

# Using Comics to Make Science Come Alive

Cara Gormally<sup>1\*</sup>

<sup>1</sup>Department of Science, Mathematics, and Technology, Gallaudet University

## Abstract

Students often see science as a fragmented set of facts to be memorized, rather than concepts and processes that are relevant in their everyday lives. This is especially true for non-science majors, who represent the vast majority of all college students. Including long-form comics, such as graphic memoirs, in the curriculum, is one approach to making science relevant. This curricular approach is designed to humanize biology so that students are motivated to understand the relationship between science and issues that they face in their lives. As a class, we read graphic memoirs about pressing socio-scientific issues, specifically, infertility, cancer, and AIDS. Graphic memoirs grab students' attention, creating a "need to know." Once students' interest is piqued, we delve deep into the biology of these issues, using a variety of active learning approaches to scaffold student learning. Comics can serve as powerful entry point to science; "story-ifying" science makes it come alive for non-scientists. By engaging with graphic memoirs, students come to see science as meaningful in their own lives beyond the classroom. A list of potential graphic non-fiction narratives and topics is provided.

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**Supporting Materials:** S1: Using Comics—Example Quiz and Homework Assignment; S2: Using Comics—Example PowerPoint; and S3: Using Comics—Reflective Comic Rubric.

\***Correspondence to:** [cara.gormally@gallaudet.edu](mailto:cara.gormally@gallaudet.edu); Gallaudet University, Hall Memorial Building, 800 Florida Avenue, Washington, D.C. 20002.

## Learning Goal(s)

- Students will appreciate the science involved in contemporary issues we face in society (AAAS 2010).

## Learning Objective(s)

Students will:

- be motivated to learn science related to specific socio-scientific issues.
- learn science that applies to specific socio-scientific issues.
- be able to discuss the relationship between science and society, as well as the biology behind the issue, related to specific socio-scientific issues.

## INTRODUCTION

Students often see science as a fragmented set of facts to be memorized, rather than concepts and processes that are relevant in their everyday lives. This is especially true for non-science majors, who represent the vast majority (82%) of all college students (2). AAAS (2010) urges science educators that a core competency of "science education for civic engagement and responsibility" includes students developing the ability to understand the relationship between science and society (3). Yet, too often, our curricula miss the mark on this goal. However, as a society, we face increasing numbers of challenging socio-scientific issues, including climate change, waning vaccination rates, and decisions about personal genetics. Now more than ever, it is critical that our students—our future lawyers, teachers, activists, and voters—are prepared to engage in these discussions. If students are to engage with science beyond the classroom, they must come to see science as relevant to everyday life (4).

To appreciate how science is involved in contemporary issues we face, students must first be motivated to learn science related to specific societal issues. "Story-ifying" science is one approach to making science relevant to students. Stories appeal to our shared humanity (5). Some researchers posit that storytelling may even be an evolutionary mechanism, which helped to keep our ancestors alive (6). Engaging with a cohesive narrative makes these critical connections between science and society blatantly clear while sparking students' "need to know more." Books, including autobiographies and realistic fiction, have been used by other faculty to compliment traditional textbooks (7,8). In fact, comic books have been shown to be an effective way to engage non-biology majors in learning science (9).

Comics are particularly well-suited to be included in science education. Pictures have a universality that words do not; thus, the visual language of pictures is easier to recognize, process, and recall than words (10). Comics, being a combination of both text and pictures, have an even greater

advantage than pictures alone. Research shows that we can recall informative images better than decorative images, since informative images provide “clarifying examples, extra-lingual information, and context for interpretation,” which facilitates learning (10). As a result, comics can make the most complex of concepts instantly understandable which is critical in our diverse classrooms, particularly for English language learners and students with disabilities. It is unlikely that we could say the same for most biology textbooks.

In this curricular approach, we used long-form comics—graphic memoirs—as a means to humanize biology so that students understand the relationship between science and issues that they face in their lives. As a class, we read graphic memoirs about three pressing socio-scientific issues: infertility, cancer, and AIDS. The graphic memoirs grabbed students’ attention, creating a “need to know.” When students’ interest was piqued, we delved deep into the biology of these issues, using a variety of active learning approaches to scaffold student learning, so that students could learn the biology behind these issues. Comics can serve as powerful entry point to science; making science come alive for non-scientists. By engaging with the graphic memoirs, students came to see science as meaningful in their own lives beyond the classroom. A list of potential graphic non-fiction narratives and topics is provided within.

### *Intended Audience*

This curricular approach was developed for non-science majors at Gallaudet University, which is an open-enrollment, non-selective liberal arts college (the Carnegie classification for the university’s undergraduate profile is described as “four-year, full-time, inclusive, higher transfer-in”). The course is open to all students. The demographics of the class reflect those of the university (88% of students are deaf and hard of hearing). This curricular approach is ideal for non-majors and introductory-level students as it is intended to motivate students to want to learn science. However, since this approach is flexible, it is appropriate for diverse audiences, including advanced courses for science majors. The curricular approach is particularly well-suited for students who are English language learners and students with disabilities. To make graphic memoirs accessible for students who are blind or have low vision, PDFs accessible to text-to-speech software can be produced with the support of the university’s office for students with disabilities. Resources for making comics accessible include LearningAlly (<https://learningally.org/Blog/graphic-novels-in-an-audio-book-format>), an organization which produces graphic novels in an audiobook format; a description of how one faculty member made comics accessible with PDFs accessible to text-to-speech software (<https://accessinghigherground.org/creating-accessible-comics-and-graphic-novels/>); and an explanation the process of producing effective alt-text for use with screen readers (<https://axesslab.com/accessible-comics/>).

### *Required Learning Time*

Instructors must use their own discretion to determine how many comics or graphic memoirs to include in their course. In our course, we created three four-week long units, each including one graphic memoir. In the course, this curricular approach was combined with the Comics Project. Students read each graphic memoir, researched their own related questions in the primary literature, and created an evidence-

based comic including citations.

### *Prerequisite Student Knowledge*

No specific prerequisite knowledge is needed. Through the process of engaging with graphic non-fiction narratives and class activities, students will learn about a variety of biological concepts and processes, depending on the books selected to meet course learning goals.

### *Prerequisite Teacher Knowledge*

There is no specific prerequisite knowledge for instructors. It is assumed that instructors are familiar with the course content in which they plan to embed the selected books.

## **SCIENTIFIC TEACHING THEMES**

### *Active Learning*

Several active learning strategies are employed in this curricular approach. First, students engage with the books, which spurs a “need to know” more, encouraging further biology learning. Students read the graphic memoirs as part of their homework assignments. Activities are designed for students to search and identify high quality sources of scientific information to address learning objectives on their homework assignments. Students’ learning is self-directed, using library searches, Internet searches, and databases such as PubMed to search for scientific information. In class, active learning techniques including think-pair-share and small group, as well as whole-class discussion about the books and the biology background of the issues presented, are used to support student learning. Student groups are often asked to share what they learned through their homework, using peer-teaching techniques.

### *Assessment*

A variety of assessment opportunities are used to evaluate students’ progress toward achieving our learning objectives. First, daily class discussions, both as a class, and through small group discussions, allow for assessment of students’ content knowledge, their motivation to learn the science related to the graphic memoirs, and their ability to discuss the relationship of biological concepts to each issue (discussion questions and prompts are provided in Supporting File S2: Using Comics—Example PowerPoint). During in-class discussion and small group discussion, the instructor informally assesses student learning with relation to biology content, in order to make just-in-time adjustments to the mini-lectures.

Students are prepared for in-class discussions via low stakes assignments such as homework and quizzes. These low stakes help to keep students accountable for their learning, while assessing students’ content knowledge related to the specific socio-scientific issues our class tackles. Quizzes primarily focus on related biology content and students’ reading of the graphic memoirs. Numerical grades are provided for homework via the course learning management system (LMS). In large enrollment courses, this might be substituted with a binary grading format (e.g., complete / incomplete). While our class utilizes quick 5-minute in-class quizzes on paper, quizzes could alternatively be on the course LMS or taken via clicker questions.

For each unit, two reflective essays are used to assess

students' motivation to learn science and their appreciation of the science involved in contemporary issues, as well as to evaluate students' learning of related biology content. On the pre-essay, students are asked to explain what they know about the biology of the topic, for example, "Describe what you know (or you think you know) about infertility and reproduction." On the post-reflective essay, students are asked, for example, "Explain the most important concepts you learned about infertility and reproduction. What information do you think people should know and why? Now, what are you curious to learn more about?"

Finally, students are asked to develop an end-of-course comic reflecting on their learning throughout the semester as a means to assess their motivation to learn science and their appreciation of the science involved in contemporary issues (a rubric is provided in the PowerPoint in the Supporting File S3: Using Comics—Reflective Comic Rubric).

### *Inclusive Teaching*

This curricular approach "story-ifies" science as a creative entryway to biology, which piques students' curiosity. The vast majority of college students (82%) are non-science majors, and so this curricular approach may make biology more relevant to them (2). Further, our classes are increasingly composed of students with disabilities, including deaf and hard-of-hearing students, and students who are English language learners. Comics benefit these learners and all students by using visual communication rather than relying on words alone. In this way, challenging scientific concepts can be clearly communicated while supporting English language learners. Additionally, visual communication is an important strategy to engage the bilingual (American Sign Language (ASL) and English) Deaf community in science (11).

## **LESSON PLAN**

### *The Course*

The course is taught at Gallaudet University, a university with a uniquely chartered mission to serve deaf and hard of hearing students. This means that classroom teaching and learning is bilingual: we use texts composed in English and ASL and communicate with one another using ASL. The course is a four-credit 200-level class that meets twice a week for 2 hours in a 15-week semester. The course serves 12-21 students led by one instructor, but this curricular approach could be scaled for a larger class. The course is not required and serves mostly non-science majors with limited science backgrounds. The course includes three units about infertility, cancer, and HIV/AIDS.

### *Classroom Seating Arrangement*

Gallaudet's classrooms are designed with deaf students in mind: student desks are arranged in a large circle, rather than in rows, to allow for clear sightlines (11). Research shows this seating arrangement benefits all students, as it encourages more social interaction (11). If possible, it is recommended to move classroom seating into a circle for whole-class discussions about the book—or into small groups for small group discussion.

### *Pre-Semester Preparation*

The following questions concerning logistics and goals may

help with decision-making about key project details.

- What topics will the course focus on? Which graphic memoirs or comics will we read together? The Graphic Medicine website (<https://www.graphicmedicine.org/>) is an excellent resource for identifying graphic visual narratives, otherwise known as long-form comics, about science and medicine. Table 1 provides a sampling of graphic memoirs.
- How many graphic memoirs will the class read? How will you integrate this reading timeline into your curriculum?
- Will classroom discussions about the book be conducted in small groups or as a whole class?
- Will students read the same comics as a class or select comics themselves to read on an individual basis?

### *Sample Reading Timeline*

There are a variety of possible timelines for integrating graphic memoirs into a science class. Students might be assigned to read the entire book outside of class time, and the instructor might devote part of one class to discussing the book. Or, an instructor might use the online learning management system for a class discussion about the book.

For our class, we read ~50 pages before each class, in addition to other homework assignments, including biology content reading. We read three graphic memoirs in a 15-week semester. Each unit was five weeks long; we spent the first three weeks of each unit discussing the graphic memoir at the beginning of each class, for the first 15-20 minutes of our 110-minute class. The remainder of the class period was spent on activities and a mini lecture about biology related to the graphic memoir (see activities and mini lecture in Supporting File S2: Using Comics—Example PowerPoint), as well as unit projects related to the topics (which are not discussed in this article).

### *In-Class & Assessment Strategies*

Class begins with a brief (5-10 minute) quiz about the book reading and homework assignment (example provided in Supporting File S1: Using Comics—Example Quiz and Homework Assignment). Class proceeds with either a whole-class or small group discussion of the book reading (discussion questions and prompts are provided in Supporting File S2: Using Comics—Example PowerPoint). Questions such as "What's the most important part of the author's story that you would share with friends?" Given what you've learned about infertility, how would you respond if you were faced with similar challenges?" "What are you most excited to learn about in terms of human reproduction, fertility, and infertility after reading this book?" can be used as formative assessment to help the instructor informally evaluate if learning objectives are met. Then, as a class, we segue into a discussion of the biology we read about, using the book and reinforcing students' learning from homework reading. We begin this with informal in-class assessment of student learning: students are asked to teach concepts they've learned in small groups and for the whole class (the activity is described in Supporting File S2: Using Comics—Example PowerPoint). A list of learning objectives for the class period is provided in Supporting File S2: Using Comics—Example PowerPoint. Then, the instructor gives a mini-lecture, scaffolding new conceptual learning on

students' prior learning (implementation details are provided in the notes under the slides in the example PowerPoint, Supporting File S2: Using Comics—Example PowerPoint). Detailed notes about implementation of the whole-class discussion are provided in the PowerPoint slide notes (Supporting File S2: Using Comics—Example PowerPoint). The notes include: discussion questions and prompts; small group activities; learning objectives for the class period; and a mini lecture.

## TEACHING DISCUSSION

A core competency of “science education for civic engagement and responsibility” includes students developing an appreciation—and an interest in the science involved in contemporary issues we face in society (3). Yet, too often, our curricula fail to achieve this goal. Simultaneously, we face increasingly urgent and challenging socio-scientific issues, with both personal and societal implications. Additionally, taking on this teaching challenge can benefit our students in other ways. Research has demonstrated that an emphasis on socio-scientific issues can positively influence students' attitudes toward science, as well as their perceptions about the relevance of science (12).

Traditional textbooks often fail to convey how science relates to big issues we face, given their dry writing style, lack of narrative; textbooks often contain more content presented with less coherence (13). In contrast, the National Science Board encourages science educators to clearly communicate the fascination, joy, and utility of science (14). Comics may meet this need. Comics, including long-form comics such as graphic memoirs, have been recognized as an effective approach to engage students in learning (8,9,15). We know that a narrative developed from both emotions and data engages people more effectively than data alone (16). Research in biology education has demonstrated that comics are an effective way to engage and motivate students in learning science (9). Comics are especially useful for non-science majors, who demonstrated statistically significant improvements in both content learning and attitudes toward biology at the end of the semester as compared with the beginning of the semester (9). Additionally, for our students who are bilingual deaf and hard-of-hearing learners, comics offer extra-lingual information (11), which may benefit all students, especially English language learners.

In our class, we read three graphic memoirs, one for each unit concerning a socio-scientific issue: infertility; cancer; and HIV/AIDS. The graphic memoirs we read as a class made this biology relevant to students, as they connected to the stories told by real people. As a result, students were deeply engaged in learning about these three socio-scientific issues. Reflective essay comments included statements such as:

*Prior to this unit, I had very little knowledge on the subject of AIDS. Through class and reading, I have learned so much I never would have otherwise. A couple things that stood out to me were what AIDS does to the body and about personal experiences of people with AIDS...Learning about people's experiences has helped me to be aware of what other people have had to suffer.*

*One of the most important things I learned about AIDS*

*was how AIDS actually works. I knew a little about HIV and AIDS, but never understood what it actually did in the body. Now I know that HIV cells multiply and take over healthy immune system cells. I think other people should learn how HIV becomes AIDS...I think most people now know how HIV is transmitted, but I wish that more people would take safe sex seriously because of this.*

*I learned that infertility is common. It is not odd or out of the ordinary for someone to struggle with infertility. It is important that people understand this in case they struggle with infertility or someone they know does. Often people hear about someone trying to conceive, having miscarriages, etc. and try to offer advice or comfort. However, often this ends up being unintentionally hurtful or rude. I think this is because there is lack of understanding on the topic...I think it is important that people know about this...so that they can be better educated about infertility if they ever experience it.*

*I learned about the cell cycle and how cancer cells ignore the checkpoints in the cell cycle. That was really cool for me because I always knew that cancer cells grew uncontrollably, but I didn't understand why.*

In each unit, students' reflections often emphasized the power of knowledge and the importance of connecting that knowledge with social issues. These issues—science-based issues—became real, relevant, and personal to students.

The depth of our classroom discussions was impressive, as students considered the societal implications of these issues (for discussion question prompts, see in Supporting File S2: Using Comics—Example PowerPoint). In our classroom discussions, students sensitively addressed and debated about these issues, while recognizing each issue could be deeply personal to individuals, as well as a public health concern. As the instructor, I was especially thrilled to see students' curiosity and their drive to learn more. This was also reflected in their learning of related biology content. On quizzes, which focused primarily on biology content and questions about the graphic memoirs we read, students earned, on average, 83%.

In our course, I chose to use online resources to support students' biology learning, instead of a traditional biology textbook. I made this pedagogical decision for several reasons:

1. Our students often come from low SES backgrounds and struggle to afford the cost of textbooks;
2. I wanted to create a learning environment that would mimic the learning that students do in their everyday lives beyond the classroom—an environment that does not involve textbooks—but does require information literacy skills to evaluate the quality of sources of information found on the Internet, via one's ever-present phone, laptop, or tablet;
3. I was curious to learn how students would respond given more freedom and choice for their learning (e.g., watching videos versus reading Internet pages, as well as choosing to use one source versus another).

To do this, I drew from freely available web resources such as Open Stax CNX, a freely available web-based textbook; reputable science centers and organization webpages such



as the Centers for Disease Control & Prevention; news media websites such as BBC Bitesize; and videos on YouTube from reliable channels such as TEDed, Fuse School, ASAP Science, and Khan Academy. Students were provided with homework learning goals and charged to use suggested sources, as well as other sources of their own choosing, to take notes in order to meet the learning goals. Students were well prepared for class. Students often went above and beyond in their homework reading, driven by their desire to answer questions that arose while they learned. I began to wonder why I would ever use a textbook.

Long-form comics could be easily integrated in a variety of science courses and adapted for particular course needs. For example, in large enrollment courses, instructors might choose to use small group discussions about the comics they have read, rather than a whole-class discussion, in order to encourage active learning. Alternatively, in an online course, students might contribute to online discussion boards to share dialogue about the comics reading.

Instructors do not need to redesign an entire course in order to include long-form comics. Instructors could choose to include a graphic memoir as homework reading for students to do outside of class time, in order to motivate students to learn in-class content. Students could then be prepared to come to class ready to participate in whole-class or small-group discussions. Or, instructors might assign students, either as individuals, or in groups, to select a comic of their own choosing, related to the course material, and create a presentation in which they explicitly describe what they have learned from the comic about how science can inform big issues we face, using relevant course concepts.

### Conclusion

Comics, including graphic memoirs, are approachable and engaging texts for students to make meaningful connections between science and contemporary issues in society. Long-form comics and graphic memoirs have been written on a variety of socio-scientific and medical issues. Comics can be integrated as an assignment in a diverse range of courses, including introductory courses, courses for non-majors, online courses, large enrollment courses, and upper-level courses for majors. Reading comics engages students in real-life science that is made meaningful beyond the classroom.

### SUPPORTING MATERIALS

- S1: Using Comics—Example Quiz and Homework Assignment
- S2: Using Comics—Example PowerPoint
- S3: Using Comics—Reflective Comic Rubric

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Course development was enhanced by discussions in the Graphic Medicine Facebook group. I am deeply appreciative to Graphic Medicine members' enthusiasm for this course. Some excellent additional resources can be found at the U.S. National Library of Medicine's website: <https://www.nlm.nih.gov/exhibition/graphicmedicine/>. Finally, I thank my excellent students, for a joyous learning experience.

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**Table 1. A list of graphic memoirs of potential interest for science courses.**

Graphic Memoir (Title, Author, Publisher, Publication Date)	Topics
A.D.: New Orleans After the Deluge, by Josh Neufeld. Published by Pantheon, 2010.	<i>Flooding; Climate change</i>
A Fire Story, by Brian Fies. Published by Abrams ComicArts, 2019.	California wildfires
Climate Changed: A Personal Journey Through Science, by Philippe Squarzoni, Published by Abrams, 2014.	Climate change
El Deafo, by Cece Bell. Published by Amulet Books, 2014.	Hearing loss
Epileptic, by David B. Published by Pantheon Books, 2005.	Epilepsy
Good Eggs, by Phoebe Potts. Published by HarperCollins Publishers, 2010.	Infertility
Graphic Reproduction: A Comics Anthology, Edited by Jenell Johnson. Published by The Pennsylvania State University Press, 2018.	Reproduction; Pregnancy
Hole in the Heart, by Henny Beaumont. Published by The Pennsylvania State University Press, 2016.	Raising a child with Down's Syndrome
IDP: 2043, Edited by Denise Mina. Published by Freight Books, 2013.	Post-climate change dystopian graphic novel
I'm Not a Plastic Bag, by Rachel Allison. Published by Archaia, 2012.	Great Pacific Garbage Patch
In-between days, by Teva Harrison. Published by House of Anansi Press, 2016.	Metastatic breast cancer
It's All Absolutely Fine, by Ruby Elliot. Published by Andrews McMeel, 2017.	Depression; Anxiety; Body image
Kid Gloves, by Lucy Knisley, Published by First Second, 2019.	Infertility; Pregnancy; Birth
Marbles, by Ellen Forney. Published by Avery, 2012.	Bipolar disorder