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Improving Student Success and Retention Rates in Engineering: A Four-Year Longitudinal Assessment of the DYP Program

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Abstract

This evidence-based practice paper presents a four year longitudinal study following the first cohort of first-year engineering students that was exposed to the "Design Your Process to become a "World Class" Engineering Student" (DYP) program at a four year institution.

Many students enter the engineering disciplines vastly unprepared to be successful in the rigors of engineering academia. Student retention numbers in engineering are low and some researchers attribute this low retention rate to a lack of academic skills needed to be academically successful. Typically, approaches to increase the nature and quality of engineering undergraduate education experience are focused on instructional and/or curricular changes. A recently developed innovative approach, called the DYP program, is different in that it focuses on what the students can do themselves to become self-regulated students and therefore are not only more likely to graduate with an engineering degree but also with a higher quality, e. g. with a higher GPA. The DYP program synthesizes what has been shown in the research literature to be effective and what should be done in first-year engineering seminars into a comprehensive, scalable and easy-to-implement approach. The main components of the approach are: 1. Coverage of student development topics in a first-year engineering course/lab/seminar to facilitate new students' growth, instilling positive change, and developing strategies that will enhance student success. 2. Building upon the student development topics introduced in the course/lab/seminar, students are asked to design their own individual process to be successful in graduating with an engineering degree and write a reflective comprehensive report at the end of the course.

Previously published results reported a positive impact on first-year engineering student retention and performance after the first year of implementation of the DYP program. The results of the four-year longitudinal study confirm an increase in overall GPA and persistence for the first-year, but more remarkably it shows that the DYP program has a long term sustainable effect on student success. Results show statistically significant differences in GPA and persistence rates between the DYP cohort and control cohort for all years. The DYP cohort showed higher overall GPAs: +0.53 year one, +0.33 year two, +0.31 year three and +0.26 year four ($p<0.001$, except for year four where $p<0.005$, $N=156$ for DYP cohort at year one, $N=193$ for control cohort at year one). Comparing persistence rates between the cohorts also show a positive impact for the DYP student cohort. Students exposed to the DYP program showed higher persistence rates by 11% and 10% for the first and second year and by 16% for the third year compared to the control cohort. All increases in persistence are significant ($p<0.05$). Comparing how many students graduated with a Bachelor's degree in any engineering major after four years at the institution reveals that the cohort exposed to the DYP program had 24 students graduated after four years compared to 10 in the comparison cohort.

Introduction

There is a current concern about the growing need for more engineers in the U.S. Therefore, both first-year engineering student retention and time to graduation need to be improved. A national study conducted by Michelle J. Johnson and Sheri D. Sheppard[1] shows that over 30% of first-year engineering students do not finish with a degree. Even more concerning is that only 8% of all students enrolling in a four year college chose an engineering program. As Veenstra et al. conclude from considering more recent data, "…there is an urgent need for more graduating engineers. Yet, the engineering colleges are challenged with retaining engineering students. Less than 57% of the students, who begin engineering college, complete their engineering program."[2]

Part of the low success rate is that students enter the engineering disciplines vastly unprepared to be successful in the rigors of engineering academia. Student retention numbers in engineering are low and some researchers attribute this low retention rate to a lack of academic skills needed to be academically successful[3]. Furthermore, although there is a wide variety amongst institutions, the GPA of engineering students upon graduation on average is 2.9[4]. Combining the average GPA with the data that only "40%-60% of students persists to an engineering degree, as reported by the National Academy of Engineering[5], it is apparent that the efficiency of engineering education is around 35%. While some attrition level is appropriate in order to ensure that resources are focused on students who are best suited for a career in engineering, retention of certain subgroups of students, i.e. underrepresented minorities and first-generation students, is differentially lower[6,7]. This issue means that students who have the potential to be excellent engineers are subject to higher attrition rates, possibly due to their lack of preparation in areas such as transitioning and being successful in college and engaging in strategies necessary to be successful engineering students. This demonstrates the need for increased focus on first-year engineering education through strengthening a student's commitment and efficiency to graduate with an engineering degree.

A study by Meyers et al.[8] investigated why students stay in engineering and found that increasing the first-year student's academic confidence helps the student adjust to the rigorous engineering curriculum. In another study, students ranked "drive and motivation" as one of the top influences to believing they could succeed[9]. Successful retention programs aimed at underrepresented students have focused on community building, academic success skills, personal development, professional development, and orientation in a first-year introductory engineering course[10]. The 2004 ACT policy report on The Role of Academic and Non-Academic Factors in Improving College Retention identified the following factors as the strongest in predicting college retention or performance: academic-related skills, academic self-confidence, and academic goals[11].

Turns et al.[12] recently challenged the engineering education community to provide more structured opportunities for students to engage in reflection in their undergraduate curriculum. Reflection allows the participant to think about the impact of a past (or future) experience in order to guide future action. In her address to the National Academy of Engineering, Ambrose[13] states that "students learn by doing, but only when they have time to reflect on what they are doing—the two go hand in hand." Citing literature on writing to learn, Ambrose challenges that the best way for students to reflect on their own learning is through the process of writing.

During this process, students have the opportunity to become more aware of their own learning processes, which can promote and sustain lifelong learning.

The DYP Program

An innovative, best practices approach, called the "Design Your Process for Becoming a 'World-Class' Engineering Student" (DYP) program, has been developed by Raymond B. Landis[14] to increase the quality of the educational experience of first-year engineering undergraduate students. Typically, approaches to increase the nature and quality of undergraduate education experience are focused on instructional and/or curricular changes. The DYP program is different in that it focuses on what the students can do themselves to become self-regulated students and therefore are not only more likely to graduate with an engineering degree but also with a higher quality, i.e. with a higher GPA. Self-regulated learning (SRL) is the process that a learner goes through in order to sustain cognitive and metacognitive functioning, as well as to regulate several affective dimensions, which include motivational, behavioral, and emotional regulation. Research has demonstrated that the ability to self-regulate is not only a better predictor of student success than IQ or economic status but self-regulation can be learned by anyone[15]. The DYP program is a comprehensive intervention to guide students to develop their own process to become self-regulated and successful students. The DYP program supports the development of SRL skills through a focus on four primary teaching and reflective components: goal setting, community building, academic development, and personal development.
The two main components of the approach are:

a) Coverage of student development topics in a first-year engineering course/lab/seminar to facilitate new students' growth, instilling positive change, and developing strategies that will enhance student success.
b) Building upon the student development topics introduced in the course/lab/seminar, students are asked to design their own individual process to be successful in graduating with an engineering degree and write a reflective comprehensive report (DYP report) at the end of the course.

Throughout the structure of the first year seminar course as well as in the final reflective assignment, students are led through a process to understand how these four components intersect with the cognitive, metacognitive, and affective domains.

The DYP program exposes students to "best practices" and how students can develop their own process to become successful within the higher engineering education environment. Situated in the SRL framework, the course content and reflective assignment structure of the DYP program focus on several theories, models and associated research ranging from social sciences, psychology and engineering education. The DYP program synthesizes what has been shown to be effective and what should be done in first-year engineering seminars into a comprehensive, scalable and easy-to-implement approach aimed at the development of self-regulatory skills. The reflective comprehensive report challenges students to evaluate themselves against a benchmark student—referred to as a "world-class" engineering student—based on the following objectives:

1. Goal setting
    a. Setting your goal(s) i.e., major, time to graduation, GPA
    b. Strengthening and clarifying your commitment to your goal(s)
    c. Setting up a 'Road Map' – a plan to guide you over the next years to graduation

    d. Understanding the essence of engineering
2. Community building
    a. Building relationships, and making effective use of your peers (help-seeking)
    b. Participating in co-curricular activities
3. Academic development
    a. Navigating the university system, resources, and academic advising
    b. Understanding teaching styles, learning styles, and how to make the teaching/learning process work for you
        i. Levels of intellectual skill
        ii. Learning Styles
        iii. Metacognition
4. Personal development
    a. Enhancing your self-awareness and improving your skills to practice academic success strategies
        i. Dealing with adversity
    b. Outlining what attitudes and behaviors you need to change/add to be successful
        i. Mindset
    c. Managing time and tasks
        i. Time management and goal setting
    d. Engaging in good health and wellness practices including management of stress
    e. Developing a high sense of personal and professional integrity and ethical behavior

To help guide students in designing their individualized process they are asked to implement a three step process:

1. Where a "world-class" engineering student would want to be on each item.
2. Where you are currently on each item.
3. What you need to do to move from where you are to where you would need to be to become a "world-class" engineering student.

Linking the coverage of student development topics in a first-year engineering course/lab/seminar and the assignment of the "Design your Process for Becoming a World-Class Engineering Student" project is key, so that students recognize what a "world class" engineering student would do to be successful. This allows students to develop their individualized process to become successful engineering students and the project provides a written document which the students can revisit and revise throughout their career as an engineering student. Successful implementation of the DYP program proposes the following benefits:

- Development of self-regulated learning leading to improved performance in all courses.
- Individual accountability for success as an engineering student.
- Reduced time to graduation and reduced number of students who "drift aimlessly" through a curriculum since setting the goal of graduating with an engineering degree and developing a plan to achieve the goal will result in more efficient students (increased grit).
- The skills students develop to be effective engineering students are the same skills they need in their future career.

- Ability to apply general student development topics from the course to their personal development plan.

Another advantage of the DYP program is that it allows instructors to adapt it to their particular course/lab/seminar. There is no set order or curriculum that has to be followed, making implementation of the DYP program possible in almost any first-year course/lab.

Results of Prior Implementation of DYP Program

The results from two four year institutions—Oregon State University and University of Alaska Anchorage—one year after initial implementation of the DYP program have been presented by Peuker and Schauss[16]. The following is a summary of their reported results.

At the Oregon State University College of Engineering the DYP program was implemented as part of a new course, ENGR 199, Foundations for Engineering Success, which targeted first-year pre-engineering students who entered with math proficiency levels below College Algebra. The ENGR 199 cohort (N=17) and control group (N=17) were comparable on measures of math placement exam score, SAT math score, first term math course, engineering major, first term of attendance, and admission type (full-time with 12+ registered credits). Of the students who completed the ENGR 199 course, 94% were retained at the university one year later, compared to 53% of the control group, resulting in a statistically significant difference ($p<0.01$). The difference in cumulative GPA after one year among students who took the course (GPA of 2.82) compared to the control group (GPA of 2.63) did show an apparent but not statistically significant increase.

Results from the University of Alaska Anchorage showed that the approach of linking a student development course, and the "Design Your Process of Becoming a World-Class Engineering Student" project had a positive impact on first-year engineering student retention and performance. The cumulative GPA of the students (N=151) who took the course, in which the DYP program was implemented was 3.00 after the first year, compared to 2.51 (N=112) of the control group—students who started the same term but did not take the ENGR A151 course—showing a statically significant difference ($p<0.001$). The retention rate after one year was not found to be statistically significant at the five percent level ($p=0.08$), however, an increase from 79.5% to 87.4% in the first-year retention rate was observed.

Results of Four Year Longitudinal Study of the DYP Program

A cohort of initially N=156 first-year engineering students exposed to the DYP program was followed over four years at the University of Alaska Anchorage. The implementation of the DYP program at the University of Alaska Anchorage has been documented and syllabus, assignments and in class presentations are available[17].

Figure 1 shows the comparison of the cumulative average GPA by year for the student cohort who took an Introduction to Engineering course which included the DYP program, compared to the first-time engineering student cohort from the previous year that was not exposed to the DYP program (control cohort). Besides not being exposed to the DYP program, the control cohort was exposed to a similar curriculum as the DYP cohort, i.e. there were no major differences between the cohorts exposure in terms of curriculum.

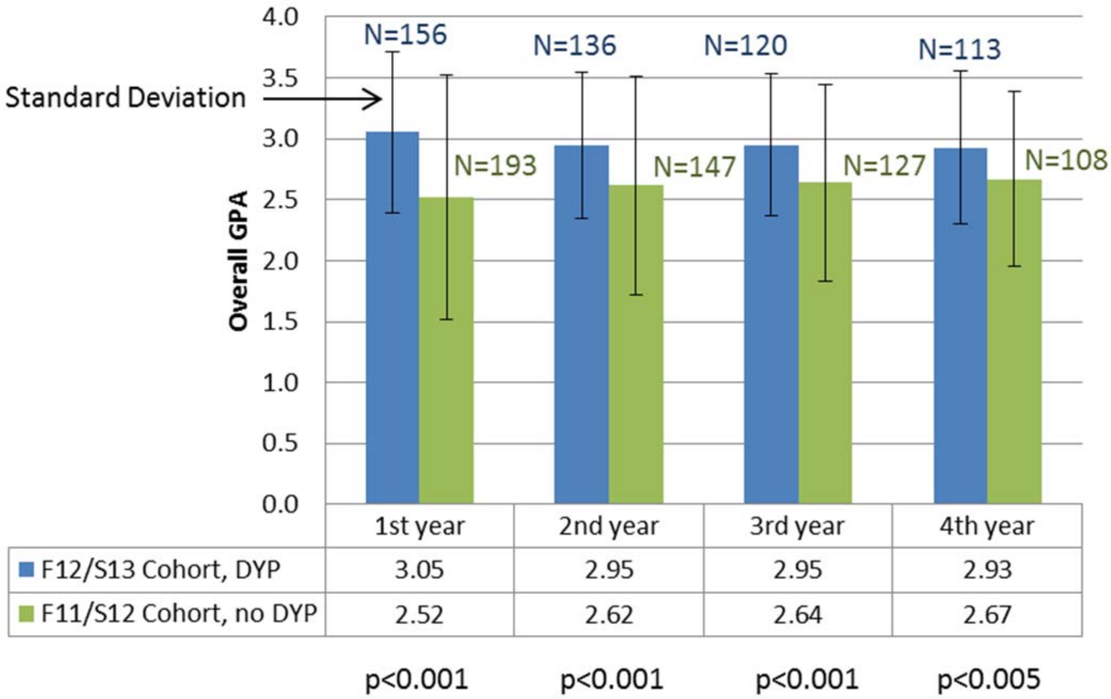

Figure 1: Cumulative GPA Comparison Over Four Year

The results from Figure 1 show a similar increase in first year GPA as reported by Peuker & Schauss[16], but more remarkably it shows that the DYP program has a long term sustainable effect on student success. Using Welch's t-test shows there are statistically significant differences between group means for all years ($p<0.001$, except for year four where $p<0.005$). The overall GPA for the DYP cohort is consistently higher, starting out 0.53 points higher than the control cohort and only decreases by 0.12 points after four years. The slightly increasing trend in GPA for the control cohort is a result of student attrition, i.e. low performing students leaving the institution and therefore the overall GPA of the remaining students increase. The standard deviation shown in Figure 1 demonstrates a wider spread of GPA values for the control cohort for the first year but as attrition sets in the standard deviation of the control cohort is approaching the standard deviation of the DYP cohort. Another interpretation is that the DYP program is especially helpful for low performing students helping this group of students to become more efficient and one manifestation of this improved efficiency is the observed increase in GPA.

Figure 2 shows the persistence rates between the cohorts, where persistence is defined as the number of students who took at least one course at the institution each year over the four year time span of this study.

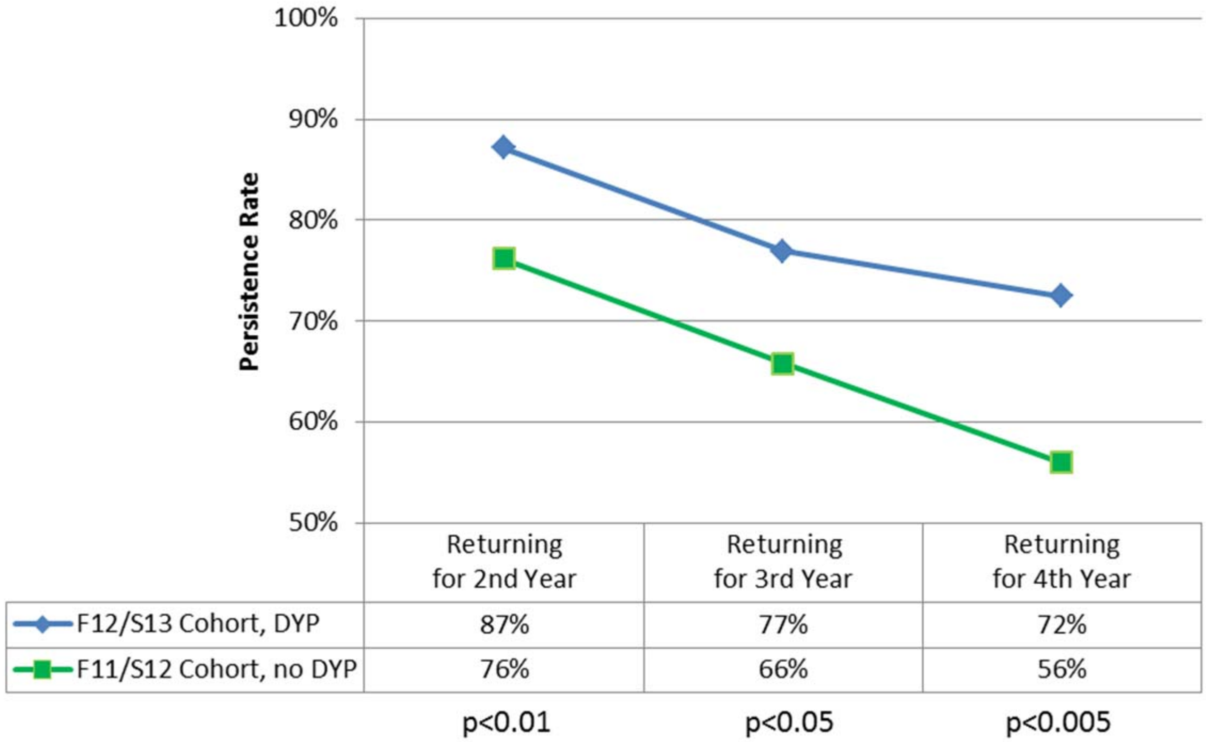

Figure 2: Persistence Rates

As expected, overall retention decreased in both groups as students transitioned from Freshman to Sophomore, Sophomore to Junior, and Junior to Senior. However, overall retention was higher in the DYP cohort compared to the first-time engineering student cohort from the previous year that was not exposed to the DYP program. For the DYP cohort, only 13% of students did not return compared to 24% in the control cohort. It should be noted that return in this context means a student took at least one course per year. A student who did not take a course over a year but took another course or more after one year did indeed return to the institutions but is removed from the data presented here for both cohorts. Of significance is also that the disparity in retention increased significantly from 11% after the first year to 16% after the third year when comparing the cohorts.

The University of Alaska Anchorage reported a 9% four year graduation rate for full-time, first-time students who graduated and began in Fall 2007 or Fall 2009[17]. Comparing how many students graduated with a BS in engineering degree in any engineering major after four years, reveals that the cohort exposed to the DYP program had 24 students graduated compared to only 5 in the comparison cohort, as shown in Figure 3. This all suggests both a large and persistent effect that is more evident over time, indicating a small initial investment (i.e., DYP) produces large yields.

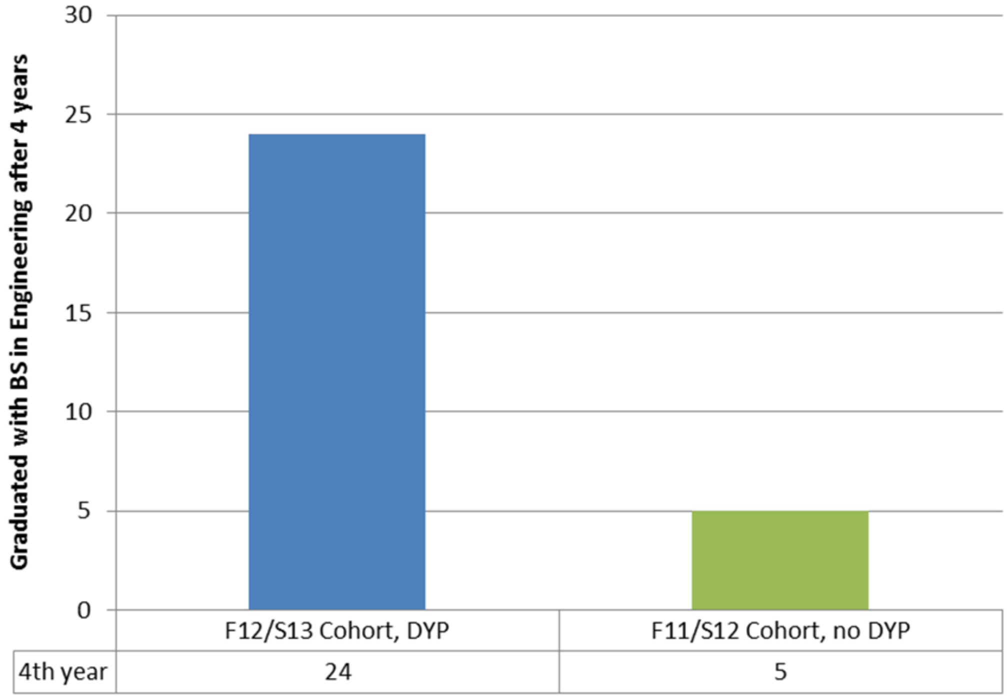

Figure 3: Student who graduate with a BS in Engineering after 4 years

Based on the student feedback gathered at the end of the term after the implementation of the DYP program, there are indications that students perceived they benefitted from the DYP approach and that they saw value in this approach for their future success as engineering students. Examples of what students responded to the question "What was the highlight of this course for you?" are presented next.

- I think a course like this should be required of all first year and transfer students. In fact, if anyone currently attending college has not had this course or one very similar to it, they should be required to take it. There is a ton of useful information on the learning process.

- I really enjoyed being able to create my project and road plan to graduating. It made me think about things that I need to do and prepare for.

- Learning how to be productive and understanding how demanding studying engineering is.

- I enjoyed learning how to become a successful student, thus, becoming a successful engineer in the future.

- The huge project at the end. I learned a lot about myself.

- Learning what behaviors I need to change.

- This course allowed me to learn more about myself. The concepts of this course should be the first requirement of any college freshmen.

- Learning how to deal with distractions and negative behaviors and attitudes.

- I enjoyed how this course made me think about and develop what I need to do to graduate with the degree I am going for.

- The highlight of this course for me was learning about myself because the course gave me the perfect opportunity to realize my flaws and what I need to change.

- I enjoyed the entire course − it was nice to take a step back from the technical side of things and really focus on student success skills

Examples of what students responded to the question "Will the material presented in this course help you in staying on track to graduate with an engineering degree?" are presented below:

- I believe it will. I feel much more motivated and confident about my ability to complete my degree than before taking this class.

- Absolutely. The Material covered is exactly what I needed to understand in order to stay on track.

- Most definitely. Honestly, I feel more prepared going into the rest of my undergrad coursework because of this class. I also feel like I have been provided more information to ensure my academic success.

- It definitely helped with my organization and planning and setting goals.

- Yes, the final project definitely helped me plan out for my future and I can refer back to it later to keep track of how I'm progressing.

- Yes, many of the things recommended in the course to help people focus and succeed while studying engineering I have not thought of.

- Yes, it has helped me develop a system for studying and doing homework.

- Yes, I feel that it has helped strengthen my resolve on my path as an engineer.

- There were several assignments that will certainly be beneficial to me as a student - like the Semester Project. It is likely that I would not have made time for these beneficial activities if they had not been assigned.

- I wrote my final paper for the class in all honesty and I plan to use a lot of what I wrote to keep me on task.

- I believe it will, as I am more aware of what is holding me back.

- I believe this course would be a great course for anyone to take, regardless of whether or not they are in the engineering department. I learned so much about myself and it really helped me decide if what I am doing is what is right for me.

Limitations

This study does not identify which individual-level or institutional-level factors influence the size or duration of the positive effects observed, and a large prospective multi-institutional study is needed to identify these factors with the goal of ultimately tailoring or optimizing the DYP program to even better address the challenges present for certain populations or certain types of institutions.

Conclusions

The "Design Your Process to become a "World Class" Engineering Student" (DYP) program is a comprehensive intervention to guide first-year engineering students to develop their own process to become self-regulated and successful engineering students. The program has been implemented at over 30 institutions[18] and the first four-year longitudinal study about the impact of the DYP program has been presented in this paper.

The results show that the DYP program has a long term sustainable effect on student success based on the observed increase in overall GPA, persistence rates and graduation rate. The DYP cohort showed higher overall GPAs: +0.53 year one, +0.33 year two, +0.31 year three and +0.26 year four ($p<0.001$, except for year four where $p<0.005$, $N=156$ for DYP cohort at year one, $N=193$ for control cohort at year one). Students exposed to the DYP program showed higher persistence rates by 11% and 10% for the first and second year and a higher persistence rate by 16% for the third year compared to the control cohort. All increases in persistence are significant ($p<0.05$). Comparing how many students graduated with a Bachelor's degree in any engineering major after four years at the institution reveals that the cohort exposed to the DYP program had 24 students graduated after four years compared to 10 in the comparison cohort.

Future research is necessary to identify why and what aspects of the DYP program—related to sub-groups of first-year engineering students—lead to the improved student success. A multi-institutional study is recommended to identify these factors with the goal of ultimately tailoring or optimizing the DYP program to even better address the challenges present for certain populations or certain types of institutions.

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