.org/10.1002/trtr.2019