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Engineering Instruction, Inclusion, and Comics – Reflections from a Student Illustrator and an Instructor

Abstract - This paper presents the opportunity gap for comics in engineering education, through reflections from a team redesigning a mechanical engineering syllabi using illustrations. To increase a sense of belonging among diverse students, the authors of this paper propose a graphic narrative focused on the curriculum of the mechanical engineering department at a large public university in Western United States. We hope that this paper addresses the underutilized and largely missed opportunity to add engagement, better conceptual understanding, and improve inclusion in engineering classrooms through incorporating visual illustrations.

Keywords – Inclusion, Comics, STEAM

Introduction

The use of comics in education has been lauded by several education researchers (e.g., Krashen (2005), Koutnikova (2017), Pascal and Pascal (2017), and most recently, Sari and Harahap, 2021) as a way for students to not only become engaged in their studies by communicating knowledge in a creative and fun way, but also develop logic and reading skills. Comics have long been used to translate information into an easily accessible and entertaining form. History is replete with examples, ranging from the propaganda comics that were introduced during World War II to more recently collection of modern science webcomics like Bird and Moon or Beatrice the Biologist (Hosler and Boomer, 2011). Many classrooms across the globe have utilized comics to generate both enthusiasm and understanding of subject matter.

Additionally, the use of comics may also address the benefit of creative expression which can help boost critical thinking and problem solving (Wylie and Neeley (2016), Tahsaldar and Semaan (2018)). Acknowledging the widely accepted benefits of integrating comics into curriculum, this innovative practice paper contributes to literature which extends the advantages of using comics in education to not only aid engagement and comprehension but also help with inclusion and belonging among students. Bettering inclusion in engineering classroom by bettering representation is a pursuit that has been advocated for by many (e.g., work done in disability representation by Syvantek (2016), gender and ethnic minorities in US engineering classrooms by Lee, Matusovich and Brown (2014), as well as student perceptions of learning about diversity by Lee, Lutz, Matusovich and Bhaduri (2021)). However, those from marginalized communities continue to feel out of place in their programs, often due to lack of representation and many become discouraged before they even start. Many freshmen, for example, may find the curriculum intimidating and confusing, and often this leads students to be unable to truly familiarize themselves with the details of their curriculum nor understand how these learnings will help them advance in their desired career trajectories (e.g., Cornwell, 1996). Using comics to illustrate what a full mechanical engineering degree course pathway would look like could potentially help students better engage with the curriculum. This could in turn provide ways for them to improve conceptual understanding and motivation/interest. We contend that an increased motivation would likely bring in students who hadn't considered engineering, felt like they did not belong, or had brushed it off due to lack of familiarity or knowledge of the subject matter.

By helping students break preconceived notions of engineering stereotypes and see characters, like themselves, take on challenging engineering concepts and tasks, we hope that inclusion and better representation are furthered. Through our paper, we posit that comics can not only be used to further conceptual understanding, but also be used to highlight diversity in engineering classrooms. We first present a background on the use of comics in the classroom, next we build a case for use of comics to support diversity education in technical courses. Last, we will present the process of building a comical illustration, highlighting the thought process used to introduce comics into a Mechanical Engineering course. Finally, we believe that this paper addresses ways to bring about convergence in engineering education, by drawing in art and creativity into the field while also intentionally emphasizing ways to become increasingly inclusive and global in ways we teach and learn.

Comics and our Classrooms

While comics are relatively common in elementary classrooms, they are practically unheard of in college studies. Understandably, some scholars refute the benefits of the use of comics in educational settings suggesting that such media have little value in more rigorous courses (e.g., Azman, Zaibon and Shiratuddin, 2016). However, there are

several studies that highlight students with limited familiarity of graphic media seem to enjoy the introduction of comics in the classroom. For example, a study in by Anand, Kishore, Ingle and Grover (2018) sought to understand medical students' perceptions of comics in their field. Graphic medicine is a growing movement of integrating sequential art into the medical field, both in public outreach and medical studies. The study asked if students were familiar with this movement and described it. Despite only 21.8% of students stating that they heard about graphic medicine, 76.9% agreed that they would find comics helpful in their studies. Many stated that it would help them memorize and understand various topics such as anatomy or community medicine, and others said that comics could be used to educate the public on medical issues as well.

While many instructors may dismiss comics as an instructional aide, students may see educational value in these tools, despite being unfamiliar with them (Pitura and Chmielarz, 2017). In a 2019 experiment by Dallacqua and Peralta (2019), a class of 5th graders were given scientific comics to analyze critically. They were then tasked with writing their own comic about a separate non-fiction text. The teacher noted how many of the students' comics were able to highlight the core aspects of the original texts and allowed for creative choices in emphasizing different aspects. This study emphasized that the value of comics in a classroom doesn't just stop with reading. The act of writing and drawing a comic requires both a firm grasp and a strong visualization of the concept at hand and researching for a comic is often far more exciting to students than for an essay. In a study conducted on 5th grade students in Turkey, Unal and Demirkaya (2019) found that there was a significant improvement in post test scores in the class that was supplemented with comics. Thus, even if comics cannot increase rigor or better conceptual understanding, they may offer opportunities to introduce fun and engagement in technically heavy STEM classrooms.

Within engineering education, the engineering department of Northeastern University, famously commissioned professional artists who worked with professors to create multi page comics explaining several difficult engineering topics (Landherr, 2016). These comics were narrated by representations of actual professors in the university and created a narrative to answer potential questions and were distributed in courses directly after their relevant topics were discussed. This allowed for the comics to supplement recall, as opposed to being the only instruction. Other examples in engineering education include Jwo (2015) who expanded on teaching software engineering through comics and micro-move design projects, Tatalovic (2009) who expanded on use of comics as tools for science education and communication, and Cervasto (2011) who described how students can use graphic novels, cartoons or comics as visual tools within engineering education. Thus, there is some evidence, admittedly still preliminary, that support comics as contributors to improving engagement and understanding among engineering students.

Comics and the Case for Inclusion

When most people visualize an engineer, they may think of a man performing a stereotypically masculine task. That is not much of a surprise when one considers the history of the profession, social justice considerations, and the engineers who dominated the field since time immemorial (Riley (2009)). In recent times, encouragingly, more and more diversity (e.g., women, racial minorities, those from marginalized communities due to caste-like conditions, those with disabilities, etc.) is entering and thriving in engineering programs. Instructors and colleges must do all they can to encourage these wide range of learners.

It is well established that more diversity brings better teamwork and problem solving, skills which in turn result in globally competent engineers (Downey, et. Al (2006)). However, in engineering, the attrition rate (rate of students who switch majors or drop out), especially of women and minorities continues to be a big issue which has seen little improvement, despite years of research (Pawley, et al (2016)). While attrition is in general tied to lack of confidence and perceived lack of achievement, many women and minorities reported 'culture' as a reason for leaving (e.g., Geisigner and Raman, 2013). Engineering has long had a problem with promoting self-gains instead of teamwork, and when that is paired with the apprehension of being an outsider, it can easily lead to lowered sense of belonging resulting in increased attrition (as described by Tonso (1999)). The need of the hour towards improving belonging among those from historically marginalized communities is use of innovative methods to introduce enhanced representation and promote diversity in our classrooms. Comics may be one such tool.

In recent years, comics have been turned to as a way of promoting diversity (e.g., Matuk, Hurwich, Spiegel and Diamond, 2019). There are several benefits to comics as a visual media - they are cheaper to produce than film, more recognizable than novels, and can be distributed widely online or in print. Indeed, in the past comics were used both to alienate and uplift minorities in America. Beginning in the era of the first world war, many superhero comics featured racist caricatures of Asian supervillains, with yellow skin and slanted eyes, intent on word domination (Yang, 2019). However, starting in the 1990s, comic books became more and more diverse, and grew out of its previous stereotypes. For example, X-Men popularly featured a cast of heroes from a large range of cultures and ethnicities, and built them up as fully developed characters, rather than hollow and insensitive stand-ins. Gene Yang, a Chinese

American comic artist, theorizes on why he and many other Asian Americans related to superhero comics, stating *“From their very beginning, comic books have been for outsiders. In the early days, voiceless sons of Jewish immigrants were able to find their voices in comics. I believe the same is true today for Asian Americans—and, really, not just Asian Americans, but “outsider” storytellers of all kinds.”* This trend can be capitalized upon as we embrace comics for engineering classrooms. Unlike lectures or readings, comics have a cast of characters. The choice of characters is an important one, as they are what the reader is seeing and relating to, and as such can have a deep effect on the reader. This can be used to our advantage in engineering. Engineering students from marginalized communities often lack a sense of belonging within the culture of their major. Given the proper diverse representation, this culture can change drastically to be more accepting of minorities and lead to a boost in confidence for otherwise underrepresented students.

Reflections from Developing and Incorporating Illustrations in the Classroom

Auto-ethnography, as detailed by Creswell and Creswell (2017) is a research methodology that analyzes a phenomenon through self-narratives. These narratives would otherwise remain “private or buried” may help understand experiences from deep reflections. The authors collaboratively decided that auto-ethnography is an appropriate strategy to use in this study because it affords the team an opportunity to document and reflect on the choices made as the comics were developed. Similar to Matusovich, et. al. (2020) we undertook an analytical autoethnography approach, borrowing from Anderson (2006), and prioritized pragmatic reflections - recollections and discussions that focussed on experiences and outcomes. A reflective assignment was shared with the first three authors of this paper. Questions on the reflective assignment helped the authors delve deeper into the need for such comics and understand their personal motivations for undertaking this project. The primary questions driving the reflections from the author/participants of this study include:

1. What do comics offer that traditional curriculum do not? What are your motivations for working on developing an illustrated syllabi?
2. What were some key steps in developing an illustrated syllabi? What would you have done differently, if any?
3. What are some anticipated outcomes of this work? What are some limitations of this approach?
4. What recommendations do you have for others undertaking similar work?

Discussions on the reflections based on the questions helped us piece together narratives from individual statements and recollections to understand and document the entire development of the comics. Through multiple rounds of discussion and debate, the following insights surfaced from the reflections:

Illustrations can be important tools for inclusion, but cannot replace deliberate inclusive pedagogy

Comics can compound the benefits of visuals in engineering education classrooms - an observation anticipated several decades ago by Felder and Silverman (1988). With this in mind, a comic was developed to introduce incoming freshmen to the mechanical engineering curriculum to relieve confusion about the complex class structure, with a focus on clear, approachable ideas narrated inclusively with diversity in mind. The idea was that the typical mechanical engineering curriculum has several disciplinary themes such as thermal-fluid sciences, solid mechanics, design – and each theme could have an illustrated representation to explain about the different areas. The incoming freshmen to seniors could be surveyed about these representations. In the future, similar illustrations may also be used as a recruiting tool to help educate prospective students about the mechanical engineering program. For a mechanical engineering class, the authors of this paper worked on developing and drafting an illustrated syllabus. Reflecting on the idea of an illustrated comic, engineering educator, Sreyoshi noted in her reflections, *“These syllabi shaped like typical comics were ideated to serve a tripartite motive – 1. Condense dense information, 2. Introduce Representation in the Classroom through diverse characters, and 3. Encourage Students to collaborate on updating these comics, based on their own experiences thus fostering increased engagement with the syllabi. Thus, it is but a start to conversations on inclusion and belonging. However, comics and illustrations, while an important and creative tool, cannot replace more deliberate effort and thought in creating and fostering inclusive learning communities.”* All authors agreed that while there are several benefits to development and use of comics in the classroom, they cannot be a replacement for inclusive pedagogy. Krishna, instructor of the course and on the author team reflected in agreement, *“The comics and illustrations are mere vehicles that inclusive instruction would be delivered in. An engaged instructor committed to bettering belonging in a classroom is a prerequisite for effectively implementing such a tool. In my classroom, these illustrations were a means to increase engagement and interaction, but not the only effort I put in to help my students learn and thrive.”*

Comics helped increase engagement and interaction during the pandemic

At the beginning of the pandemic, as the learning communities rapidly pivoted to the virtual, several instructors took to creative approaches to help maintain student engagement and interaction. Krishna, who is a Professor of Mechanical Engineering extensively used comics and illustrations in his classroom to help better engagement and interaction, despite the stresses of the pandemic. Reflecting on the past few semesters, Krishna writes – *“As an instructor it was important to engage students especially during the pandemic to help them stay motivated about their learning and achieve their goals. These innovative assignments provided a creative outlet to our students to explain concepts in a graphical form. Students regularly expressed that such assignments are refreshing to break the monotony of typical assignments.”* Figure 1 shows an illustration of the instructor created by a student, wearing a face shield, while conducting an extra credit quiz. The students in Krishna’s class responded very well to these illustration assignments. First author, Addie, an engineering student, recounted, *“Most of the engineering courses that I have taken in the past, did very little to merge art and creativity into their syllabi. To visually see characters describe and define key mechanical engineering concepts helped me stay engaged in the world of thermodynamics. It felt like I had insights into real-world problems that characters were facing - keys to which lay in this course. I was intrigued and encouraged to connect the dots.”* Thus, the idea that illustrations could connect the core concepts and learning themes from the course to the real-world can help in the creation of engaging content that students will find interesting.



Figure 1: A student’s illustration of an instructor teaching class during the pandemic.

Inclusion through comics cannot be a top-down approach

Working through the development of the illustrated syllabi, the authors quickly realized that comics need to be created through interactive, iterative, and participatory processes. Creating the illustrations essentially comprised three main phases – In the first phase subject matter is condensed into 3-4 big ideas/takeaways. Next, these ideas are captured into a set of examples that can be easily visualized. Finally, the characters are created to support the narrative. The first author of the paper, Addie, is the illustrator of the proposed comic. Reflecting on the illustration process, she remarks, *“To create this comic, I studied the ME class catalog and tried to find the most important classes to focus on.. I wanted the comic to have characters that people could relate to, but might not see as engineers very often. Max is a black man, and he wears a trans pride bracelet, something that most people wont recognize, but transgender students will. Julia is a woman engineer with an insulin pump on her arm. I've met many minorities that have said they would like to see someone like them represented in the media, and that resonated with me, especially as a*

chronically ill woman in engineering. In addition to explaining the curriculum in an entertaining and engaging way, I hope people can look at it and see themselves as engineers with Max and Julia.” Addie’s reflections shed light on characteristics of characters that help her feel most represented. As Krishna reflected, “We quickly realized that illustrations couldn’t be pre-designed. They needed to have a more participatory and ever-evolving nature! As an Indian man, the characters I choose and prioritize may be different from the characters that my students will want to see. The beauty of illustrations that are designed - by students and for students, rather than handed down to them, is that they have autonomy in creating characters based on parts of their identity that are most important to them”.

Thus, while there are several benefits to incorporating illustrations in the classroom, using them to better inclusion and belonging needs an iterative approach and deliberate intent. In addition to the above themes, authors also agreed that working closely with DEI experts, if a department does have the necessary resources, could definitely further the impact of illustrations as an effective teaching and learning tool in engineering classrooms.

Summarizing Thoughts

This paper provided an overview of ways in which convergence with the humanities and arts can be envisioned in engineering education by exploiting use of comics – an underutilized and largely missed opportunity, to integrate knowledge and techniques to help better engagement, inclusion, and possibly even better conceptual understanding in engineering classrooms. We presented reflections on developing and using illustrations of a Mechanical Engineering syllabus. We hope that the reflections and arguments included in this paper will be of use to fellow educators considering the use of visual methods to help engineering learners grasp difficult technical concepts.



Fig. 2: Illustrated summarization of the paper, from the authoring team.

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Appendix A: Draft from the Illustrated Syllabi



Figure: Max and Julia - characters under development by this team of authors, who will be used to illustrate the engineering curriculum, as described in earlier section.