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Gender and Human Imagery in the Halls of a BME Department

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Colleges and universities struggle with the numerical representation of women in engineering departments as well as the often chilly climates found therein [1]. Studies of women in engineering academic environments mostly focus on human components of the environment, such as the experiences of women in the environment, media representation, and the organizational supports and barriers for women's success. Features of a university's physical environment, like visual artwork and signage, inhabited by those women (and their male peers) are far less studied but just as important because these components may influence inhabitants' behavior [2]. The university's physical environment, however, is not impermeable to popular culture: Underrepresentation and prevalent stereotypical perspectives of women in STEM fields can invade students' learning spaces. These societal influences manifest themselves in the art, signage, flyers, and the like adorning the hallways of an academic building [2].

Our study is situated at the intersection of the physical college environment and the representations of women in STEM throughout popular culture. The purpose of this study was to explore the prevalence and portrayals of gender identities in human imagery found in the artwork, posters, and displays within the biomedical engineering department's hallways. We begin with an exploration of the portrayal of women in media and the parallel mis- and under-representation of women in STEM academic environments. Then, we describe our study about how these societal norms around women in STEM manifested in the physical spaces of our university's biomedical engineering department. The two research questions guiding our study were:

1) What is the relative representation of women and men within human imagery adorning the walls in the physical spaces inhabited by a biomedical engineering department?
2) In what ways do gender-based stereotypes, i.e., widely held beliefs about roles and expectations of genders, appear in lab safety posters in the physical spaces inhabited by a biomedical engineering department?

Background

The cultures of STEM disciplines in the workplace are generally perceived as having inherently masculine traits [3, 4, 5, 6]. Engineers value the traditionally 'masculine' qualities of technical and tactile prowess, and situate these competencies as diametrically opposed to social skills, which are historically viewed as feminine properties [5]. However, these same engineers acknowledge that interpersonal skills are vital in carrying out their day to day work, perhaps even more so than performing "calculations". In engineering management, social relationships dominate daily responsibilities and therefore become more important than technical competency; though these skills may align with what workers expect of women, men often hold these positions of power. If women do hold managerial positions, however, they are more likely to lose their credibility of being a 'real engineer' [5]. Furthermore, daily interactions in the engineering workplace privilege men even when the overall culture is mostly "respectful" [6].

As such, the idea of women working in these disciplines is seen as contradictory to the disciplines themselves [3], [7]. Even in countries with relative gender parity in the science professions, researchers have identified an enduring strong association of science as a discipline for men [4]. This association of gender and career field also impacts young people before they commit to a career path: middle schoolers have parroted the assumption that engineering is a career for men [8].

The Media and Women in STEM

These disciplinary norms and perceptions are reflected in the ways in which, and if, women in STEM are portrayed in art, media, and popular culture around the world [3, 7, 9, 10, 11]. The media reflects the truth of underrepresentation in STEM [7, 10]. Of the 391 most popular STEM-themed YouTube channels, only 32 hosts presented themselves as female [9]. In a comprehensive study of entertainment media specifically, researchers found that women are not portrayed as frequently as men in STEM [10]. Yet, female characters in entertainment media working in STEM served as role models for many women who chose to pursue a STEM degree.

Unfortunately, the media may also further the underrepresentation through the roles and ways in which women STEM professionals are portrayed in negative and narrow ways [7, 12]. Newscasters often highlight the "exceptionality" and attractiveness of women working in STEM professions rather than highlighting their accomplishments, competencies, and responsibilities [7]. In children's television programming in the United Kingdom, a 2005-2006 study of two sample weeks found that not only do television shows need a more diverse representation of who "does" STEM, but also should show the diversity and authentic STEM work looks like in its variety of contexts [12]. One specific genre of entertainment media, animated cartoons, has significant sexist and racist historical origins that surface to this day [11].

Gender, STEM, and the University Environment

In our buildings, we anecdotally noticed myriad examples of art, media, and animated cartoons on signage and displays in our halls. This casual observation motivated our formal study, as the physical environment of a university is known to influence the behavior of the individuals inhabiting that environment [2]. Broadly, a university's physical environment includes buildings, roads, sidewalks, as well as furniture (and its arrangements), artwork, and signage. The focus of this study is the artwork, including decorative paintings, honoraria, sculptures, and scientific creations, as well as the formal and informal (e.g., flyers) signage adorning the walls of our buildings.

Some physical features not only perform a distinct function for the environment, but also communicate something about that environment and how to behave within it [2]. For instance, classrooms with moveable chairs and tables, as opposed to those bolted down and arranged in an auditorium style, encourage students and instructors to engage in active learning and collaborate with individuals at other tables. Similarly, a campus covered with trash and broken furniture allows students to litter and engage in other destructive behaviors. As our department continually works to become more inclusive, we sought to intentionally and in detail examine the physical environment we inhabit to supplement our more people-focused and curricular initiatives.

One research team conducted a series of studies addressing this issue of inclusivity in a physical environment: they captured how powerfully physical artifacts in a learning space can influence its women and men computer science students [13]. In a series of experiments, the researchers manipulated artifacts within an environment to reflect stereotypes of students in computer science. Using things such as Star Trek memorabilia, junk food, and video games scattered around a messy room, the authors conveyed a male-gendered stereotype of computer science. In another room, the authors conveyed a different image of computer science by placement of objects considered gender neutral into the environment. In their multiple analyses, the researchers found that women, but not men, were affected by the male-gendered stereotypical environment in terms of their interest in the field and their "ambient belonging." The authors

defined ambient belonging as "fit with the material (e.g., physical objects) and structural (e.g., layout) components of an environment along with a sense of fit with the people who are imagined to occupy that environment".

Using these findings pertaining to the ambient environment [13], another research team [14] modeled the variables affecting women's academic engagement and persistence, along with self-concept. They found that students' "immediate campus environment" is indeed a predictor variable, along with others, impacting the aforementioned outcome variables. They urged faculty and staff to attend to factors influencing social identity threat, and specifically called attention to the physical environment, like posters adorning the walls that subtly communicate that women do not belong. Specifically, intentionality is required in the seemingly mundane components of an academic environment: "How often do we think about what photos and posters we put up in our hallways and offices and what messages these cues may communicate to the undergraduates who are exposed to them?" [13].

As our purpose was to explore the prevalence and portrayals of gender identities in human imagery found in our department's hallways, our study provides a snapshot of the amalgamation of the seemingly mundane elements of our physical spaces. Building upon prior research [13], we opted to study the organic physical environment of our biomedical engineering department to describe what exists in the environment without any experimental interventions. Specifically, we explored "artifacts of material culture" within two of our biomedical engineering buildings to understand the totality of what these artifacts may be communicating to our students [2].

Methods

Setting and Context

The setting for this study is a biomedical engineering department, at a highly selective, STEM-focused university with very high research activity in the eastern United States. Two of the department's buildings are represented in this study and contain classroom, lab, and office spaces[1]. Work on the study originated as part of a committee tasked with addressing diversity, equity, and inclusion issues. One objective of the committee was to identify and address ways of increasing the inclusiveness of physical spaces. We began with this exploration of gender inclusivity found in the art, scientific creations, displays, and posters/flyers adorning our department.

Data Collection and Preparation

In January 2019, two researchers walked the buildings together, identifying instances of human imagery. We created a catalogue of all human imagery in the publicly available spaces of the two main biomedical engineering buildings (i.e., we included signage on doors on the outside of a lab, but did not enter or catalogue any signage within individual, restricted lab spaces). As we created this catalogue, we jointly classified each human image as representing either a male or a female. Simultaneously, we also classified each human image in terms of the represented race(s) or ethnicity(ies). We reached agreement on each identity as we were cataloguing the data.[2] We

[1] In total the department utilizes space in five buildings across two university campuses. The buildings in our study are entirely inhabited by the department, whereas the others include shared space with multiple departments.
[2] We acknowledge the problematic nature of researchers assigning identities to other individuals (in human images) and that approaching gender identities from a binary perspective is also problematic.

quantitized these data as we recorded them in the catalogue (e.g., one woman, Black) [15]. In this catalogue, we also noted the topic, content, message, and/or context of the artifact (e.g., a flyer advertising a symposium with four male speakers or a student mental health facility with two females and three males represented).

It is this catalogue that formed our initial dataset: we found 337 images of humans across 206 artifacts (e.g., one artifact of a lab team photograph included seven humans). 43 artifacts only included males, whereas 23 artifacts featured all females. We selected individual humans, rather than artifacts in which those humans were represented, as our unit of analysis.

We summarized these data to share with our committee and found that though women were represented in the human imagery, they were used to portray non-scientific, unprofessional, or unintelligent stereotypes and in problematic contexts. Recalling two specific examples of such gender bias, we returned to those example laboratory safety posters, took pictures, and included these illustrative instances of gender bias for qualitative content analysis to complement our analysis of the quantitized catalogue [16].

These two illustrative images, along with the catalogue, formed our complete, multi-method dataset.

Data Analysis

Our data analysis process applied quantitative and qualitative content analysis to the catalogue and illustrative images respectively [16].

The lead researcher and a student researcher analyzed the data in two different ways to address our two research questions. To answer our first research question about the images' relative representations of women and men in the building, we tallied the frequencies from our catalogue for these two genders across the two biomedical engineering buildings. To determine the appropriateness of the relative representations, we compared the percentages of genders in the images to both our undergraduate and our graduate student enrollment using two respective Chi-square tests of goodness of fit.

To answer our second research question about gender-based stereotypes (i.e., commonly held gender roles and expectations) evident in the portrayal of women in these images, we engaged in content analysis [17] for the two lab safety posters of interest. Content analysis supports our goal "to analyze data within a specific context in view of the meanings someone- a group or a culture- attributes to them" [17]. The method is frequently used by social scientists to explore media, including comics and television shows.

Specifically, for the illustrative images, we extended Bengsson's description of a process to analyze text in context to images [18]. We decontextualized the data in these images by identifying individual details of each image that illustrate stereotypes. For instance, we noted eyeglasses as a societally coded method of representing intelligence, and blonde-hair on a female as representing the opposite [19]. We then categorized and compiled the data, highlighting latent meanings. To build trustworthiness for our qualitative content analysis, the lead and student researcher engaged in peer debriefing with the third author.

Findings

Research Question 1: Relative Representation

Our first research question asked about the relative representation of women and men in the human images displayed in the two biomedical engineering buildings. When compared to the gender representation of students in our department, imagery coded as male is overrepresented in the department's physical spaces.

In the 337 total images, we identified 58% of the images coded as male (n = 196) and 42% as female (n = 141). This proportional representation in images is not different from the gender representation in our graduate student enrollment, which is 44% women [$\chi^2(1, N = 337) = .638$, $p = .84$). However, the proportion of images coded as female is statistically significantly lower from the portion of women in our undergraduate enrollment [(60%), χ^2 (1, N = 337) = 46.309, $p < .001$].

Research Question 2: Lab Safety Poster Content Analysis

Our second research question investigated the portrayal of women, specifically portrayals of positive or negative stereotypes, as the statistical under-representation of women did not tell the entire story of human imagery in our buildings. In the process of collecting quantitative data, we specifically noted several images representing females in highly gendered ways that differentiated female images from images of those participating in STEM activities. Therefore, to complement the quantitative analysis, we qualitatively analyzed two examples of this gendered bias; both were lab safety posters. In these posters, one depicted women from a STEM animated cartoon using gendered negative female stereotypes, while the other excluded women altogether. These two exemplar images drew from two popular cartoons airing in the 1990s. In this section, we present the images as they appear in student spaces and then analyze their content apart from and within the cartoon's context.

Figure 1

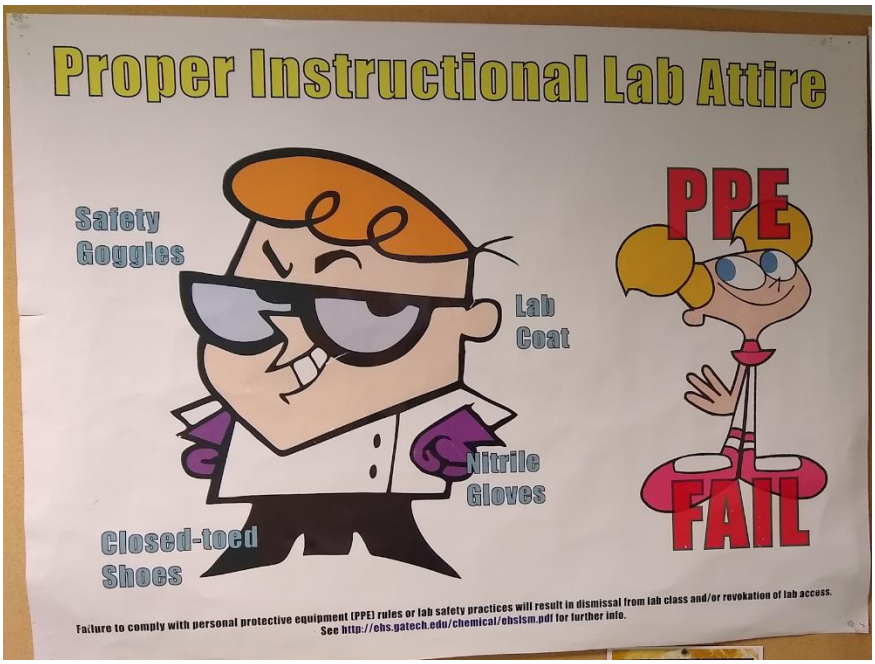

Image 1: Characters from Dexter's Laboratory

Note. This image depicts a poster outside a lab room in the basement of the main Biomedical Engineering building. The poster shows an example of "proper instructional lab attire" using characters from the cartoon *Dexter's Laboratory*.

Image 1: Characters from "Dexter's Laboratory". The first image is located in a hallway of the main building, an area highly trafficked by students for its classrooms, labs, and machine shop. In the poster, Dexter, the main character of the show, is contrasted against his older sister, Dee Dee.

Viewers of Image 1 are presented with multiple subliminal stereotypes of capable men and incapable women. First, the image contrasts Dexter's successful use of personal protective equipment (PPE) with Dee Dee's "PPE *fail*" (italics added for emphasis). Dexter is shown with full PPE, except he wears glasses instead of safety goggles. In stark contrast, Dee Dee is shown with blonde hair and wearing a short, pink, sleeveless dress, and ballet shoes; she is wearing no PPE. Dexter's glasses and lab coat stereotypically represent intelligence. Yet, Dee Dee's small, pink clothing is suggestive of softness, youth, and frivolity. Moreover, Dee Dee's blonde hair connotes the "dumb blonde" stereotype [19]. Notably, all embodied characteristics of Dee Dee's character in the show. Dexter is shown much larger and in the foreground. His upright posture and hands on his hips demonstrate a character designed to project confidence. Dee Dee's stance and sideways look projects a flighty personality, unconcerned with serious matters like engineering. Historically, the posture of women in animation, like those of Disney princesses, is meant to capture the "artful artificiality of classical ballet" [20]. While both characters are technically projecting their chest, an expansive body position such as Dexter's invokes power while DeeDee's small frame and hand position do not [21].

Compounded upon one another, these details in the image strongly harken negative stereotypes of women in general and then use those negative stereotypes to communicate instructions to laboratory students. Knowledge of the cartoon's storyline further problematizes the image. In the cartoon series, Dexter is a focused boy-genius with a secret home lab known only to his older sister Dee Dee, who is portrayed as clumsy and unintelligent (catchphrase, "Oooh what does *this* button do?"). Their maturities are reversed for their relative ages, with Dexter's complexity being akin to an adult's, and Dee Dee's to that of a child. Dee Dee's entire storyline revolves around her interest in Dexter's activities, and how her lack of understanding constantly results in her ruining his experiments.

Image 2: Professor Utonium from "The PowerPuff Girls". Image 2 is also a lab safety reminder. The image is located in the formal entryway of the main building, on a restricted access door into a subarea of faculty offices and labs. This simple image also includes a link to the relevant PPE policies.

While there are no negative stereotypes of women in this image, *The Powerpuff Girls* themselves—who are the main characters in the cartoon—are entirely excluded from this lab safety reminder. Instead, the man, Professor Utonium, who created them *using* science is featured. The professor, a secondary character from *The PowerPuff Girls*, is depicted wearing a lab coat and holding a pipe, with the surrounding text reminding viewers that PPE is a requirement. The professor, however, lacks any PPE beyond a lab coat. He is standing straight, pipe extended in one hand, another behind his back, eyebrows raised. Always drawn with unrealistically squared and broad shoulders, his stance conveys thoughtful confidence and

power. Underneath his lab coat, is formal, professional business wear: black dress pants and shoes, along with a necktie.

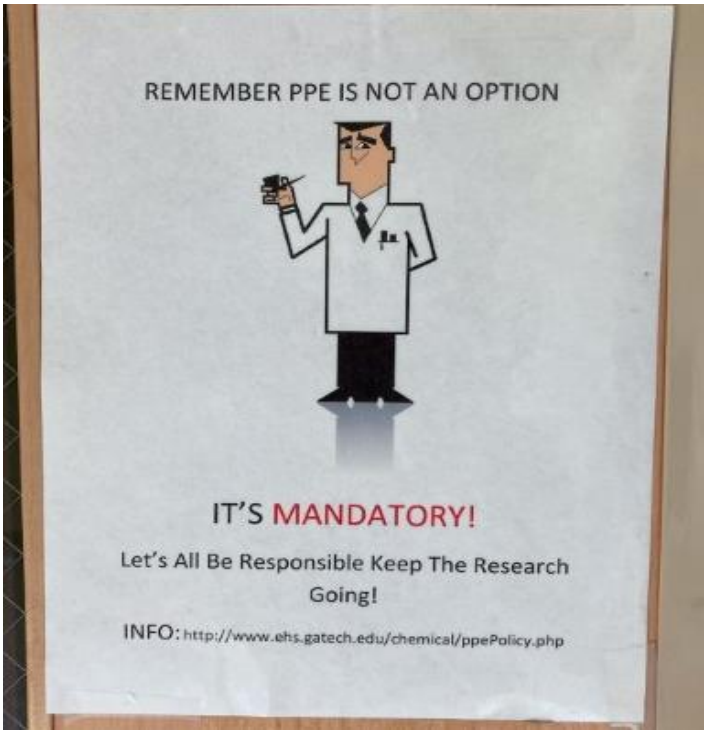

Figure 2

Image 2: Professor Utonium from The PowerPuff Girls

Note. This image depicts a flyer on the door of a lab room on the ground floor of the main biomedical engineering building. This poster is a reminder to wear proper personal protective equipment using Professor Utonium from *The Powerpuff Girls*.

On a poster advocating for proper PPE, pipe smoking (an obvious lab safety violation and outdated indoor practice) is particularly ill-suited. Smoking is highly gendered in general, particularly so for pipes [22], and is more socially acceptable for men than women [23]. In this way, the image may further connote to students that labs are "old boys' clubs" [24]. Smoking is also differentially acceptable across socioeconomic classes [25] and thus the image may suggest labs are reminiscent of all-male spaces such as parlors or drawing rooms in private residences where elite men socialized and conducted business and politics with other elite men [26].

The exclusion of the main characters, who give the show its title, from this lab safety poster is notable. These young girls are sister superheroes who use their super-powers, including super strength, to save their community from innumerable threats. Such exclusion may suggest to women students that being perceived positively as a strong female and main character (e.g., influential individual) is insufficient, or perhaps unacceptable, for inclusion in the space behind the door where this sign hangs. Unfortunately, however, the PowerPuff Girls' exclusion from the sign aligns with the lack of inclusivity conveyed in media [10], children's television programming [12], and animated cartoons [11].

Discussion

We found that the portion of female-coded images do not statistically reflect the gender composition of our undergraduate student body, as the majority of our department's student body consists of undergraduates. This finding is troublesome. While we do not advocate for a perfectly proportional relationship in human imagery to that of our student body, we do argue for the ideal: a space characterized by artifacts, art, and signage not stereotypical to *or* representative of any particular gender, as created in the experiment with computer science students [13].

Secondly, we found the imagery in the lab safety posters reinforces negative stereotypes of females in a department inhabited by women engineering students, even without considering the context of the cartoons' storylines (i.e., decontextualized). Primarily, the "PPE fail" displayed in Image 1, *Dexter's Laboratory*, is portrayed by the character who is built to convey non-scientific female tropes. Image 2, *The PowerPuff Girls*, excludes the female main characters of the show, who both embody and counter gender stereotypes. Furthermore, both images portray a male scientist as the example for proper PPE, even though there are examples of PPE violations on both males. Image 1 mislabels Dexter's eyeglasses as safety goggles, and Image 2 shows Professor Utonium holding a tobacco pipe and wearing only one piece of PPE - a lab coat.

Yet, contextual awareness of the cartoon storylines further problematizes both images: Dexter is younger than Dee Dee, but is more mature and the immature Dee Dee's lack of intelligence and understanding causes her to ruin all of Dexter's experiments. The PowerPuff Girls were created by science but do rarely participate in science as Dee Dee attempts to do; thus, the image does not create the same issue as in Image 1. Though one explanation for this exclusion is that the girls are created from science by a man but they do not do science, an alternative explanation from a critical perspective is that excluding girls and women from science is permissible. Most of our undergraduate students are too young to be familiar with the storylines of these cartoons, but some students may be familiar with *The Powerpuff Girls* cartoon, as it recently received a reboot in 2016 [27].

At face value, Image 2 then seems a more desirable way to promote lab safety and use of PPE, as it does not show a female character as a "failing" example like Image 1. However, Image 2's use of a secondary character paired with exclusion of the female main characters continues a long established pattern of excluding women from representations of science and engineering. This example suggests that men can function without women but the opposite is not true. Here, our dataset provides further support: 43 artifacts were all-male, opposed to 23 artifacts featuring females only. As such, the image reminds viewers of this pattern, particularly those familiar with the cartoon's storyline, and may suggest that the same pattern exists and is permissible in the engineering department.

We therefore conclude there is gender bias in the frequency and content of human imagery in the physical environment of our main biomedical engineering buildings. Both images align with the historical instances of sexism in animated cartoons [11], as well as the non-, under-, and mis-representation of women STEM professionals in entertainment media [10]. Though lab safety posters are not intended to provide role models for women in STEM like entertainment media characters, the images in our department's two main buildings do not convey a sense of ambient belonging to our women students [13].

Our Future Work

Critically, the data we presented and analyzed here excluded racial and ethnic identities, abilities, and intersectionalities, but these identities should be addressed in future research. To further this research, future work should use a photo elicitation method [28]. Using this method in semi-structured individual interviews with students, we will analyze how students perceive the human imagery in the halls of an academic department, outside of controlled experimental contexts.

Conclusions

For this work-in-progress, we inventoried the images of humans displayed in the halls of a biomedical engineering department. Though our undergraduate student population is majority women, the human images in our department depict women less frequently than men. We also illustrated two contrasting lab safety posters based on cartoons from the 1990s. These images, located in an area heavily used by students, mirror problematic and established stereotypes with respect to women and their representation in science and engineering. Each of these two images was problematic in their own ways. The first employed negative stereotypes about women, thus reinforcing those stereotypes as acceptable in student spaces. The second image excluded women (the main characters of the cartoon) entirely, in favor of a secondary, male character. Both these images depicted the men as the standard bearers of proper PPE, even though there were violations of proper PPE.

Recommendations

We, as individuals and as academic units, must critically evaluate the artifacts found in our departments, *especially* those as mundane as lab safety posters, and then fight for inclusion in these mundanities. Because physical environments, including artwork and posters, communicate values and influence behavior in spaces we inhabit [2], [13], a key implication is that academic departments should carefully observe how different identities are portrayed, as well as the frequency with which these identities are depicted, throughout their environment. However, we then must take one step further than observing: we must then intentionally curate the art and signage in our physical environments to reflect inclusive values.

We suggest the following steps to work toward enhancing the inclusivity of the physical environment in your departmental spaces:

- Walk around your buildings with the specific purpose of observing human imagery in the art, signage, and displays decorating your spaces. Check the lab safety posters, flyers announcing speaker series, memes conveying office hours, and banners.
- Reflect when you return to your working space. How are different populations under- or mis-represented? In what ways do popular culture references in these artifacts reinforce negative stereotypes and exclusionary behaviors? In an attempt to humanize the environment and relate to students through popular culture, are you unintentionally conveying bias?
- Talk with your faculty about the artifacts you observed and the messages those artifacts suggest. Ask them to look, from a critical perspective, at the things they post on their doors and walls. Celebrate their intent to connect with students through popular culture images, but have them answer this question: How would a student perceive those references?
- Choose better imagery. The key to success here is to provide your faculty and staff with alternatives that are more inclusive; simply encouraging them to consider their messaging

will not create change. Engage students by having a contest for the best lab safety posters. Make inclusivity real, personal, and relevant.

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