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Better Student Presentations: A Mini-Course in Visual Design Principles to Turn Engineering Students Into More Effective Communicators Immediately (Work in Progress)

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Introduction

Undoubtedly oral communication is an important skillset for engineers. Many studies conducted on the topic of how to make engineering students better presenters find, in essence, that getting better presentations requires making students better graphic designers. As computer-aided design tools have evolved, good design has become more accessible, with complex software becoming less of a barrier through tools such as Canva, Figma, Adobe Color, and Adobe Express. These tools provide well-designed templates, graphics, and AI features geared toward non-designers.

Even if educators themselves grasp the importance of applying thoughtful graphic design to multimedia instruction to prevent cognitive overload in students, how do they impress upon students to follow suit, especially if educators have no formal training or expertise in the fundamental principles of visual design? Importantly, how do educators then assess visual design elements if the topic is far outside their area of expertise?

This work-in-progress paper describes electrical and computer engineering undergraduate seniors at Mississippi State University who were explicitly taught basic visual design principles during a capstone design course. The first course in the two-course capstone sequence is taught by a professor who holds degrees in both computer science and fine arts and has worked as a graphic designer. The first-semester capstone design course is also taught in conjunction with a technical writing course. To satisfy the requirements of both the Capstone Design I course and Technical Writing, the ECE students prepare two presentations.

Starting in fall 2024, with the entrance of this capstone design professor with a professional background in graphic design, the Capstone Design I and Technical Writing educators— the former formally trained in design thinking and the visual arts, the latter not—have made a more concerted effort to emphasize visual design principles throughout both courses. Doing so has meant that the Technical Writing instructor herself has had to learn basic design principles.

This paper outlines their initial implementation, which, after three semesters, has produced positive results thus far. The authors provide resources so that other educators—especially those with no training in visual design—can emulate these results. This paper includes practical, classroom-ready tips—including a sample presentation checklist and instructional slide deck on designing oral presentations—to make visual communication easier for engineering educators to teach and simpler for engineering students to grasp and apply. The authors share samples of engineering undergraduate students' work "before" and "after" this teaching approach was implemented starting in fall 2024. This paper also points to open-access and/or free online resources that serve as easy-to-comprehend primers for students and educators alike who are interested in learning introductory design principles.

The goals of this paper are twofold: 1) to allow engineering educators to incorporate beginner-friendly design principles into their own classrooms quickly and 2) to help engineering students become better scientific communicators as a core skill for working in industry, strengthening the broader impacts of their work.

Background

Content, delivery, and design are often termed the "three pillars" of an effective presentation. While engineering educators may be comfortable coaching students to improve their content and delivery, the idea of teaching visual design (or visual communication) may be unnerving. After all, visual design goes far beyond aesthetics; its goal is to help audiences "connect" with a person or product. Shao's research into the "emotional resonance" of visual design found that not only does visual design help a company's products stand out in terms of distinguishability, but it also boosts consumers' satisfaction with those products. Shao calls good graphic design a form of "emotional design" [1]. Kolosnichenko *et al.* describe graphic design as "psychological manipulation" [2]. It is a subject that has implications beyond classroom presentations, affecting multiple facets of students' professional lives, from eye-catching résumés to engaging work presentations.

Additionally, evidence continues to mount in support of the value of effective visual design. Decades of studies support Dual Code Theory [3], which states that an audience retains more information, and for a longer time, when words are combined with visuals.

Furthermore, by controlling the visual flow, we prevent forcing the viewer to multitask. Multitasking by listening and reading simultaneously has been found to harm both retention and comprehension [4]. The viewer cannot process text-based information and oral information at the same time. We process visual information significantly faster (in approximately 0.25 seconds) than text-based information [4], reducing the amount of multitasking the viewer must do.

For one to manage visual communication effectively, many principles of visual design must be considered, such as Emphasis, Contrast, Balance, Alignment, Hierarchy, Harmony, Whitespace, Color, Typography, and more. To improve the effectiveness of visual communication by ECE senior design students, this paper focuses on a core set of four design principles taught in the Capstone Design I course: Typography, Hierarchy, Alignment, and Whitespace.

An engineering educator's primary objective is not to make engineers expert visual designers or artists, but rather to instill enough understanding of design principles to increase students' awareness and attention to detail when producing visual communication. They must appreciate that the level of professionalism in one's visual communication improves how the information is received. An estimated 65% of the population are visual learners [5].

The "Before" approach

Prior to fall 2024, the Capstone Design I course's long-time instructor of record was an ECE professor who valued, but did not receive formal training in, visual design. This instructor reflected on how he impressed the importance of visual design upon senior undergraduate engineering students, especially as they prepared pitch decks and design showcase presentations:

> *An effective presentation requires students to communicate through a combination of visual information on slides and the spoken explanations provided by a student. Therefore, I taught students that the design of slides accompanying a presentation of a capstone design project should embrace the following principles:*

- ***Summarize:*** *Recognize the audience cannot digest complex visual information while listening to a student's verbal explanation; keep the slides focused on high-level approaches, not on formulas, source code, or low-level implementation details.*
- ***Simplify****: Use a small number of phrases for text; use one or two images that convey high-level concepts.*
- ***Visualize****: Incorporate clean, focused visual information in the form of diagrams, icons, or photos rather than dense textual content; instead, students should verbally communicate these details.*
- ***Outline:*** *Employ text and graphics that provide cues for the presenting student, enabling them to complement the slide with appropriate verbal information instead of constant reference to written notes during the presentation.*

The above is sound advice, with the professor intuitively touching on many fundamental principles of visual design. Two sample Capstone Design I teams' pitch deck presentation drafts from fall 2019—very representative of the visual design choices teams submitted in response to the "Before" instruction — are provided as **Appendix A**.

The "After" approach

Unlike in the "Before" approach, in which the professor taught visual design principles instinctually, in the "After" approach, the incoming professor drew upon her background in fine arts and professional experience as a graphic designer to teach visual design principles overtly, focusing her instruction on four key ideas.

I. Typography

As Ellen Lupton of the Maryland Institute College of Art so aptly stated, "Typography is where design and text gently collaborate to enhance understanding" [6]. Typography resides at the core of visual communication and has a significant impact on the legibility and hierarchy of how information is visually conveyed. The human eye is drawn to text that is 1) larger, 2) has more contrast, or 3) is called out with the use of color; any of these tools can effectively drive the viewer's attention to key information quickly, improving viewer engagement and setting the tone of a presentation.

To understand Typography, one can approach the text as "a continuous field whose grain, color, density and silhouette can be endlessly adjusted" [6]. Effective visual communication can be achieved solely on the basis of Typography, if necessary, as Hierarchy, Alignment, and Whitespace are all ingrained components of effective Typography.

Key tips for improving Typography include the following:

- Urge research of effective font pairings to improve consistency and avoid using too many font styles. The site Fontpair is a helpful resource.
- Encourage students to avoid widows, orphans, runts and rivers, shown in Fig. 1.
- Educate on the supporting elements of Hierarchy, Alignment, and Whitespace and how they affect the impact of the Typography.

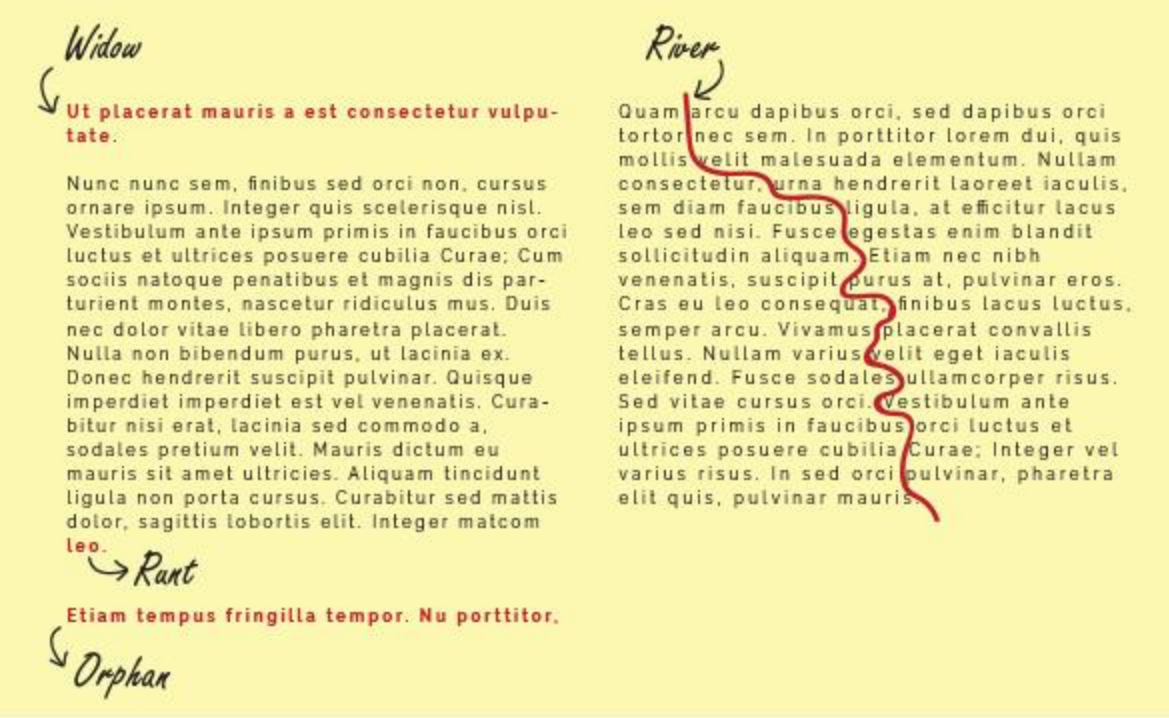

Fig 1. Widows, orphans, runts, and rivers [7]

II. Hierarchy

Visual hierarchy controls the delivery of the experience. If you have a hard time figuring out where to look on a page, it's more than likely that its layout is missing a clear visual hierarchy.

- Kelley Gordon, The Nielsen Norman Group [8]

Hierarchy drives the viewer's eye through an arrangement of images and text using tools such as position, contrast, and size to imply an intended order of importance. It tells the viewer what information is most worthy of their attention and most critical to understanding. Regardless of the medium, the viewer's attention is being subtly controlled through the structure of media such as web pages or slides and the implicit hierarchy of tools like bold headers, graphics, and color provided in the viewer's day-to-day encounters with media. The conceptual structure of information is communicated through this Hierarchy, aiding the viewer in comprehension and efficient information processing. Color, when effectively employed, can create additional structure, increase comprehension, or draw attention to important points [9].

Key tips for improving Hierarchy include the following:

- Explore the application of size, position, contrast, and color as tools to draw the eye through text or around an image; uxtoast provides a helpful 5-tip tutorial [10].
- Demonstrate good examples of Hierarchy, such as at Flux Academy [11] and Visme [12].
- Educate students on eye movement patterns such as F- and Z-patterns.

A good starting point for determining hierarchy is understanding standard eye movement patterns such as the F-pattern and Z-pattern, shown in Fig. 2. In the F-pattern, objects are typically aligned to the left-hand side of the page as it is the most common eye movement pattern

in the Western world, where children are taught to read from left to right. The Z-pattern occurs when the user scans a page from left to right and then down, repeating until all the content has been scanned.

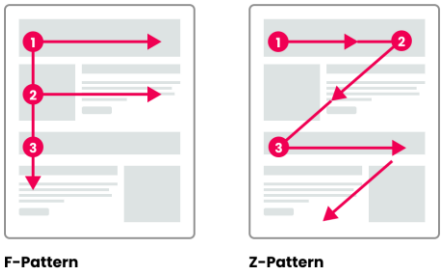

Fig 2. Illustration comparing eye-movement patterns [13]

III. Alignment

Alignment is the third principle of visual design we encourage instructors to emphasize. This is a frequent problem and is primarily a result of students being inattentive to details. Like Hierarchy, Alignment directs the eye and aids users in rapidly locating desired information.

The easiest way to employ Alignment is to use a grid-based approach that supports the F-pattern or Z-pattern. Instructors should encourage students to use grids for spatial organization to help establish Alignment; grids also are conducive to incorporating Whitespace and Hierarchy. This level of structure, while often seen as stifling to the creative, is a less esoteric, more direct tool that resonates well with engineering students, removing the element of taste and convention and applying a systematic methodology to visual communication.

Grids consist of the following components: margins, rows, columns, and gutters (Fig. 3). Columns and rows provide alignment points for text and images to connect visually. Aligning text and images along a common axis anchors the design and prevents elements from feeling like they are floating. Gutters indicate the minimum amount of space that should be maintained between each element, providing breathing room for a relaxed design that does not feel overcrowded. The use of margins ensures that text and images do not reside too closely to the edge. While they may initially appear rigid, grids are a highly flexible framework to operate within and are frequently used for web page design and book and magazine layouts in addition to presentations.

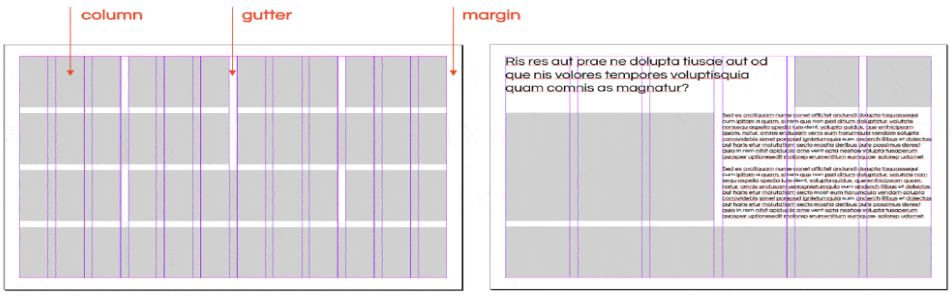

Fig 3. Example of a grid with an indication of a column, gutter and margin [14]

Key tips for improving Alignment include the following:

- Encourage the use of grids and rulers for spatial organization to help establish Alignment and enforce an effective use of Whitespace and Hierarchy, as seen in [15], [16].
- Show direct examples of effective use of margins (typically 1 in.), aligning bullet points and text.
- Remind students to align images to either a vertical or a horizontal axis already created by text that resides in the presentation.

IV. Whitespace

Whitespace, sometimes referred to as negative space, imposes a sense of clarity and harmony to provide a balanced look and feel to a visual design. Whitespace prevents visual aids from feeling cluttered and wards off cognitive overload and multitasking. It also reinforces Hierarchy and organization. The viewer subconsciously relates elements that are visually close together. Providing breathing room for visual elements improves viewer focus and increases clarity, legibility, and, by association, comprehension of the verbal concepts being discussed.

Key tips for improving the use of Whitespace include the following:

- Demonstrate the effective use of Whitespace, such as available at Venngage [17].
- Encourage an economical usage of text to prevent the viewer from having to read and listen at the same time.
- Encourage students using equations to spread them across multiple slides in the order in which they arise during the presentation. It is acceptable to have a single equation per slide or to use a step-by-step approach.
- Encourage students' strategic use of imagery to support the main concept without overcrowding the slide with too many images.

After incorporating these four principles, students should regularly "zoom out" on their work; flipping an image or walking away to approach a design with new eyes helps students see their designs as whole compositions.

An introductory presentation about oral presentations and visual design is provided as **Appendix B**, along with a general presentation checklist (**Appendix C**) for students to utilize. Lastly, two sample student pitch decks submitted in response to the "After" instructional approach are provided as **Appendix D**.

Students' design challenges and lessons retained

Since implementing the "After" approach, this paper's authors have observed some challenges for students:

- **Typography:** Inability to create a consistent look and feel. Students mix font styles and image styles—for example, using both photographic images and illustrated images
- **Visual Hierarchy:** Lack of hierarchy in the use of Typography, such as failing to use appropriate font sizing and weights to indicate hierarchical information, such as headers versus body text, or not using bold/colored text to draw attention to important concepts
- **Alignment:** Images and text, such as bullet points, not being properly aligned to the left; text and images not being aligned along an axis if a conceptual grid is placed on a slide

- **Whitespace:** Inconsistent line spacing and ineffective use of Whitespace; engineering students tend to add too much text or too many formulas, attempting to put too much content overall on a single slide
- **Visual Tension**: Students lack the recognition of what creates visual tension, such as overcrowding, images and text being too close to edges, or square edges forming tangents with rounded edges added as borders
- **General Visual Communication Struggles:** Inability to use an image that conceptually relates to the concept being discussed, either to emphasize or clarify a concept or to provide visual support. For example, inserting screenshots of code for a project, thinking it works as an effective visualization, instead of using a diagram such as a flowchart that would be more suited to the context

The collection of qualitative feedback about students' self-reported key takeaways from their exposure to visual design principles in Capstone Design I is ongoing. Meanwhile, students who completed the course one or two semesters ago shared key lessons they retained:

1. Students reported that they notice when teachers put effort into slide design during their everyday instruction. Students said realizing that a teacher cares about nice slide design made the students recognize that they would be wise to care also. Students said they were more likely to invest time into making their own presentations nice-looking if their teacher had modeled that expectation, effort, and professionalism throughout the course.

2. Students reported mimicking similar design choices that their instructor had made. If an instructor clearly favors sleek, minimalist design—for example, clean lines and fewer, often neutral colors—then students said they would likely parrot back the instructor's aesthetic. If an instructor opts for maximalist design—e.g., full of bright colors and mixed patterns—then students change their slides accordingly. In other words, it seems that instructors will reap what they sow in their own slide design choices.

Tips and additional curated introductory visual design resources

In addition to the aforementioned resources, the authors provide additional curated resources below, using three main criteria in selecting the following references: 1) these resources are meant to be simple and clear descriptions of basic visual design principles, suited for a novice aesthete; 2) they are succinct for busy teachers and students who may already be grappling with very full curricula; and 3) they are available at no cost.

- R. Kuba, "Presentation matters: Basics of graphic design in educational technology," *C2C Digital Magazine*, vol. 1, no. 15, July 2021. [Online]. Available https://www.researchgate.net/publication/353327299_Presentation_matters_Basics_of_graphic_design_in_educational_technology (accessed Nov. 11, 2024).
  Comprised mostly of graphics serving as clear, easy-to-digest examples, this 14-page article discusses fundamental principles of visual design, including alignment, contrast, repetition, proximity, fonts, and colors. It also lists free resources for sourcing images, icons, audio, and fonts.

- J. Cabading, "Beginners Guide to Graphic Design," Jan. 16, 2016. [Online Video]. Available

https://www.youtube.com/watch?v=WONZVnlam6U&list=PLYfCBK8IplO4E2sXtdKMVpKJZRBEoMvpn&index=1
This YouTube series contains short videos—each under 15 minutes—comprising brief lectures on various visual design principles, such as a definition of graphic design and lectures on line, color, shape, texture, space, form, typography, contrast, hierarchy, alignment, balance, proximity, repetition, simplicity, and function. A free, downloadable PDF is available to reinforce each lesson. Teachers could use this resource by assigning students to watch one video per week during a 15-week course.

- Harvard Catalyst, "Fundamentals of Slide Design," 2024. [Online]. Available https://writingcenter.catalyst.harvard.edu/fundamentals-slide-design
  Resources on this site include the "Qualities of Strong Slide Design," the "Research Presentation Rubric," the "Checklist for Assertion-Evidence Slides, and the "Templates and Examples for Assertion-Evidence Slides," including information on inclusive slide design. This website reinforces the "Present Your Science" teachings of Melissa Marshall at Penn State.

- Pixelixe, The Art of Minimalism in Graphic Design—Less Is More," 2023. [Online]. Available https://pixelixe.com/blog/the-art-of-minimalism-in-graphic-design/
  This site explains numerous principles and characteristics of minimalism and points to real-world examples of companies famous for their minimalist aesthetic, such as Apple.

- P. Twa, "The Case for Maximalism," 2024. [Online]. Available https://paultwa.com/the-case-for-maximalism#:~:text=Maximalism%20is%20often%20described%20with,be%20described%20much%20more%20positively.
  In this article, graphic designer Paul Twa espouses the benefits of maximalist design, showing five iconic representations of maximalism in visual design since the 1800s.

Conclusion

As shown in a comparison of Appendices A and D, by exposing students to a few key principles of visual design, educators can push students closer to becoming the dynamic, engaging public speakers employers seek. Along with their students, educators can begin modeling better visual design in their own classroom materials to improve student focus, clarity, and comprehension but also to demonstrate a sense of passion for information being communicated. Students resonate with genuine effort. Ultimately, when educators demonstrate care in their visual communication, students often echo that sentiment back in their work.

This paper compiles several resources that have helped ECE undergraduate seniors at Mississippi State University become more intentional with their slide design. The authors encourage the use of the visual communication resources listed herein—already designed and vetted by professionals—as a way that students can work smarter, not harder. By minimizing the learning curve using design tools, educators can focus on core design principles to improve the delivery and impact of visual communication for engineers. Furthermore, by modeling good design principles themselves, educators help their students understand technical and scientific content better and retain it longer, and they also impress upon students the value of preparing well-designed, polished presentations for the workplace.

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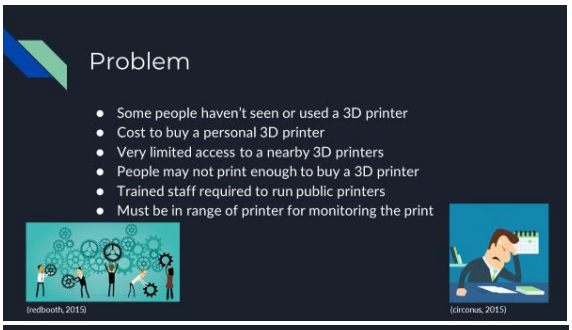
Appendix A. Two ECE Design-Team-Developed Pitch Deck Drafts (Fall 2019)

Team 1 – Project: 3D Printer Vending Machine Pitch Deck



Team 2 – Project: UAV Based Livestock Tagging Pitch Deck

Problem/Opportunity

- **Time** spent taking manual inventory of livestock.
- **High value** livestock should be accounted for daily.

Automating the livestock inventory process could revolutionize the market.

Solution

- Autonomous UAV
- Radio Frequency Identification
- Geographic Information System

Customer

- Farmers, Ranchers, and Agricultural Managers
- We are a multi-sided business selling to both business and customers that have livestock.

Sales and Marketing Strategy

A good way to market our livestock tagging drone is via social media.

While using social media, we shall upload a simple video briefly explaining how the drone works and its mission.

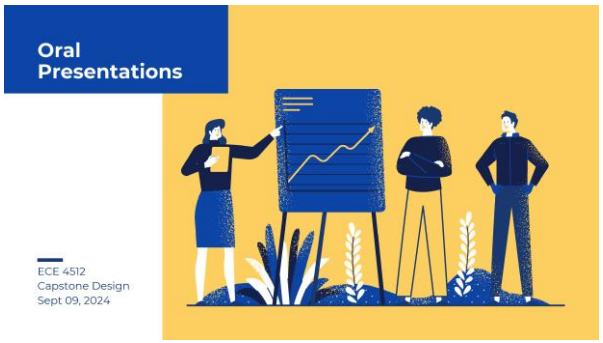
A strategic relationship worth pursuing would be with the Mississippi State University Agriculture department.

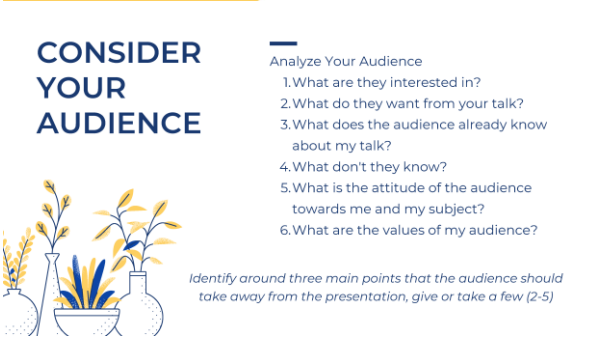
Competitive Advantage

We have the massive advantage of an untouched market.

Today's rancher has to scan every cow tag manually, provided they have RFID tagged livestock.

Appendix B. Example Slide Deck with Presentation and Design Tips





EFFECTIVE INTRODUCTIONS

Goal: Get the Interest of the audience

- Rhetorical questions
- Narrate an experience the audience can relate to
- Motivate them to listen by answering What and Why it's important.
- Use a joke (if you are brave)

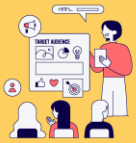
FORMULA FOR SUCCESS

Successful Presentation

- Know the subject
- Know the audience
- Prepare

The Conventional Wisdom

- Tell them what you are going to tell them.
- Tell it to them.
- Conclude by telling them what you just told them.



PRESENTATION STRUCTURE

INTRODUCTION

Take time to explain the problem clearly and in simple terms. If the audience doesn't understand they will tune out!

THE BODY

Organize it to support those main points - 2-4 slides
Increase the level of complexity as the talk proceeds.
Don't be overly technical, reduce jargon, use analogies.

THE CONCLUSION

As important as the intro
Summarize the main points
Explain next steps or motivate them to take action or conduct further research.

WHAT MAKES A BAD PRESENTATION?

1. Too much text
2. Too many equations without explanation
3. Too many animations
4. Too many colors
5. Too minimalistic
6. Using only pictures and hard-to-read fonts
7. Text over an image.
8. Diagrams that are unclear
9. Using only bullet points and no paragraphs
10. The font is too small
11. Screenshot of code - use flowchart instead

ADDITIONAL ADVICE VISUAL GUIDELINES

- Use >= 24pt font.
- Use a pleasing color palette.
- Pair fonts properly - don't use to many at once.
- Let the design breath.
- Don't cram text onto a slide.
- Don't use more than 5-7 bullets per a page.
- Use animations and sound effects sparingly.

ADDITIONAL ADVICE PACING

- Be aware of time constraints
- Don't go **to fast** or **too slow**.
- Don't exceed the allotted time.
- Estimate : Time (mins) / 2 = n-slides (2 mins per slide)
- Don't forget to practice, but don't OVER prepare.

SUMMARY

- Prepare for your presentation
- Identify the important points.
- Analyze your audience and address their needs.
- Organize - Use Presentation Structure
- Teach – don't do a data dump.
- Practice - Be aware of time!
- Be ready for questions.

Appendix C. General Presentation Checklist

Text:

- The presentation text is concise and has been thoroughly proofread, especially for major grammatical or mechanical errors.
- The type size should generally be 24+.
- Fonts should pair well together. (Google it or consult Fontpair!)
- Use high contrast for readability (e.g., light text on a dark background or vice versa).
- Don't overcrowd your slides with text. Let your design breathe. Use only as much text as needed to get your point across; don't write out a "script" on your slides and then read slides to us.
- Bulleted text lists, when used, are written in parallel structure, with consistent capitalization and punctuation (e.g., you're not randomly capitalizing some words and not others, you're not randomly inserting periods, etc.). Text does not wrap underneath bullets, and bullets are in a straight line.

Graphics:

- Use tools/templates (like those in Canva—***RECOMMENDED!***) to jumpstart the presentation design process.
- Use graphics (e.g., photos, illustrations, lines, geometric shapes, etc.) to infuse visual interest/variety throughout the slides.
- **Alignment** is key; a grid or rulers will help you align your design elements (e.g., in Canva > File > View Settings > Show Rulers and Guides).
- Just like with text, don't overcrowd your slides with graphics! If you NEED multiple images on a slide, consider grouping them cohesively using a grid layout rather than having each image floating around separately on the slide. Change the background color of an image to match the background color of the slide—e.g., a graphic with a white background pairs well with a slide with a white background.
- Use a pleasing color palette (e.g., check color.adobe.com/explore for suggestions for cohesive color palettes).
- University templates (available on the Office of Public Affairs site) are a helpful resource to know about, but don't use them in this class. Be creative!
- Visuals should help the audience digest the information (e.g., chunking up information into bite-sized pieces, helping the audience "see" how the design would be used, etc.).
- Be mindful about choosing images of people from various backgrounds, reflective of the modern American workplace.

Citation/source use basics:

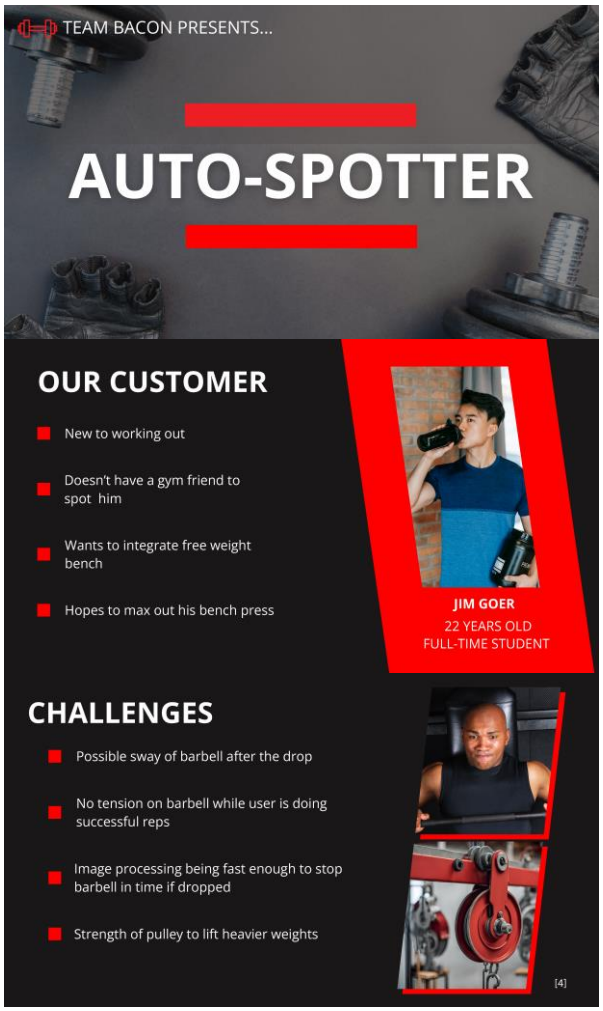
- **Bottom line:** Make a good-faith effort to provide appropriate attribution for outside sources/artwork that you use. If you pull a source/graphic from a journal, book, etc., provide a citation (and a references page). Use graphics in the spirit in which the creator intended—for example, an image that requires payment may not be used for free. If you find some interesting artwork online, credit the creator (e.g., name, location). Unspash.com and creativecommons.org are good places to search for free images. Follow the attribution cues on these sites. If an image specifically says no

attribution is necessary, then you do not need to provide any citation. You may add attribution/acknowledgement and citation slides at the end of the presentation.

- ***When in doubt, always cite! You should over acknowledge rather than under acknowledge sources.*** **If AI is used, <u>provide an acknowledgement statement, as specified on the course syllabus</u>. Failure to acknowledge use of generative AI could violate the University's Honor Code.**

Appendix D. Two ECE Design-Team-Developed Pitch Deck Drafts (Fall 2024)

Team 1 – Project: Auto-Spotter



Team 2 – Project: Cardmaster