Thesis Project Prospectus

AIAA HDI-25 Aircraft Design Unmanned Homeland Defense Interceptor Critical Design

(Technical Project)

The Influence of Gender & Race on Women in Engineering

(STS Project)

An Undergraduate Thesis

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On my honor as a University of Virginia student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor guidelines for Thesis-Related assignments.

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INTRODUCTION

Engineering has traditionally been male-dominated, and this disparity is still prevalent today, particularly for women in science, technology, engineering, and math (STEM). From academia to the industry, engineering requires effective teamwork to succeed (Slaton 2010). My technical research project surrounds a competition where a team of undergraduate students will dismantle a current problem given by the American Institute of Aeronautics and Astronautics (AIAA). Underneath the work and team structure, there is an underlying presence of social influence– of the 9 group members, 6 identify as men. This leaves 33% of the team to be influenced by the expectations and pressure that non-male engineers face within the field. Previously, there have been no women on the team representing the University of Virginia. Noticing such, the two non-male members took up positions of leadership in an attempt to stand out. I quickly took the position of Communications Lead, where my responsibilities lay with organizing deadlines, interactions with professors, team bonding, and other clerical duties. As a female engineer, I somehow found my position as the lead including the work typically associated with women, otherwise known as secretarial duties. This caused me to reflect on the role I played within the team. I would do technical work, specifically roles on cost efficiency, mass budget, and integration but the skills required for the position I was charged with traditionally 'female' duties. I had taken similar roles many times throughout my years in university and even in high school. 2

TECHNICAL RESEARCH PROJECT

Every year the American Institute of Aeronautics and Astronautics holds a competition for undergraduate students to design an unmanned interceptor aircraft that will fulfill requirements for a current or future technological vacuum within the industry. An interceptor is an aircraft that is specifically designed to block enemy attacks including drones and bombers and can also be utilized for reconnaissance missions. Currently, with the boundaries of defense capabilities moving into space and growing political instability, it leaves the United States vulnerable to attacks from the outer atmosphere and beyond (AIAA 2024). Technological capabilities have allowed for aircrafts that are traditionally manned by at least two pilots to be controlled from the ground, not only that, but it involves deploying weapons and maneuvering around attacks. The government does not have an unmanned interceptor the size being asked by the competition, in use. This is mostly due to the usage of older models that can do the job desired and more.

The United States stealth-focused fleet composed of F-22 and F-35 aircraft has a projected retirement of 2045. This specific fleet is tasked with defense missions, defending against opposing larger and more advanced air systems (Kass 2024). This requires a small, high-performance, cost-effective, and production-efficient aircraft in the form of an unmanned homeland defense interceptor. Production must be one thousand units within a given budget therefore the minimization of cost through government-furnished equipment, accessible patents and inexpensive materials is key to optimization.

The objective of this project is to design an aircraft suitable for usage by the United States military in order to replace and exceed the precedent expectations set by the current aircraft the fleet is composed of. The basic requirements given are the prioritization of a cost-effective aircraft, $25M per unit, and the ability to execute several missions including point defense interception, defensive counter-air patrol mission, and intercept/escort mission. Furthermore, design requirements surrounding minimum performance, weapons carriage capabilities, and engine design. The design allows for the creation of a remotely piloted aircraft that is easily accessible for maintenance, the structure is able to hold the desired load of the equipment and standard fuel tanks and has stable operation within the unaugmented subsonic longitudinal static margin in all weather conditions. Meeting these requirements will create an aircraft that fully upholds the standard of the United States military operations and completes the missions.

As mentioned previously, the United States' current fleet can accomplish more than is desired by this design. What is the point if the existence of this aircraft barely holds up to its predecessor? Why not simply produce more of the current models? The short answer is money. It is true that the older planes do twice as much, but at what cost? Just the engines of the current models cost more than the desired budget for one of the interceptor units. In a larger context having a small, inexpensive, dispensable, and easily produced aircraft to block attacks allows for the United States military to keep their soldiers out of harm's way of incoming missiles without throwing some super high-tech expensive aircraft in the path of destruction. These aircraft's uses are endless when it comes to such defense options that keep both civilians and soldiers safe without costing the government as much money as the F-35's, at $35M per engine, which is more than the $25M budget given by the design competition guidelines for the entire interceptor (Hadley 2023).

Undergraduate engineering design projects, often rooted in collaborative, team-based problem-solving, reflect broader societal structures, including neoliberalism's emphasis on individual achievement and market-driven goals. Neoliberal ideals prioritize competitiveness and efficiency, which can unintentionally reinforce systemic inequities within engineering education (Carrigan 2021). These dynamics can exacerbate the existing divide between white women and women of color in engineering (Cross et al. 2017), as the latter often face compounded challenges tied to race and gender biases. While white women may find incremental representation and support in predominantly male spaces, women of color often confront additional barriers of exclusion and underrepresentation. This disparity can manifest in team dynamics, leadership roles, and the allocation of tasks within engineering projects, further highlighting the need for more inclusive approaches to fostering equity in STEM education.

STS RESEARCH PROJECT

Undergraduate engineering design projects, such as the AIAA Homeland Defense Interceptor Request (AIAA 2024), are heavily shaped by the ideologies of neoliberalism and capitalism. These frameworks prioritize competition, efficiency, and individual achievement, often sidelining systemic inequities embedded within academic and professional environments (Jenkins & Choudhury 2014). Neoliberal values that reward individual success while disregarding structural barriers frequently exacerbate this divide, perpetuating inequalities within capitalistic economies and reinforcing social structures that marginalize underrepresented groups. This disparity undermines the potential for engineering design projects to foster inclusivity and promote innovative solutions that benefit from diverse perspectives (Riley 2007).

In recent years, academia has made significant strides toward increasing diversity in engineering, with initiatives such as mentoring programs, scholarships, and STEM competitions aimed at engaging women and people of color (Espinosa 2011). These efforts reflect a growing recognition of the value diversity brings to problem-solving and innovation. However, for universities, diversity is often tied to monetary incentives, as inclusivity correlates with improved institutional reputation, increased funding opportunities, and access to a broader talent pool

(Espinosa 2011). These benefits often align with a capitalistic agenda that prioritizes measurable outcomes over substantive cultural transformation. Capitalism thrives on competition, where fresh perspectives and unconventional approaches can drive technological advancement and secure a competitive edge (Saxena 2014).

While diversity in engineering has improved, particularly among white women and women of color, systemic racism and sexism persist, shaping the experiences of these groups differently. Women of color, in particular, face compounded barriers due to the intersection of race and gender, which white women do not encounter at the same level. To better understand the nuanced challenges faced by women of color in engineering, qualitative methods such as university surveys and interviews can provide deeper insights than demographic data alone (Cross 2018). Such analyses not only illuminate the systemic obstacles within academia but also reinforce the need for equitable solutions that bridge the gaps between race, gender, and economic opportunity in engineering.

The intersectionality of race and gender is evident in the United States' perspective on diversity within engineering, which often categorizes diversity as anyone who is not a white man. Women of color occupy the lowest position in this "privilege hierarchy," positioned below other marginalized groups due to their compounded disenfranchisement. This hierarchy is defined by the group's relation to white men, who remain the standard within societal structures that "reward whiteness" (Hurtado 1989). White women share racial privilege with white men, while men of color share gender privilege, reinforcing systemic inequities. These dynamics manifest in engineering, where designs often reflect the needs and experiences of those who designed them. For example, seat belts were historically designed for male anatomy, increasing the risk of injury or death for women in car crashes (Perez 2019). Similarly, mainstream sunscreen products, formulated for lighter skin tones, perpetuate inequities by leaving a visible white cast on darker skin (Addae & Weiss 2024). This shows the existent bias within engineering and shows the need for diverse engineers to accommodate everyone, from grocery store products to life-saving technology.

Diversity drives innovation, and for pragmatic reasons, private companies, governments, and universities have increasingly prioritized equity, recognizing its potential to enhance creativity and economic growth. In engineering, however, significant disparities remain between white men, women, and people of color. These disparities have prompted universities to expand initiatives aimed at increasing participation from underrepresented groups in STEM fields. Yet, higher education systems were historically designed to support and privilege white men, leaving white women, women of color, and men of color to navigate frameworks not tailored to their needs. Despite efforts to promote inclusion, only 13% of the STEM workforce comprises women, and 67% of the total workforce remains white (Funk et al. 2021). This highlights the limitations of integrating underrepresented groups into systems without addressing structural inequities. By critically examining the interplay of capitalism, competition, and diversity within academia and industry, we can identify barriers and bias that perpetuate inequality and develop actionable solutions.

White women and women of color share many struggles in their pursuit of STEM careers, but the challenges they face are not identical. While white women contend with barriers in a system built to uphold the advantages of their white male counterparts, women of color face compounded obstacles due to both their gender and ethnicity. This intersectionality creates a layered experience of marginalization that disproportionately affects women of color, making their journey in STEM even more difficult. The competitive nature of STEM fields, often framed as a race for limited resources, opportunities, and prestige (Slaton 2010), further exacerbates these disparities. In an increasingly capitalistic society, the financial rewards associated with success in STEM are immense, which trickles down into the students' motivations and decisions (Carrigan 2021). Therefore contributing to the race to succeed in STEM becomes not only a matter of personal achievement but also of securing financial benefits and contributing to economic outcomes.

However, this drive for success does not operate equally for all groups. While white women may experience the structural limitations of a male-dominated system, their proximity to whiteness affords them certain advantages, including higher earning potential and access to networks and opportunities that are often less accessible to women of color. This economic divide is particularly evident in the disparity of wages, where white women earn approximately 78% of what their white male counterparts earn, but women of color often earn significantly less—between 62-65% of what a white male makes (Bureau of Labor Statistics 2014). The systemic racism embedded in STEM fields ensures that women of color are less likely to access the same economic opportunities, further widening the gap in earnings and professional success. This divide is amplified by what has been termed "white feminism," which often centers the struggles of white, middle-class women while failing to address the unique challenges faced by women of color. White feminism's focus on achieving equality within a system that has historically "awarded whiteness" overlooks the additional layers of racism and sexism that women of color must contend with in both academic and professional environments (Liska 2015). When efforts to advance gender equality do not account for the complexities of race, they risk reinforcing existing inequalities, making feminism not only ineffective but, at times, counterproductive. A comprehensive approach to addressing inequality in STEM must account for the interconnectedness of race, gender, and economic opportunity, recognizing that diversity in the workforce not only benefits individuals but also fosters innovation and economic growth on a larger scale.

For engineering to achieve true equity, white women must recognize the harm perpetuated by a system that, while disadvantageous to them as women, simultaneously grants privileges that are inaccessible to women of color. Research has shown that women thrive in STEM when they are supported by communities that foster mutual relationships and solidarity (Seymour & Hewitt 1997). Therefore white women must not prioritize their individual voices at the expense of women of color, particularly when striving for recognition in male-dominated spaces. Instead, white women must engage in collective efforts that amplify the voices of marginalized groups, acknowledging the complexities of intersectionality within feminism and working toward a more inclusive and just professional environment within a neoliberalist society.

CONCLUSION

The AIAA Homeland Defense Interceptor competition highlights the intersection of innovation, practicality, and equity in aerospace engineering. By challenging students to design a cost-effective unmanned aircraft, it addresses the growing need for advanced, affordable defense systems amid global instability and the retirement of legacy fleets. However, such projects also mirror systemic inequities within STEM education, where women and people of color, particularly women of color, face compounded barriers. Addressing these disparities is crucial, as diversity enhances creativity and ensures designs serve all communities equitably. As future engineers navigate the challenges of developing cutting-edge technology, they must also engage with the societal structures shaping their field, fostering solutions that are inclusive, efficient, and socially responsible.

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