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**UNDERGRADUATE HYPERSONICS RESEARCH:
THE FOURTH YEAR OF THE REU SITE HYPER**

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ABSTRACT

Progress towards future modes of transportation and energy production has uncovered significant knowledge gaps impeding technical progress. Realizing aircraft that regularly operate in supersonic and even hypersonic regimes and turbomachinery supporting carbon neutrality can be addressed only through multidisciplinary research. The University of Central Florida (UCF) equips future engineers and scientists for research-oriented careers through a variety of programs and initiatives. One key initiative is a Research Experiences for Undergraduates Site housed within the Center for Advanced Turbomachinery and Energy Research and the Department of Mechanical and Aerospace Engineering. Now hosting its fifth cohort, the site unites multidisciplinary projects around HYPersonic, Propulsive, Energetic, and Reusable Platforms (HYPER). Beyond graduate-level research with expert faculty, participants engage in a professional development series, industry tours, and computational software training. UCF plays a key role in preparing a workforce of young scientists for research careers in hypersonics. This paper presents data drawn from the four completed cohorts of HYPER participants on how exposing participants to the various disciplines has impacted their self-efficacy, as well as a brief summary of lessons learned along the way. With this site, UCF plays a key role in preparing a workforce of young scientists for research careers in hypersonics.

Keywords: hypersonics, education, undergraduate research, turbomachinery

1. INTRODUCTION AND BACKGROUND

Advanced aircraft, increased propulsion efficiency, and decreased costs to operate these systems are all strongly desired by society. Bringing these advances to fruition will require solving the grand challenges that currently impede technical progress [1, 2]. Certainly, reusability and efficiency of propulsion systems in

current-generation platforms have improved steadily. However, the transformative advances to propulsion systems, materials, and manufacturing that will eventually lead to the greatest technical leaps will be fulfilled by individuals with interdisciplinary skillsets [3]. The NSF- and DoD-funded Research Experiences for Undergraduates (REU) Site HYPER exposes participants to a broad-yet cohesive-set of experiences that equips individuals to pursue research-oriented careers enabling advances in hypersonics, propulsion, and turbomachinery. Turbomachinery is at the heart of these anticipated advances in power generation, aviation, and space propulsion, as seen in Fig. 1. As such, it is perhaps not surprising that HYPER is hosted by UCF's Center for Advanced Turbomachinery and Energy Research (CATER) and the Department of Mechanical and Aerospace Engineering (MAE).

A fundamental attribute of HYPER is that students not only are exposed to each discipline required to achieve next-generation flight and turbomachinery, but they also see research advances realized in systems via rocket launches/landings and industry tours. HYPER has seven objectives with associated assessment metrics: (1) present an REU site that is diverse in terms of student participation (e.g., demographics, research experience), (2) present an REU site involving students with fewer STEM research opportunities, (3) technically prepare students for graduate school and/or research-oriented careers; (4) escalate students' abilities to simulate multi-physics phenomena using finite element analysis; (5) improve participants' oral/written technical communication skills; (6) enhance participants' research skills/attitudes of contemporary and future technology for hypersonic flight, space propulsion, and power generation; and (7) provide high-quality mentoring to equip students for research-based careers. An independent group provides an annual assessment of the Site through pre- and post-experience surveys, focus groups, and additional analyses.

At the heart of HYPER's seven objectives is a desire to prepare and equip students for research-oriented careers. Focusing on turbomachinery and hypersonics applications, HYPER part-

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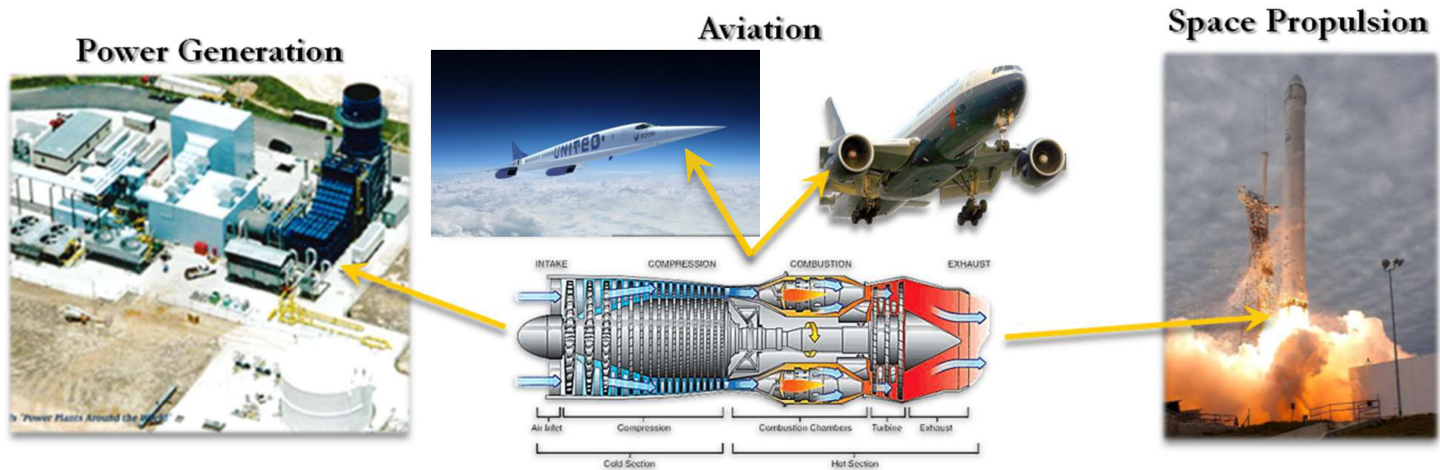


FIGURE 1: HYPER ADDRESSES MULTIDISCIPLINARY RESEARCH RELATED TO HYPERSONICS, SPACE, PROPULSION, AND ENERGY. MANY OF THE RESEARCH PROJECTS INVOLVE ADVANCED TURBOMACHINERY TECHNOLOGY.

ners each participant with a faculty mentor and a graduate student or postdoctoral scholar from the mentor's research group. In this way, participants receive extensive one-on-one experience and training on a project of great interest to them. Moreover, the participants are able to engage in PhD-level research over their ten-week experience. The projects also are inherently multidisciplinary, such as transforming detonations into a sustainable propulsive mechanism, life prediction for materials in extreme environments, and developing thermal protection systems to provide structural integrity of critical flight surfaces. The projects typically involve multiple research techniques as well, for example involving experiments, numerical simulations, and analytical calculations.

Several factors favorably influenced the establishment of HYPER, and these factors explain the hypersonics and energy focus. Located in central Florida, UCF has strong ties with the many major aerospace, defense, and turbomachinery OEMs and companies in the region. Building on the associated expertise, faculty in MAE and CATER frequently interact with these companies and conduct advanced research on a variety of aerospace and defense needs. The development of CATER in particular has established a habit of multidisciplinary research, with faculty regularly collaborating to tackle the many facets of modern challenges relevant to hypersonics and advanced energy generation. The faculty mentors also have vast experience mentoring undergraduate students: UCF enrolls approximately 60,000 undergraduate students (almost 4,000 of them in MAE), and CATER and MAE faculty routinely recruit multiple undergraduates to conduct research. These mentors may benefit from some self-interest as well; these students who conduct undergraduate research often choose to stay at UCF to continue their work. In these cases, they enter the graduate program already trained in the necessary research techniques to contribute successfully to the research group (or already have been contributing!). As such, the faculty mentors are strongly motivated to and have experience in encouraging undergraduate researchers to pursue graduate school.

The faculty mentors already conduct research related to HYPER, such as developing new transportation modes, seeking in-

creased propulsion efficiency, and, based on strong ties to industry, even consider the business cases needed to see these new technologies move from the lab to production [4–7]. The first HYPER cohorts have graduated with many students now in graduate school or otherwise working in a research-oriented position in the aerospace, defense, and energy industries. Evaluation of the site thus far indicates that HYPER is preparing students and exciting them to pursue these research-oriented careers by tackling multidisciplinary challenges in an undergraduate research setting [8–11].

2. HYPER PROGRAM ELEMENTS

Participants in the HYPER program engage in a multidisciplinary research experience and multi-modal professional development encompassing both technical and soft skills. In addition, HYPER provides a social program to foster a greater sense of community both within the HYPER cohort and among several other undergraduate research programs at UCF.

2.1 Research Project Objectives and Accomplishments

The HYPER program runs for ten weeks from late May through July. Each year's cohort consists of at least ten students funded from NSF-DoD sources. In recent years, HYPER directors have partnered with other externally funded programs to enable additional students to participate. Regardless of funding source, each student conducts research directly with a faculty mentor and a graduate student. The research projects evolve over time but remain centered on some aspect of hypersonics and advanced energy or transportation technology. All available projects are described at the time of application on the main site [<http://cater.cecs.ucf.edu/hyper>], and abbreviated versions of recent summaries follow.

- **Hypersonic Propulsion**, with a goal to develop sustained high energetic modes of propulsion for high-speed capabilities. The project has application to hypersonic propulsion and flight. The participant will explore hypersonic propulsion methods through optical and laser diagnostics

and data analysis. The participant will study propulsive systems based on detonation, a key enabling technology to maintain superiority in high-speed propulsion and power.

- **Analysis of Cooling Systems for a Hypersonic Leading Edge**, with a goal to develop thermal protection systems and new materials for leading edges of hypersonic vehicles. This project has application to thermal protection of hypersonic flight structures. The participant will learn design and optimization of sCO₂ power systems and perform CFD analyses of film, transpiration and impingement cooling. Research will include experimental measurement of impingement cooling and extend advances made by prior REU participants. The participant also will learn how to create a digital twin of the cooling systems with experimental and numerical data.
- **Continuum-Level Life Prediction of Materials under Combined Extreme Environments**, with a goal to conduct numerical analysis of thermo-mechanical loading of hypersonic aircraft beams during a typical flight. This project has applications to structural integrity of hypersonic vehicles. The participant will learn how to conduct finite element analysis using ANSYS, an industry-standard software. The participant then will conduct analyses of straight and curved beams under mechanical and thermal loading to simulate the force, deflection, stress, and strain experienced by a hypersonic vehicle flight structure in operation.
- **Evaluation of CFD Models for Solid-Propellant Rocket-Exhaust Modeling**, with a goal to understand the relationship between nanometric aluminum particle sizing, burn rate, and combustion performance in solid rockets. The project has applications to hypersonic propulsion. The participant will learn how to master such tools as computational fluid dynamics and key concepts of compressible jets. Using STARCCM+ (another industry-standard software), the participant will evaluate various particle injection levels and associated performance. In these simulations, the participant also will consider multiphase flow, with particles in the liquid state at the inlet of the nozzle.
- **Atmospheric Entry, Descent and Landing (EDL) for Manned Mars Missions**, with a goal to model and test control algorithms for orbital motion. The project has application for hypersonic entry and space travel. The participant will develop models for a 9DOF rapid orbital motion emulator robot using a camera system for position feedback. The participant will simulate motion using Matlab in conjunction with the mobility software and develop ways to further optimize the code for the mobility of the rover to improve the simulations.
- **Additive Manufacturing of Ceramic Turbine Blades**, with a goal to investigate process-structure-property relationships in vat photopolymerization additive manufacturing. This project has applications in a wide range of lightweight aerospace components. The participant will survey various additive manufacturing approaches, focusing in particular on tensile bar parameters, structures, and ensuing properties. The participant will print several tensile specimens in various orientations to explore the process parameters that may lead to dramatic differences in surface quality and print quality, in turn leading to significant differences in overall tensile bar properties.
- **Fundamental Combustion Studies of Renewable Fuels for Hypersonic Propulsion and Rocket Engines**, with a goal to analyze the effect of impurities on methane / natural gas ignition at high pressures. The project involves energetic reactions with application to rocket propulsion. The participant will study the ignition delay time for various impurity levels to determine whether some known impurity level can reliably ensure ignition. The participant may use this initial research to develop more affordable fuels that do not require such a low level of impurities.
- **Mechanics of Ultralightweight Origami-Core Hypersonic Structures**, with a goal to enable weight reduction and multifunctionality using origami architected sandwich structures. The project has applications for hypersonic flight structures. The participant will learn about the geometry of origami structures using paper models with mechanical testing at lab scale. The participant then will fabricate structural origami using 3D printing with polymers and assemble sandwich structures, comparing their analytical models with finite element (FE) and experimental results. Typical loads would include load-displacement, low speed impact, thermal expansion (simulated or real), 3D digital image correlations (3D DIC) and visual data. The models would be used for optimizing weight, elasticity and failure.
- **Precision Cooling Loop for Space-Based Payloads**, with a goal to modify an existing one-stage liquid cooling loop, previously designed in support of a suborbital flight payload, to a LEO SmallSat platform carrying the same experiment. The project has applications for payload support in space transport and operation. The new design will need to consider space environmental conditions, as well as aim for increased efficiency and miniaturization. The participant will include thermal design development in ANSYS, CAD in SolidWorks, prototype parts selection and assembly, and prototype laboratory testing.
- **Lightweight High-Temperature Carbon-Metal Radiator Structures**, with a goal to develop new methods for heat rejection on hypersonic vehicles and spacecraft. This project has application to thermal control on hypersonic vehicles. The participant will investigate the radiative and mechanical behaviors of carbon-metal composites with hybrid carbon nanotube and carbon fiber filler/reinforcement architectures. The participant will learn to preform heat transfer and stiffness calculations using finite element numerical techniques, fabricate material samples, and conduct

thermal profile measurements. Based on the results, the participant will design a monolithic composite radiator structure with seamless integration of heat pipes and panels.

- **3D-Woven Polymer-Derived All-Oxide Ceramic Matrix Composites**, with a goal to develop high-temperature oxide-oxide ceramic matrix composites. The project has applications to the structural integrity of hypersonic vehicles, gas turbine blades, and aircraft engines. The participant will contribute by processing, characterizing, and testing the ceramic matrix composites using oxyacetylene ablation to explore variation in burn-through time versus composite construction.
- **Damping of Anisotropic Composite Structures Under Extreme Multi-Axial Mechanical and Thermal Loads**, with a goal to expand on a testing framework to understand how multi-axial mechanical loads affect the damping of anisotropic composite structures. The project has applications for the structural integrity of hypersonic vehicles in flight. The participant will continue characterization and analysis of a test rig that imposes controllable multi-axial loads and can accommodate mixed boundary conditions, including using ANSYS. The participant also will gather experimental data on the trends of damping based on in-plane loading to explore how well the test rig can capture both basic and complex boundary conditions.

2.2 A Well-Rounded Experience: Training, Professional Development, and Social Activities

Participants spend the overwhelming majority of time (32-36 hours each week) engaged in their graduate-level research projects. To develop stronger future researchers, HYPER also incorporates a robust supplemental program of professional development and additional technical content (averaging 4-8 hours each week). These events include a few hours of training on the use of ANSYS (a common commercial numerical simulation software for structural, thermal, aerodynamic/fluid problems, and more). Notably, an ANSYS expert provides this training in a series of seminars that expand beyond the standard tutorials ANSYS provides online; Fig. 2b shows one such training session. One of the faculty mentors provides a one-hour research seminar each week, enabling students to understand the other aspects of their multidisciplinary project in more detail. To extend that benefit, the directors have planned for additional laboratory visits among the HYPER participants and faculty.

The cohort also travels to several industry sites for tours (though COVID-19 has curtailed some of these activities). As discussed above, UCF's location in central Florida is a key benefit. There are numerous OEMs, research centers, and maintenance facilities close to campus, sufficiently close to make morning or afternoon tours a viable option. Even Cape Canaveral is only 35 miles from campus, meaning that most launches (the rocket plume, anyway) are visible through Main Engine Cutoff. For evening or night launches, the Stage 2 plume is readily visible, and in some cases even fairing separation and boostback burns can be observed. However, HYPER prefers to expose students to these ideas more directly: each cohort visits NASA Kennedy

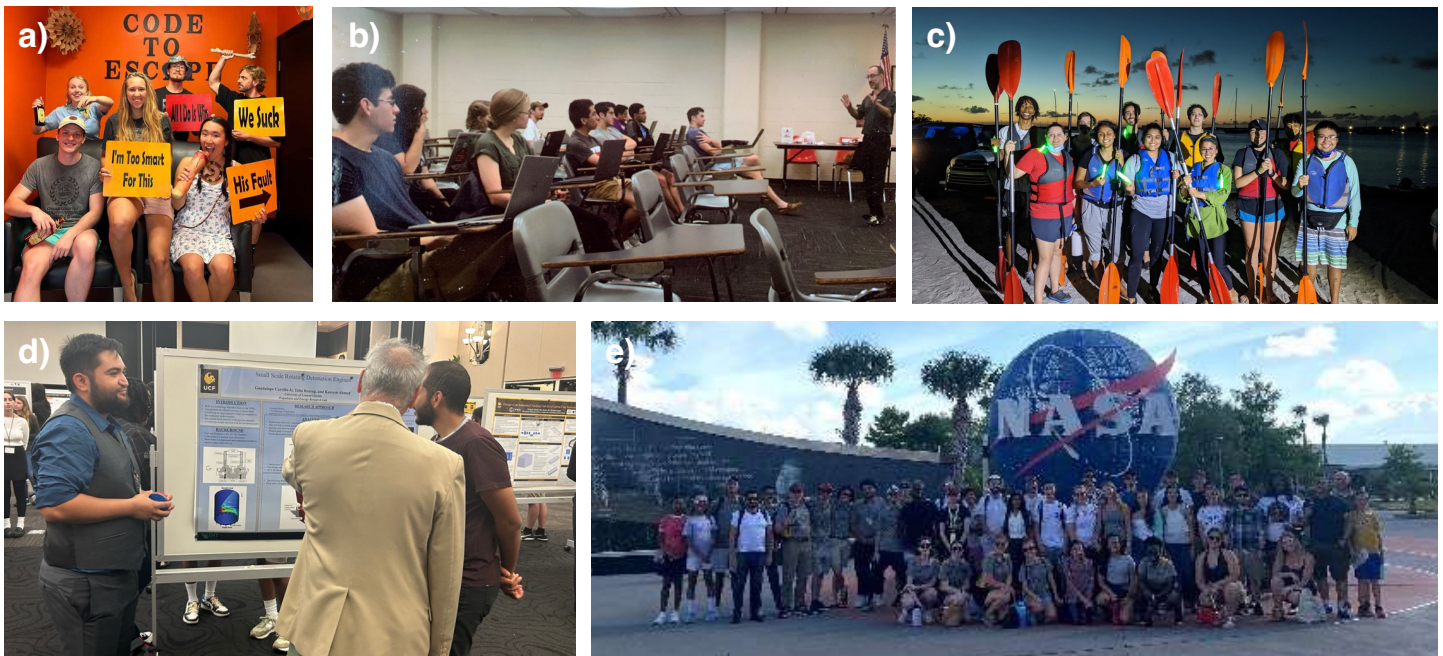


FIGURE 2: HYPER PARTICIPANTS ENGAGED IN PROFESSIONAL DEVELOPMENT AND SOCIAL ACTIVITIES LIKE (A) AN ESCAPE ROOM, (B) ANSYS TRAINING, (C) A NIGHT-TIME BIOLUMINESCENCE KAYAK TOUR, (D) A CAMPUS-WIDE POSTER SESSION, AND (E) CROSS-REU TOURS AT NASA KENNEDY SPACE CENTER

Space Center (KSC) in their first week at UCF, shown in Fig. 2e.

In 2022, a SpaceX Falcon 9 launch conveniently was scheduled for the first week, so of course we chose that day for the visit. For most of that cohort, that was the first time they ever saw a rocket in person. Not only did they watch it launch from five miles away (the distance from KSC viewing area to the launch pad), they also watched it land back at KSC (rather than on a drone ship). Those ten minutes set the stage for the entire summer: participants observed the rocket travel to hypersonic speeds via advanced propulsion, appreciated the energetic nature of the propulsive reaction and corresponding kinetic reentry, and understood the reusable aspect as the first stage slowed and landed upright just a few miles away! (Students also heard the sonic boom less than a minute later!) For many folks, such an event is a literal once-in-a-lifetime joy. In most summers, students organize additional trips to watch and hear more rocket launches.

HYPER also benefits from UCF's size and other research activity. In recent years, UCF has hosted approximately five NSF-funded REU Sites each summer, as well as a variety of additional undergraduate research experiences, either funded externally or through UCF mechanisms like the Office of Undergraduate Research or the Burnett Honors College. As such, HYPER participants take part in the campus-wide weekly seminar series with topics like "Ethics in Research," "Presenting Your Research," and "Imposter Syndrome: The Human Side of Research," among others. Near the conclusion of the summer, participants also present their research via a poster session in the campus-wide Showcase of Undergraduate Research Excellence, as shown in Fig. 2d. Throughout these offerings, HYPER participants interact with researchers from numerous disciplines, enriching their experience. For its part, HYPER helps coordinate unique opportunities like the KSC tour and rocket launch viewing; several REU groups typically attend KSC with HYPER (note approximately fifty attendees in Fig. 2e).

Finally, the HYPER program includes several social outings, including cohort-specific events like an escape room (Fig. 2a), a night-time kayaking outing to observe the bioluminescence of dinoflagellates in Indian River Lagoon (Fig. 2c), and a day at Universal theme park. Of course, many students organize additional outings; a small sample from the 2023 cohort includes Barbie and Oppenheimer, beach trips, hiking, and line dancing! Most of these events naturally occur on weekends or during the evening. More importantly, HYPER again benefits from the

many undergraduate students conducting research at UCF over the summer: the cross-REU interactions help foster a greater sense of a scholarly community while exposing students to ideas and new ways of thinking even outside of engineering.

3. COHORT RECRUITMENT

HYPER recruits broadly to develop a competitive and diverse pool of qualified applicants. Methods include online and social media, direct emails to engineering departments, the NSF REU website, flyers to the faculty mentors' technical communities, and the HYPER website. Additional details on recruitment are available in Refs. [8, 9], with significant additional information on the effect of recruiting timeline and various methods in Ref. [11].

More recently, the directors have put additional emphasis on students not already on the research-oriented or graduate school path. Indeed, HYPER seeks to identify students who may not have been initially interested in a research-oriented career but have the potential to thrive if given graduate-level, research-intensive safe spaces. Part of this motivation to recruit students from institutions with fewer research opportunities stems from the understanding that undergraduate research experience increases retention, graduation, and graduate admissions rates [12]. As such, the directors have modified recruitment materials to emphasize even more that no prior research experience is required. In addition, recruiting efforts focus on institutions with fewer research opportunities, including colleges without engineering graduate programs and two-year institutions. Table 1 displays the full applicant and participant numbers for the four cohorts; the percentage of students hailing from institutions with fewer research opportunities has increased dramatically, from approximately 28% to over 50%. We also observe that of all HYPER participants, 45% are female, 38% are from underrepresented minority (URM) groups, and only 16% are from UCF. (HYPER typically includes one or two UCF students; 2021 was an outlier in part due to restrictions at UCF associated with the response to COVID-19.)

3.1 Scaling

A significant aspect of HYPER's success has been the directors' efforts to scale the REU site by partnering with additional external institutions and HYPER faculty members. These efforts have dramatically increased participation; a typical REU Site would host 40 students over 4 years, while HYPER has hosted 58. These

TABLE 1: HYPER SELECTION IS EXTREMELY COMPETITIVE, WITH ONLY 5% OF APPLICANTS ABLE TO PARTICIPATE IN THE SUMMER RESEARCH EXPERIENCE

Summer	Applicants			Participants				
	All	Preferred	Semi-finalists	Total	Female	URM	UCF	Limited Research
2019	703	246	20	11	4	6	2	3
2020	618		Site postponed; numbers not included in total					
2021	419	352	19	14	7	5	4	4
2022	278	217	60	17	6	3	2	5
2023	236	177	39	16	9	8	1	9
Total	1636	992	138	58	26	22	9	21

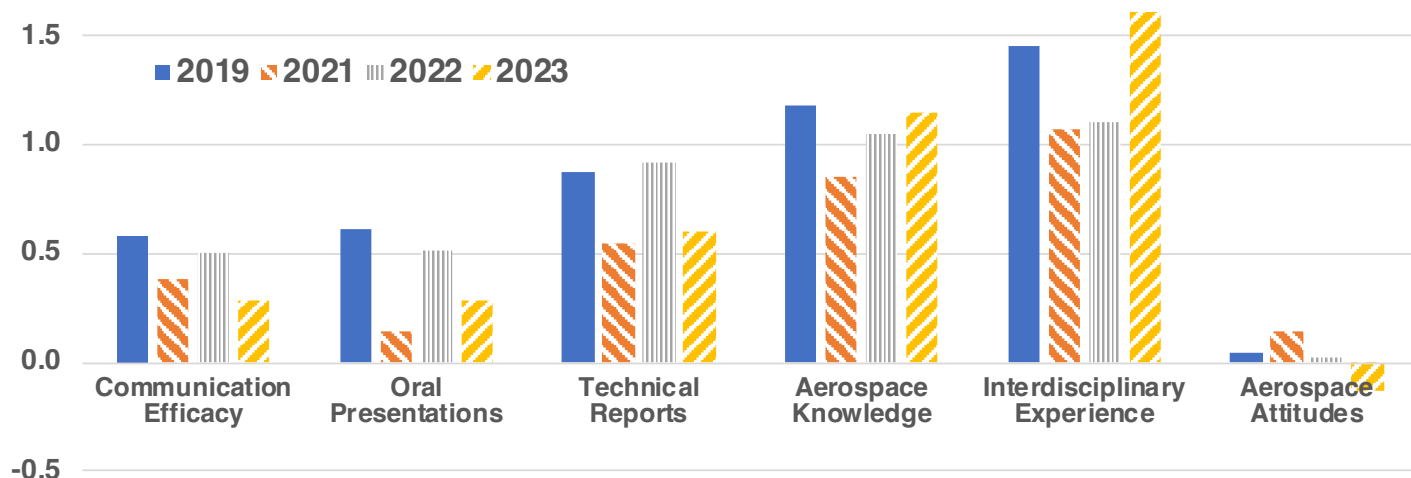


FIGURE 3: HYPER PARTICIPANTS REPORTED THE GREATEST IMPACT OF THE PROGRAM ON THEIR INTERDISCIPLINARY EXPERIENCE AND KNOWLEDGE IN AEROSPACE ENGINEERING TOPICS

additional participants apply and are evaluated in the same manner as all other applicants, but their activities are funded through external means. The HYPER site was renewed for another three-year term in 2023; in this second three-year installment, the directors expanded the scope of available research projects by inviting additional mentors to supply new research topics. This increased availability serves two key purposes: first, it provides additional opportunities to match the many outstanding applicants with a project of their choice, and second, it enables accommodation of the additional students and potential scaling of the REU Site to ensure participants will achieve their learning objectives given the fixed number of faculty mentors. That is, instead of having only 10 mentors for 10 participants, HYPER utilizes a pool of 12-15 mentors, relying on the external funding to provide additional participants without overloading any individual faculty mentor.

4. HYPER IMPACTS ON PARTICIPANT ABILITIES AND ATTITUDES

The HYPER directors assess how the program impacts students through pre- and post-experience technical quizzes, questionnaires, and independent evaluation through the Program Evaluation and Educational Research Group (PEER) involving additional pre- and post-experience surveys and focus groups [13–16]. These assessments routinely show evidence of significant gains in project-specific and aerospace technical knowledge, as well as skill sets like communication efficacy, technical report writing, and interdisciplinary experience.

One of the primary assessment mechanisms is a pre- and post-experience survey of the participants' self-reported skills and attitudes. Consisting of approximately twenty questions and statements, the topics are grouped into six primary areas: "communication efficiency," "oral presentations," "technical reports," "aerospace knowledge," "interdisciplinary experience," and "aerospace attitudes." Some of these categories may be self-explanatory; for example, "oral presentation" consists of several questions that inquire about participants' comfort, experience, and perceived ability in delivering oral presentations effectively.

Of note, all responses are self-reported. Questions are generally posed on a 5-point Likert scale, with a response like "Strongly Disagree" corresponding to a numerical value of 1 and a "Strongly Agree" corresponding to a numerical value of 5, with responses of "Disagree," "Neither Agree Nor Disagree," and "Agree" linearly spaced between these extremes.

Figure 3 shows the change (i.e., the delta) from the pre-experience surveys to the post-experience surveys for each cohort. Statistical variation is to be expected, and no persistent trends are observed in the deltas. The deltas are generally consistent for each category, with approximately half-point increases in communication efficacy and oral presentations. This relatively small change may be due to the fact that many participants arrive with previous oral presentation experience, since a speech class is a fairly common first-year college course. Significantly larger gains are observed in other categories, with 0.75-point increase in technical reports. Following the same line of thought as with oral presentations, some students arrive to HYPER without having taken any engineering laboratory courses yet, so some participants have had limited opportunities to write technical reports. The HYPER experience involves a scaffolded series of assignments to assist participants in constructing both a midterm and final written report.

The largest gains are observed in participants' abilities in both aerospace knowledge and interdisciplinary experience (1.06 and 1.32 points, respectively). These topics are at the core of HYPER, so it may not be a surprise to see such large gains there. The same logic might lead one to predict very large increases in aerospace attitudes as well, yet here we see almost no effect (the average is a 0.02-point pre- to post-experience gain). Note, however, the distinction between abilities (which increase significantly over the HYPER experience) and attitudes (which remain approximately constant). We believe this is largely a self-selection issue: students choose HYPER because they already are excited about and have positive attitudes about aerospace engineering, specifically hypersonics and advanced modes of transportation and energy generation.

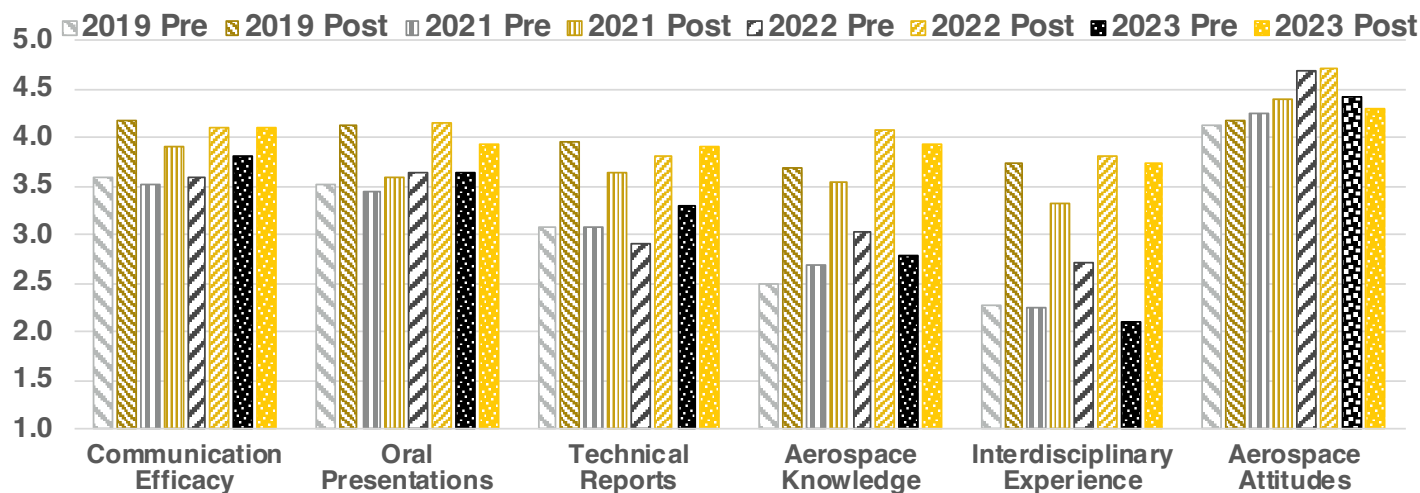


FIGURE 4: HYPER PARTICIPANTS REPORTED STRONG INCREASES IN ABILITIES AND ATTITUDES TOWARDS RESEARCH-ORIENTED CAREERS IN AEROSPACE ENGINEERING

Examining the full array of pre- and post-experience scores in Fig. 4 shows that participants enter the experience rating their aerospace attitudes at 4.4/5. As such, there is not much room to improve, especially relative to their entering aerospace knowledge, which they rate at 2.7/5. There also is a general upward trend in both the pre-experience aerospace knowledge and aerospace attitudes of HYPER participants. One possible reason for this trend is greater awareness of HYPER and its topics. With hypersonic flight and weapons receiving increased media coverage and rockets launching to space more frequently, there simply are additional opportunities for students to learn more and get excited about these topics. Moreover, the HYPER directors have posted a significant amount of information from prior cohorts on the HYPER website, and prospective participants now have the benefit of engaging with that material prior to their research experience.

Recall that for the 2023 cohort, there was an increased emphasis on applicants hailing from institutions with fewer research opportunities. Thus, the 2023 cohort likely included more students with less research experience and even less understanding of what research entails. This change in emphasis may help to explain the significant 2022-to-2023 drop in pre-experience interdisciplinary experience, for example. Similarly, it may account for some of the decrease in pre-experience aerospace knowledge and aerospace attitudes relative to 2023. Another factor in 2023 was the compressed applicant recruitment and selection timeline due to the timing of the REU renewal. Working optimistically, HYPER continued to recruit early in Spring 2023, but at a lower level of activity until the REU was formally renewed. Upon renewal, HYPER directors actively recruited a strong pool of applicants, but as has been observed previously, starting earlier generally nets a stronger and more diverse applicant pool [10, 11]. A brief comparison of application statistics showed a decrease in the total number of applicants, as well as the percentage of preferred applicants, from above 80% down to 75%. The effect is relatively small, but it still may be significant given the smaller applicant pool size. The directors will continue to track these

metrics through the coming years, as both 2024 and 2025 will afford a regular recruiting and applicant selection timeline.

4.1 Assessment Results

Examining the most recent annual assessment from PEER reveals additional details on the participant experience [16]. Figure 5 shows the overwhelming majority of participants had a positive experience; all participants found it provided a challenge that encouraged them to pursue their interests. Participants were overall neutral on the potential effect on their GPA, but all felt it helped them better understand how to do research.

Almost all (90%) faculty mentors rated their mentor-mentee partnerships as effective, though only 80% of participants felt their partnership with their primary mentor was effective. This statistic may be more difficult to interpret: with each participant partnered with both a faculty member and graduate student, most participants spent far more time in the laboratory with a graduate student, and 73% of participants answered this question about their graduate student mentor. Some participants expressed a desire for additional interaction with their faculty mentors regarding both their summer project and longer-term research interests (“[m]y faculty advisor was hard to reach”).

When queried on the “most rewarding aspect” of HYPER, participants spoke primarily of their research experience, technical skill development, and networking opportunities. For example, one participant highlighted “[t]he fact that I got to study, fabricate, test, and simulate samples which incorporates a bunch of great research experience.” Another participant celebrated a successful experiment, indicating the highlight was “seeing my experimental set up working once actually being able to collect data.” The poster session was a high point for many students, in part because it combined UCF’s diverse undergraduate research: “[t]he poster presentation was very rewarding because I got to discuss the work I had done with people at varying experience levels. I loved the conversational component of it as opposed to a slideshow.”

Of course, there is a parallel query on the “most frustrating

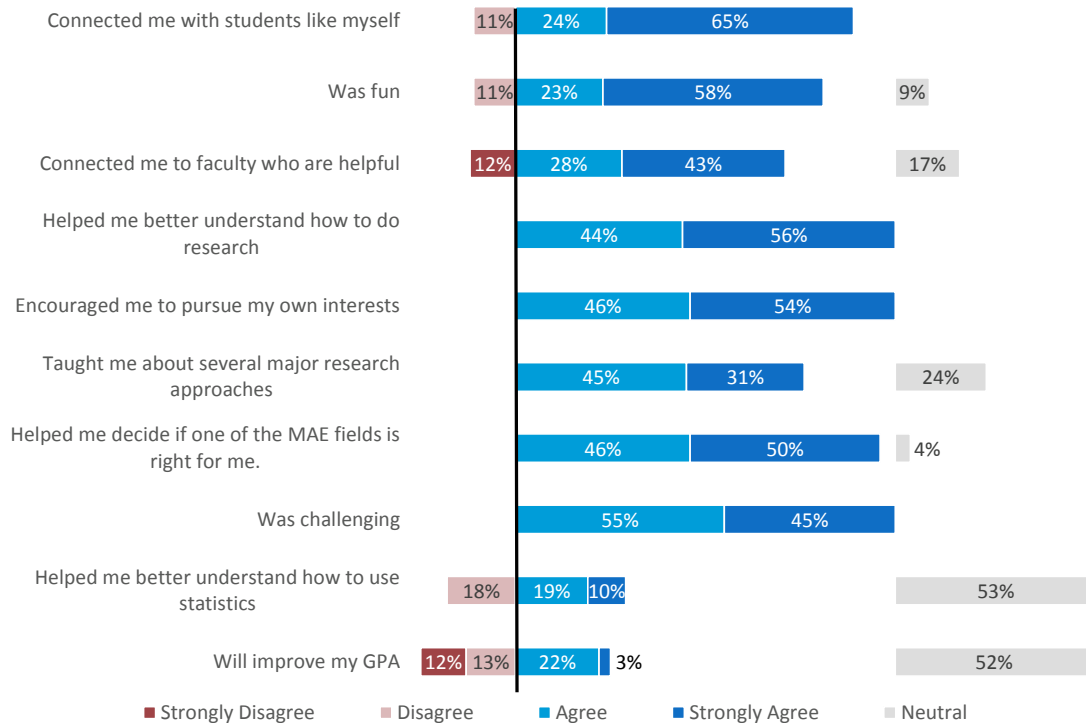


FIGURE 5: HYPER PARTICIPANTS EVALUATED VARIOUS ASPECTS OF THE HYPER PROGRAM AND ITS IMPACT ON THEIR ACADEMIC AND CAREER PROGRESSION

experience.” Many participants lamented a failed experiment or the challenging aspect of research: “[t]he most frustrating part was the running into a new obstacle every time I tried to do something and needing to find workarounds or solutions every time. It made my work run behind schedule and I was not able to get as much done as I hoped.” Another spoke of “[t]he wall of research. I was warned by my post-doc that I would hit a wall in research and I did.” In contrast to prior years, more participants in the 2023 cohort expressed frustration regarding insufficient direction. One noted the “[l]ack of direction for project. Determining what exactly I would need to do at some parts was difficult.” It is possible the increased focus on recruiting students from institutions with limited research focus created a cohort with less research experience and affinity: “Learning enough about the field surrounding my project left me feeling like I had little direction in the beginning. There were also times that I felt like my research held little significance since it was not incredibly novel, but my faculty mentor helped me see its applications.” The PIs anticipate tracking these sentiments closely in the next cohorts.

Finally, participants indicated overall satisfaction with HYPER. Recognizing that research can be frustrating, a majority (60%) of participants were satisfied or very satisfied with their research experience; only 7% were not satisfied. Almost all participants (93%) expressed satisfaction with the interaction with other students. When asked to reflect on the program in general, all participants expressed satisfaction, with 93% either extremely or very satisfied. Moreover, all participants indicated they likely would recommend HYPER to others.

5. CONCLUSION

UCF plays a key role in preparing a workforce of young scientists for research careers in hypersonics. This paper presents data from the 4 cohorts totaling 58 HYPER participants, as well as several lessons learned along the way. We observe that exposing participants to the various disciplines required to achieve next-generation flight and turbomachinery, as well as demonstrating how seeing research realized in systems (e.g., via rocket launches/landings and industry tours), significantly improves participants’ self-efficacy. In this way, HYPER trains and equips these students for impactful research-oriented careers.

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