A Case Study of Success: Mentoring and Supporting Underrepresented Transfer Students in a Mechanical Engineering Program

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Teodoro Navarro

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Abstract

California State University, Northridge (CSUN), like many large urban institutions, has a very diverse student body. This diversity is not only reflected in ethnic and racial differences, but also in the students' educational backgrounds. Our institution enrolls a large number of transfer students, mostly from community colleges in California. These students face a number of challenges, including the adjustment to a new learning environment, issues related to transfer credits, and the necessity of taking additional courses to complete lower division major requirements.

In 2011, CSUN received a five-year, $5.5 million dollar HSI-STEM grant from the Department of Education to address the challenges faced by transfer students from under-represented groups. Glendale Community College and College of the Canyons are partners in the grant. The main goals of the grant are to recruit promising students from community colleges, and then provide them with financial and academic support to ensure their success. There are also opportunities to work on summer research projects under the guidance of their faculty mentors. The initial cohort of students that entered the program is now nearing graduation.

Students in the program are enrolled in a variety of engineering disciplines, including computer science, and are expected to spend additional time on campus in order to become more fully engaged in their department's activities. Assessment of the academic impact of these experiences on the first cohort of transfer students in this program is presented. Also considered is the impact of working on summer research projects with their faculty mentors. Specific benefits were associated with research interaction with faculty, including faculty accessibility and responsiveness, faculty research connections to coursework and career, and academic effects of student-faculty research interaction on students. This paper also describes a particular summer research project performed by a group of mechanical engineering students (five from CSUN and two from Glendale CC) in the summer of 2013. Their work was related to CSUN's human powered vehicle project, which is one of the senior capstone options for mechanical engineering students. Specifically, the group worked on developing methodologies for predicting drag on human powered vehicles, using the previous year's vehicle as a test bed. The drag on this vehicle was estimated using computer simulation, wind tunnel tests, and field measurements.

Introduction

Increasing the number of graduates from STEM disciplines is clearly a national priority. Given the evolving demographics of the U.S., it makes sense to focus on ethnic and racial groups who are historically under-represented in STEM fields. The percentage of engineering professionals who are identified as minority is about one-third of the percentage of minorities in the national population[1]. The reasons for this disparity are varied and complex. One factor which has been identifies as a barrier for students from under-represented groups is a lack of a “sense of belonging” once they are enrolled in a STEM field at the university level[2]. This may be particularly true for students who are transferring from a community college to a baccalaureate program, particularly during their junior year.

California State University, Northridge (CSUN) is in a large urban area with a significant Hispanic population. Reflecting the demographics of our community, our student body consists of a very eclectic racial and ethnic mix. We also have a significant international student population. For the mechanical engineering program, during the interval from 2007 to 2011, the percentage of students enrolled who identified as Latino/a averaged 33.4%. During the same time interval, the percentage of students who were admitted as first time transfers, and identified as Latino/a, averaged 24.5%. The percentage of Latino/a first time transfers varied significantly from year to year, from a maximum of 38.2% in Fall 2007 to 13.5% in Fall 2009. These numbers would seem to indicate that more can be done to encourage Latino/a students from community colleges to transfer to our institution.

In 2011, CSUN partnered with two local community colleges (Glendale Community College and College of the Canyons) to address some of the challenges faced by under-represented groups who wish to transfer to our STEM programs. This effort, funded by a five-year, $5.5 million dollar HSI-STEM grant, was designed to meet three main objectives:

- To increase the number of Hispanic and low-income students who transfer from the community college partner institutions to pursue STEM degrees at our institution
- To assist these students to successfully graduate with a STEM degree in a timely manner
- To streamline the transfer process between the community college partners to our institution by expanding existing articulation agreements

The Principal Investigator of the grant is the Dean of the College of Engineering and Computer Science (CECS) at CSUN. Co-PI’s include the department chairs in our college, as well as their counterparts at the two partner institutions. The organization chart for the program implementation is shown in Figure 1. An advisory board for the program has been appointed to provide feedback and guidance. Included on the board are alumni from our institution who are members of under-represented groups. Assessment of the program is performed by a faculty member from our College of Education (one of the co-authors of this paper) with assistance from graduate students and college staff. Each department in the College of Engineering and Computer Science is an active participant in the program. Program activities are coordinated by the department chair, but faculty mentors are appointed to interact directly with the students. Also, funding is provided to hire senior students to act as tutors and mentors for students in the program. To reflect the various types of support provided for these students, the program has been named Attract, Inspire, Mentor, and Support Students (AIMS^2).

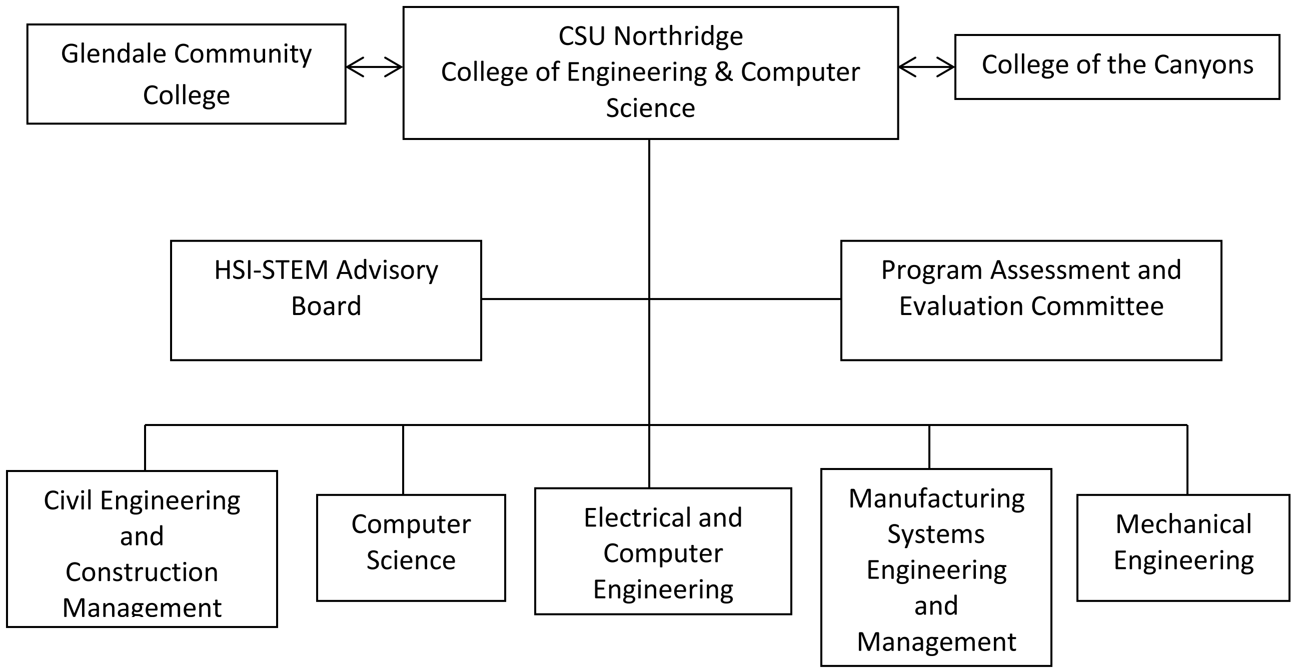

Figure 1. Program Organization

Monthly meetings are held which include the PI's from CSUN as well as representatives from the community college partners. These meetings are used to plan special events for students in the program, share best practices, and discuss matters related to articulation. Several additional courses at the two community colleges have been articulated with our institution since this program began, which has helped to meet the third objective of the grant. Faculty mentors from CSUN have also made visits to the community college campuses to discuss our institution's academic programs and design projects, in order to encourage students to continue their pursuit of a STEM degree at our institution.

To be eligible for the program, students must be an individual who has faced or faces social, cultural, educational, or economic barriers to a career in a STEM field, and must be a U.S. citizen or a Permanent Resident. Students in each annual cohort at CSUN are selected by contacting eligible transfer students and asking them to fill out an application and review a contract which defines their obligations for being a member in the program. Subsequently each student is interviewed by the department chair and faculty mentor corresponding to their field of choice. Thirty students are chosen for each annual cohort, with priority given to students transferring from our community college partner institutions. The first cohort was chosen in the 2011-2012 academic year. In order to remain in the program, students must successfully pass 24 units per academic year and participate in other program activities such as periodic meetings with their faculty mentor and participation in college outreach activities. If they remain in good standing, each student receives a stipend of $2400 per year for a duration of two years. This stipend helps students to minimize their off campus work hours and direct more focus to their studies.

At the same time, cohorts of fifteen students are recruited annually at each of our partner community colleges. They receive a smaller stipend of $1200 per year. They receive similar support services as their counterparts at our institution. If they decide to transfer to CSUN, they have first priority to join the program as transfer students.

Faculty mentors provide regular advisement to the students in the program, and encourage them to become involved in extracurricular activities related to their chosen discipline. In mechanical engineering, students were encouraged to become volunteers in senior design project tasks, or become involved in the Student Section of ASME.

An additional opportunity for students in the AIMS^2 program is to be eligible to work as a Summer Research Assistant under the direction of their faculty mentor. Research Assistants were chosen based on their interest in working on campus during the summer and their good standing in the program (based on units completed during the fall and spring semesters). There was no attempt to select the Research Assistants based on their GPA. The grant allocates funding for hiring the students as well as supporting the faculty mentors with a summer stipend. Students from our community college partners are also eligible to participate in this opportunity. In the mechanical engineering department, the research projects tend to be related to senior capstone projects. Later in this paper, summer work associated with the Human Powered Vehicle project will be discussed in detail as a case study for the kind of research that the students were able to experience as part of the AIMS^2 program.

The next section of this paper describes the methodology used to assess the impact of the AIMS^2 program on the academic success of the students.

Assessment Design and Methodology

The purpose of the program assessment is to attempt to answer two research questions. First, how do academic success and persistence differ between under-represented transfer students who participate and do not participate in a faculty mentor group in engineering and computer science? Second, how does participation in faculty research in engineering broadly and mechanical engineering specifically shape academic and career development of under-represented transfer students?

An embedded, mixed-methods case study design was used to frame a formative evaluation that explored how participation in engineering/mechanical engineering faculty research shaped underrepresented transfer student experiences. Merriam[3] and Stake[4] argue that case studies examine bounded systems—bounded by time, place, and function—that describe particular details of the case. In the context of this study, the case—a faculty mentor/research group—is bound by the project period, resources, goals, and faculty research projects. In addition, the case details that are examined relate to the particular approaches to project implementation within this faculty mentor/research group.

Given that it is still early in the five year project period, it was recognized that using a formative evaluation approach was needed to focus on student experiences in relation to faculty mentor/research group work. In fact, the implementation phase of the project guided us to use an evaluation that helped us understand how project activities shaped student experiences and development (Shaw[5]; Patton[6]). What is more, the nature of the project's objectives supported the use of a mixed methods design - with a focus on historically under-represented students from transfer partner colleges - using both quantitative and qualitative methods (Shaw[5]).

A grounded theory tradition was used within the case study design. Specifically, we used what Glaser and Strauss articulated as grounded theory, which argues for the emergence of explanatory models from systematic examinations grounded in data. In essence, grounded theory directs the examination of relationships between factors that shape student experiences and the effects of these factors on their development. In using a grounded theory tradition, the model that Birks and Mills proposed as essential grounded theory was employed. Consequently, the approach directed the use of theoretical sampling (for interviews), initial coding and categorization, concurrent data collection and analysis, a constant-comparative analytical approach, and finally identifying core categories and producing an explanatory model.

A number of data sources were used for the assessment process. Institutional data included enrollment and demographic datasets to produce a sample of student participants and non-participants in the project for academic achievement analyses. Accordingly, the student participant group consisted of all Cohort 1 students in the AIMS[2] program that entered CSUN in Fall 2011 as transfer students—from any sending institution, including community colleges in a CECS major. By contrast, a comparison group of student non-participants was created, matched closely to student participants on student background characteristics. The comparison group consisted of all students who entered in Fall 2011 as transfer students—from any sending institution, including community colleges—in a CECS major. Data elements consisted of student background characteristics (i.e., gender, ethnicity, age, Pell grant status, and transfer status) and enrollment data (i.e., course enrollment, course grade, and GPA) from Fall 2011 to Spring 2013.

Student data included monthly structured journal entries and semi-structured interviews. All student participants (n=59) were required to complete monthly journal entries. Further, a mixed sampling strategy was used that included a criterion and stratified purposeful sample of student participants for semi-structured interviews. First, student participants were identified who had participated in a faculty summer research project and created gender, ethnic, and discipline/major strata from which we selected student participants within these strata. Then, one to two students were selected from each strata to invite to interview. The final sample consisted of 10 transfer students—from sending institutions that included community colleges—from across engineering and computer science fields who participated in faculty research in either Summer 2012 or Summer 2013. The final sample characteristics included seven Latino/a students, one Middle Eastern student, one Persian-Ecuadorian student, and one White student. Further, the majority of the sample identified as first-generation college student, while the sample was a mix of traditional (18-22) and non-traditional (over 22) aged college students. Within the sample, one Latina, one Latino, and one Persian-Ecuadorian student were interviewed from the mechanical engineering research group.

To facilitate an efficient journaling process**,** a web-based structured journal guide for student participants was used on a monthly basis to record experiences related to the project. CSUN's content management system - Moodle 2 – was used to host journal guides and journal entry submission from February 2012 to December 2013. Prompts related to project activities of student-faculty interaction, peer-peer interaction, research participation, and career development. Items consisted of check-off, fill-in, and open-ended response sets. At the end of each month, email reminders were sent to each student participant to complete journal entries.

Semi-structured, in-depth interviews were conducted with the selected student participants. Interview questions related to project activities of student-faculty interaction, peer-peer interaction, research/academic participation, career development, and gender/ethnic experiences. Student participants were invited to interview in a conference room on campus at a time convenient for the student. Interviews were conducted, which lasted an hour, during the Summer 2012 and Spring/Summer 2013 terms.

The data were analyzed using the following methods. Descriptive statistical analyses were performed on all questionnaire and survey items to assess the distribution of both samples. Agresti and Finlay[7] define descriptive statistics as summary-level information. In this study, descriptive analytical techniques included frequency analyses. Frequency distributions were produced from the analyses.

For the interview data, a thematic analysis was performed. Audio interview files were transcribed, and preliminary data analysis was performed during data collection, using a concurrent data collection-analysis process. The transcribed data files were prepared, sorted, labeled, and coded. Then, thematic data analysis was used to analyze data and develop meaningful interpretations of the data. Through thematic data analysis, an examination of patterns and trends in the responses was performed. Using ATLAS.ti, a qualitative data analysis software program, these tasks were performed in an application with responses in one column and a coding category or categories in an adjacent column. Here, responses were interpreted and larger patterns and trends (i.e., networks) identified. Finally, the themes that emerged were described through narration.

Assessment of Academic Achievement

Results of data analysis point to general trends in student achievement for Cohort 1. (Cohort 1 was the first group of 30 CSUN students admitted to the program in the Fall 2011 semester.) Overall, we found that student participants recorded higher per-term units completed, per-term and cumulative GPAs, and next-term persistence rates compared to their non-participant student counterparts. Specifically, student participants (vs. non-participant students) completed an average of 13.3 units (vs. 10.4) in Fall 2011, 12.43 units (vs. 11.04) in Spring 2012, 12.19 units (vs. 11.52) in Fall 2012, and 12.12 units (vs. 11.18) in Spring 2013. By contrast, student participants had lower average cumulative units completed: 47.08 vs. 47.59 in Spring 2013. When we look at GPA, we see that student participants recorded a slightly higher average GPA (2.83) compared to their non-participant counterparts (2.78). Similarly, student participants persisted at higher rates than their non-participant counterparts, recording a persistence rate of 96.7% vs. 83.3% for Fall 2011-Spring 2012 and 86.7% persistence rate vs. 76.2%. These results are summarized in Tables 1 through 3.

Results from analyses of academic achievement reveal a consistent pattern of higher academic performance by cohort participants compared to their non-participant counterparts. On the whole, cohort participants completed more per-term units than their non-participant counterparts. One reason that students who participated in the project logged more units term-over-term than students who did not participate in the project may relate to the project requirement to remain enrolled in 12 or more units (i.e., full-time equivalent basis) each semester. However, on a cumulative basis, non-cohort participant appeared to catch up to and pass their cohort participant counterparts. This latter result may be explained by overall degree program requirements that all students must complete and perhaps by the need for non-cohort participants to repeat classes at a higher rate than cohort participants.

With respect to per-term and cumulative GPA and next-term persistence rates, results show that, compared to their non-participant student counterparts, cohort participants consistently performed at higher rates. We may cite several reasons for the difference in academic achievement between cohort and non-cohort participants. First, the peer tutoring and mentoring resources available to cohort participants likely provide specific support mechanisms needed for their academic work in the classroom. Further, the frequent peer-peer interaction within faculty mentor groups—specifically via peer tutoring and mentoring groups—may shape students academic outcomes positively. That is, the higher frequency of peer-peer interaction among students who participate in peer tutoring and mentoring may create a peer environment where academic achievement is highly valued. Finally, we know that student-faculty interaction promotes a broad set of positive outcomes for undergraduate students. In fact, Pascarella and Terenzini[8] report that student contact with faculty members on college campuses consistently supports the educational outcomes like persistence and degree attainment but also tends to facilitate student learning, intellectual growth and cognitive development, career aspirations, and attitudinal changes. Accordingly, we may be able to extrapolate that the more frequent interaction between faculty mentors and cohort participants supports higher GPAs and next-term persistence rates.

Table 1. Cohort 1, Mean Local Units Completed by Term, All CSUN Courses, Transfer Students by Group, Fall 2011-Spring 2013

Group	Project Year 1				Project Year 2				Total**	
	Fall 2011*		Spring 2012*		Fall 2012*		Spring 2013*		Spring 2013	
	n	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$
Cohort 1	30	13.3	30	12.43	27	12.19	26	12.12	26	47.08
Comparison	107	10.4	104	11.04	84	11.52	80	11.18	80	47.59

*Mean local units completed for all CSUN courses in term in column
**Mean cumulative local units completed for all CSUN courses at end of term in column

Table 2. Cohort 1, Mean Local Term GPA by Term, All CSUN Courses, Transfer Students by Group, Fall 2011-Spring 2013

Group	Project Year 1				Project Year 2				Total	
	Fall 2011*		Spring 2012*		Fall 2012*		Spring 2013*		Spring 2013**	
	n	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$
Cohort 1	30	3.19	30	2.65	27	2.74	26	2.85	26	2.83
Comparison	107	2.46	104	2.60	84	2.57	80	2.55	80	2.78

*Mean local term GPA in term indicated in column only
**Mean local cumulative GPA at end of term in column

Table 3. Cohort 1, Next-Term Persistence (Enrollment in One Term and Enrollment in Next Term in Any Course), Transfer Students by Group, Fall 2011-Spring 2013

Group	Project Year 1				Project Year 2	
	Fall 2011-Spring 2012		Spring 2012-Fall 2012		Fall 2012-Spring 2013	
	N	%	n	%	n	%
Cohort 1	29	96.7	29	96.7	26	86.7
Comparison	90	83.3	85	78.7	80	76.2

*Program completion (degree attainment) cases excluded

A Case Study of Summer Research Experience

This section describes the research work that a group of seven students (five from CSUN and two from Glendale Community College) performed in the summer of 2013. It is presented as an example of the research experiences that were available to students in the AIMS^2 program.

The human powered vehicle designed by one of our senior design teams was used as a test bed to study methodologies for determining the drag coefficient of the vehicle. Reducing aerodynamic drag is one of the important design considerations for this project. The drag coefficient was determined using three different methods: software simulation of the flow around a SolidWorks model of the vehicle fairing, wind tunnel testing of a three dimensional model of the vehicle fairing, and field tests of the actual vehicle. The SolidWorks model was tested using the Flow Simulation tool in SolidWorks, which calculates the drag force, which can be used to evaluate the drag coefficient, knowing frontal area, velocity, and air density. The SolidWorks model was also used to print a three dimensional model, which was then placed in the wind tunnel in our fluids laboratory and tested at different velocities and heights. The drag was measured and used to calculate the drag coefficient based on vehicle frontal area. Finally, the actual vehicle was tested on a variety of streets with one designated rider, and a power measurement wheel hub was used to measure data such as power and velocity. Coefficients of drag were determined using each method, and then compared to each other. Each of these methods are subject to error and uncertainty, and one of the key lessons for the students was that the methods might not agree with each other.

Figure 2 shows the SolidWorks model of the vehicle fairing, the model of the ground surface, and the size of the computational domain used by the Flow Simulation software. In actual road conditions, the air and the ground are not moving, while of course the vehicle does move at a velocity V. In the simulation, the vehicle is fixed and the ground and air move at a velocity –V. This is an equivalent situation which simulates the so-called “ground effect” on drag in a proper way, since the ground moves relative to the vehicle. Simulations were also done with the ground fixed relative to the vehicle, in order to model the conditions seen by the scale model in the wind tunnel. In this way, an “apples to apples” comparison could be made between computational and experimental results. While the SolidWorks model of the fairing was provided to the students (from the previous year’s design group), the AIMS[2] student team was responsible for creating the simulation model shown in Figure 2, and learning how to use the Flow Simulation software.

The actual vehicle fairing was slightly over 8 feet long, so a scale model had to be created for wind tunnel testing. Once a length scale of 8:1 was chosen, a new scaled solid model had to created in SolidWorks. From this solid model, a file was created which could be input to a 3D printer in order to make the wind tunnel model. Also, a support structure was designed by the students and manufactured by our college’s technical shop. Figure 3 shows the model mounted in the wind tunnel ready for testing.

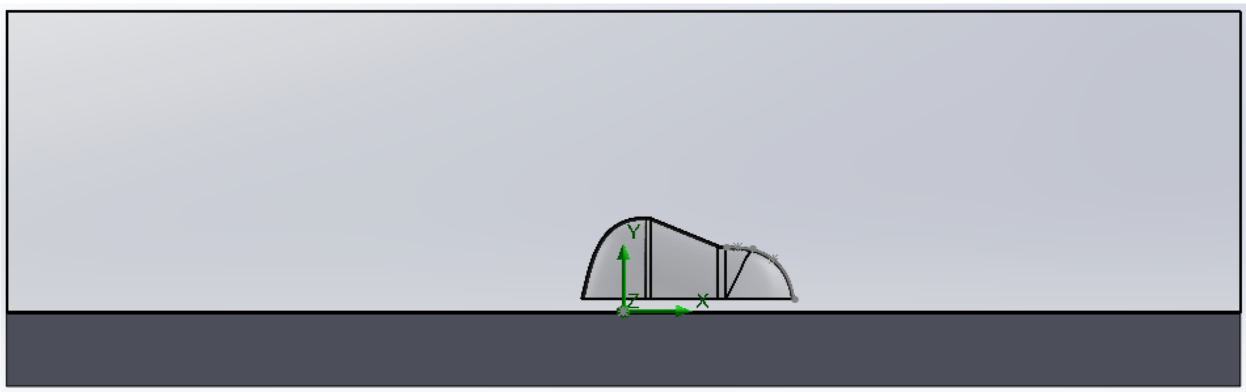

Figure 2. Flow Simulation Model

Table 4 shows a summary of the drag coefficients determined from the simulations and wind tunnel testing. Values from the simulations are given for a stationary and a moving ground surface. As explained above, the stationary ground simulates wind tunnel conditions and the moving ground simulates actual road conditions. It can be seen that the ground condition has a minimal effect on the drag coefficient value, and that the value found from wind tunnel testing is significantly (~ 50%) higher. It was not possible to determine the reason for the discrepancy, although it is likely that the Flow Simulation software is not accurately modeling the separated flow on the rear of the vehicle.

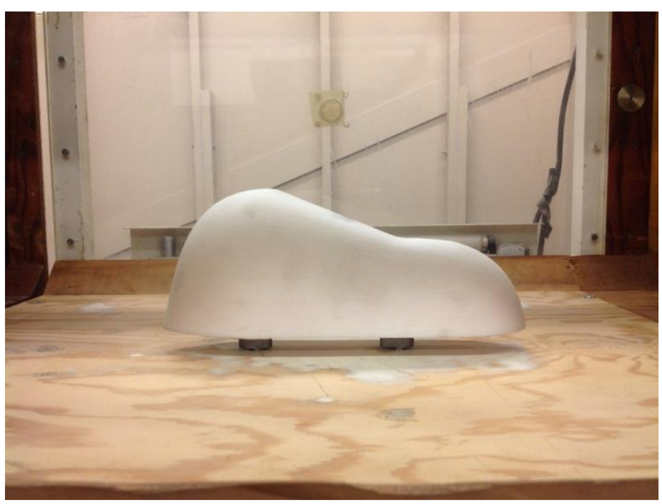

Figure 3. Test Model Installed in Wind Tunnel

Table 4. Comparison of Drag Coefficient Values

Case	Drag Coefficient (Cd)
Wind Tunnel	0.230
Simulation, Stationary Ground	0.153
Simulation, Moving Ground	0.149

The last method used to calculate drag values was based on an actual field test of the human powered vehicle, with a PowerTap hub installed in the rear wheel (see Figure 5). This hub is capable of sending torque, power, and velocity information through a wireless connection to a data logger. Since the power required to move the vehicle at a constant velocity is the drag force times the velocity, the aerodynamic drag force can be evaluated from the data collected, once the rolling friction is accounted for. However, to use this method, the vehicle must be ridden smoothly at a constant velocity on a level road with no wind. Through preliminary testing on campus, it became clear that there was a lot of "noise" in the data and the results were not usable. The vehicle was taken to a local bike path which was level for a long distance. Testing at this location produced better results but the values were compromised by windy conditions. By averaging values obtained going upwind and downwind, a drag coefficient of approximately 1.1 was obtained. This value is much higher than expected and produced some doubt on the part of the team that the PowerTap was giving accurate values. Consideration was given to designing an experiment to calibrate the PowerTap, but it was not done due to a lack of time.

Despite the discrepancies found among the various testing methods, the results were interesting and have been useful for the senior team designing this year's version of the human powered vehicle. A number of lessons about experimental uncertainty, data reduction methodology, and software simulation accuracy were learned by the team of AIMS^2 students, which was an important outcome of their research work.

Figure 4 PowerTap Hub Used for Field Testing

Assessment of the Impact of the Research Experience for AIMS^2 Students

A number of themes emerged while examining the journal entries and interview transcriptions from students who had been involved in research groups. As students joined faculty research groups, they reported changes in how they relate to faculty. In one case, a student reported that he or she "didn't really talk to anyone before." Once part of a research group, two students discovered: "I've been talking to a lot more faculty members" and "I feel like I'm better at talking to faculty." Indeed, students shared how accessible faculty were in a research context, describing: "I went to his office hours and when I asked my questions he helped me to answer the problems I had." When we look at students in mechanical engineering, we find a similar pattern. Here, a student shared: "If I have a question he tells me to come up to his office or answer my emails." The student continued: "He responds pretty promptly." While most students found faculty more accessible, one student seemed to identify a lack of connection to faculty at times. For example, he or she reported brief, disconnected encounters: "He sits down asks a question and that's the end of it. There's no thread from one meeting to the next." The student continued: "I don't really know the tone of those meetings."

Overall, students in faculty research groups reported a sense of friendliness in faculty and helpfulness from their research interactions. One student shared: "I do see him a lot, sometimes he is serious with me, and…he's friendly." Other students claimed simply: "He is involved with us and helpful with us," "He's very helpful," and "Yeah he helped me." While most students shared how helpful faculty were, one student found a formality to relationships with faculty that seemed to conflict with his or her ability to relate well to faculty. This student shared the following story: "He just sort of asks people what people are working on and we go around and give a basic idea. He asks if we used this facility and if we used tutoring, just basic questions. It's all a formality. He sits down asks a question and that's the end of it."

An academic advisement function seemed to accompany student participation in faculty research. In fact, faculty tended to serve as a source of information that extended beyond the research setting and appeared to naturally emerge from research interactions with students. In mechanical engineering, one student shared how her faculty mentor supports her engagement more broadly because he talks "about upcoming things that are going to happen" so that he or she "can participate and be more active." Other students were more explicit about the advising function of their interaction with faculty. For example, one student shared: "I do my academic advising with him. If I have questions on what class I should take, I often go to him." Another student offered: "The one that sticks out the most is we've been working on academic advisement. I was picking my courses for the fall and I was asking other students and they said that seems fine." Another student confirmed: "For this coming fall he looked at mine and then about a month ago I created one for the rest of my bachelor's program." Finally, a mechanical engineering student echoed these sentiments: "[My faculty mentor] laid out what senior electives there were and planned which ones I would have to take."

What students consistently shared about their research interaction with faculty are the connections to concepts in class and expectations for career development. In fact, students reported that by presenting them with typical problems and solutions in the field, faculty research sessions strengthened connections to what they were learning in class. On this point, a mechanical engineering student reported: "It's been really good. I am better prepared for my future classes because my research is on thermal-fluids. I've been doing experiments that are going to be very similar to a future class that I'm going to take so it is preparing me for that class." Another student commented, "I'm already aware of what they're going to be doing throughout the semester." During research sessions, one student indicated that he asked questions about his or her homework: "I'd ask him questions about homework and labs." Another student confirmed: "I asked him a lot of questions to make sure I understood what we were doing in class."

In addition to connections to classes, student-faculty interaction in research contexts appeared to prepare students for careers in engineering fields. One student illustrated this point: "It's preparing me because it's all hands on. Doing analysis on it is real world. [I]f I want to do anything with energy or fluids. It's giving me perspective on how my career can end up as." Another student shared: "I feel like it is giving me more of a professional ability to talk to people in higher positions. I believe this will be helpful when I need to get a job and I have to talk about people above me like my bosses and stuff." Yet another student simply stated: "I believe this will be helpful when I need to get a job."

When students expressed indecision about their career interests, they seemed to find space where they could explore career directions in research interaction with faculty. On this point, one student reported: "I'm not quite sure what I'd like to do. That's why we've been discussing a specialty that might help me a little bit more with what I'd like to do after school." Another student shared: "[T]he way that he changes for me is that he's very familiar with the outside world of school as well. He knows what's going on outside. He knows the internships happening and he always emails me. That changed my view of the outside world." What may be at work here is the reproduction of professional environments. For example, one student shared an immediacy to participation: "I started working…and as soon as I told him I wanted to be part of it, he threw me right into the project." Another student commented: "It's also helping me learn to work well with someone else…to have a partner and work together."

When students interacted with faculty in research settings, they seemed to develop a sense of faculty expectations for academic and professional performance in engineering fields. On this point, one student shared: "I don't want to disappoint my faculty mentor or anyone else in the cohort. So that keeps me pretty active." Another student commented: "Well I participate more in things because I feel like I should live up to some standards." Still another student reported: "Every time we talk he lays out what he expects me to do." One student explained how this dynamic may work: "Yeah, just if we had questions or problems ask him after the meeting and then he helped us to change it in the best way to do it." Another student illustrated how faculty articulate expectations: “[He] told me I could do it but I had to put my courses before everything else so I can get good grades.”

What seemed to emerge as a clear benefit to student research interaction with faculty is the building of graduate school capital. As students participated with faculty, undergraduate students with senior-standing, and Master’s students in research settings, they shared how they asked questions, discussed opportunities, and learned about navigating graduate school admissions. Here, a mechanical engineering student shared: “If I have questions about grad school or anything I ask him because he did grad school.” Another student offered: “We talked about that one semester and they we talked about taking my senior year and adding some masters courses in there so I can work on my Master’s program.” Finally, a student confided: “I’m not quite sure what I’d like to do. That’s why we’ve been discussing a specialty that might help me a little bit more with what I’d like to do after school.”

Conclusions

When we consider how academic success and persistence differ between under-represented transfer students who participate and do not participate in the AIMS[2] program, we see clear advantages to student interaction with faculty in a mentor relationship. Indeed, across a set of achievement measures—term and cumulative GPA and next-term persistence—students who are mentored by faculty outperform their counterparts who do not. Whiles descriptive in nature, these results reveal a pattern of achievement for students who as a group share common experiences in faculty mentoring.

When we interpret the results of achievement data in light of the themes that emerged from what students reported to us directly, we can tentatively conclude that faculty mentoring in a research context benefits students academically and professionally. Indeed, specific benefits were associated with research interaction with faculty: faculty accessibility and responsiveness, faculty research connections to coursework and career, and academic effects of student-faculty research interaction on students. Across these benefits, what appeared to work to support student academic and career development are explicit connections between research participation and expectations for performance in the undergraduate classroom, graduate school programs, and the professional field of engineering. The information that faculty shared with students through research project development facilitated building capital for course, career, and graduate school success. Finally, the results that we observed for students across engineering fields held for students in mechanical engineering.

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