Revisiting the Definition of Overpersistence

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***Abstract* — In this Full Research Paper, we propose a new definition of overpersistence in an engineering discipline and investigate its implications at one institution. Precisely defining overpersistence in both a conceptual and operational sense is a critical step in predicting overpersistence and identifying indicators that will allow for personalized guidance for students at risk of overpersisting. We have previously identified our population of interest as students who enroll at the institution as first-time-in-college students for at least one year, attend full time, have had six years to graduate, and have enrolled in only one degree-granting program. Within this group, we operationalized overpersistence by identifying students as overpersisters if they either (i) left the university without a degree or (ii) enrolled in the same major for six years and did not graduate. In this work, we revisit our definition of overpersistence using more recent data by reconsidering two groups of students in particular – those who spend only a short time in the discipline before leaving the institution (formerly classified as overpersisters), and those who spend a long time in the discipline but eventually switch majors (formerly excluded from the initial population). We conclude that the most appropriate definition of overpersistence at an institution with a first-year engineering program is when a student spends three or more semesters in their first discipline-specific major and does not graduate in that major within six years of matriculation to the institution. These results will be useful for researchers and practitioners seeking to identify alternative paths for success for students who are at risk of overpersisting in a major.**

Keywords—persistence, overpersistence, institutional data

I. Introduction

While persistence in a STEM major is generally encouraged, some students "overpersist" in their first major without making timely progress toward graduation. Our project is investigating this phenomenon at the engineering discipline level. Our goal is to recognize when students are "spinning their wheels" in a program and help them find a path with more traction. To find indicators of overpersistence, we start with historical data of students with known outcomes to decide who will be considered overpersisters. Identifying indicators of overpersistence will help provide more personalized guidance to future overpersisting students so that they may find a more strategic degree path. In this paper, we will explore changes to the operational definition of overpersistence to make it more congruent with our conceptual definition.

In addition to the benefits to individual students finding a degree program that can lead them to graduation, understanding, and ideally minimizing, overpersistence will be beneficial to departments and colleges of engineering as well. By helping students find degrees best suited for them, six-year graduation rates for the institution should improve. Additionally, understanding early indicators of overpersistence can help inform curriculum development, academic policy, and student support resources.

II. Literature Review

Persistence in engineering is well studied [1]–[7]. The literature indicates that eight-semester persistence in engineering exceeds the rates of persistence of all other groups of majors [2]. While a high rate of persistence is normally celebrated, some students who persist in a major are likely not making timely progress toward their degree. Therefore, it would likely be in the best interest of many of these students to switch from their current major to another major, inside or outside of engineering, to find a degree path that will lead them to success. Switching majors within engineering is not uncommon and is another topic that has been well documented [7]–[11]. Even students who are initially very confident in their major choice when they matriculate to the university often decide to switch their intended major a year into their studies [10].

A combination of factors likely increases the pressure on students to persist in their major when making a change earlier would lead to degree completion. A study by Matusovich, Streveler, and Miller [12] found that identity as an engineer is important for persistence. Additionally, many students cite proficiency in math and science as reasons they chose to major in engineering [13]–[15]. The literature also reports that students who ultimately do not persist in engineering are more likely to have studied engineering because of family influences [3]. And

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Seymour and Hewitt reported that many students who leave their STEM degrees are capable of completing them [16]. Therefore, being able to identify these students who are most at risk of not completing their degree and would be best served by switching majors are the priority of this project; by identifying these students earlier in their academic careers, they can be provided with additional academic support to find a major where they are more likely to be successful.

III. Prior Work

We have previously identified our population of interest as students who enrolled at the institution as first-time-in-college undergraduate students for at least one year, attended full time, have had six years to graduate, and have enrolled in only one degree-granting program. Within this group, we operationalized overpersistence by identifying students as overpersisters if they either (i) left the university without a degree or (ii) were enrolled in only one degree-granting major and did not graduate within six years of matriculation [17].

The definition described above was used in a 2017 work-in-progress paper in which we sought to explore a method for identifying indicators of overpersistence [17]. As we continued to refine our method for identifying indicators of overpersistence, questions arose about who should and should not be considered overpersisters. Through conversations with the research team as well as with the project evaluator, we decided it was best to revisit our definition of overpersistence before moving forward with identifying the indicators of overpersistence.

We identified two primary concerns with our existing operational definition. First is students who leave the institution early. For example, a student who leaves the institution after only one semester in the major would be classified as an overpersister which is inconsistent with our conceptual definition of spending too long in a major that is not working for them. Early departure is a concern, but conceptually different from the overpersistence issue we seek to address.

The second concern with our existing definition is students who persist in one major for many semesters before changing their major. For example, a student who studies in the same major for six years and then switches programs was not included in the initial population, due to the major change, and thus was not classified as an overpersister even though, conceptually, we believe the student should be. Late major changes would tend to indicate overpersistence in the first degree program.

IV. Research Question

Taking the abovementioned concerns into consideration, we have now conceptually defined overpersisters as those students who spend a significant amount of time in a major that they do not graduate from in a timely manner. In this paper, we will address the research question: How can overpersistence be redefined and operationalized to exclude students who leave the institution "early" and include students who switch majors "late"?

In our prior work, a student could only be considered an overpersister if the student never changed majors while at the institution. In this work though, this definition has been relaxed. To update our operationalization, we will now consider students who begin and end in different majors. Part of this work is determining how long a student must be enrolled in a major for there to be a reasonable expectation that the student will graduate in that major. This idea is similar to, but more restrictive than, the stickiness metric [7], [18]. Overpersistence is an individual phenomenon, whereas stickiness is a characteristic of a program or a group of students.

Prior to completing the analysis and viewing the results described below, the authors met to discuss the minimum time to be enrolled in a specific engineering major before which a student would likely switch majors due to lack of interest, fit, or satisfaction, among other reasons. The consensus hypothesis was that before three semesters in a specific engineering major, a student switching majors could be attributed to reasons other than overpersistence. In other words, a student who leaves after one or two semesters in a specific major could have been "trying it out" before switching to another major that the student considered more suitable. Because we only count Fall and Spring semesters, the third semester in a major would typically be the student's junior year, due to the first-year engineering program. The authors agreed that this time point is a reasonable threshold for considering students who do not graduate as overpersisters in historical data.

A literature search for other definitions of overpersistence was generally unsuccessful. There is at least one other study [19] that uses the term overpersistence in STEM disciplines which they define as "choosing STEM even when doing so is likely to lead to less academic and professional success." In their study, the authors investigate overpersistence as choosing math or verbal questions as well as retaking STEM and non-STEM courses previously failed. There is some similarity between our conceptual definition of overpersistence and the one presented in [19] especially regarding retaking STEM courses. However, they conclude that retaking courses may be beneficial for some students and not others, and thus may not be a clear indicator of overpersistence. In our work, we use timely degree completion as the determining factor of overpersistence.

V. Data and Methodology

Our work to update the definition of overpersistence utilizes institutional records from one large, public, research university in the southeastern United States. The institution is the same as our prior work in [17], however, the data are more recent (2006-2014 vs. 1987-1997). Students at the university who desire to major in engineering must complete a first-year engineering program (FYEP) prior to enrolling in their degree-granting major. The institutional records include each student's matriculation term, major for each term attended, and, if applicable, graduation term and major. Our quantitative analysis was conducted in the R programming environment [20].

While some inclusion criteria from our prior work were relaxed for this investigation, others were maintained. To be included in this population of interest, students were still required to be enrolled in an engineering major for at least one semester, to be undergraduate students, to enroll full-time as first-time-in-college students, and to have matriculated between Fall 2006 and Fall 2014, inclusive, to allow for a six-year graduation window. Transfer students were excluded because

TABLE I. DEMOGRAPHICS FOR STUDENTS EVER ENROLLED IN SIX ENGINEERING MAJORS

	Mechanical	Civil	Industrial	Electrical	Chemical	Computer
Students Ever Enrolled in Major	1,590	1,061	816	607	545	509
Male	1,425	855	523	514	386	451
Female	165	206	293	93	159	58
White	1,449	940	652	473	473	397
Black or African-American	46	57	87	76	20	58
Asian	35	24	36	34	29	29
Native Hawaiian or Other Pacific Islander	3	3	1	4	0	3
Other / Unknown	57	37	40	20	23	22

we have little information about their pre-transfer experiences where most academic major choices are made. The study was limited to full-time students (evaluated in the first semester) because part-time students have varying timelines to their degree. For this exploration, the criterion that students are only ever enrolled in one degree-granting major was removed as well as the restriction for a minimum time of enrollment.

For each student in the population, an attendance record was created. The attendance record cataloged each students' matriculation term, major for each fall and spring semester, and, if applicable, the graduation term and major. Additionally, this attendance record counted the number of fall and spring semesters each student was enrolled in each of six engineering majors – Chemical (CHE), Civil (CIV), Computer (CPE), Electrical (EE), Industrial (IE), and Mechanical (ME) – and the required FYEP.

Finally, the students in the sample were assigned an overpersistence status for each of the engineering majors that they were ever enrolled in. Students who graduated in the major within six years of matriculation were labeled "graduate." Students who graduated in the major more than six years after matriculation or did not graduate in the major were labeled "overpersist."

Then, in order to investigate the rates of overpersistence, we created subsamples of students who ever enrolled in each of the engineering majors. Because students could switch their engineering majors, some students are included in more than one subsample. The number of students who were ever enrolled in each of the majors studied as well as the gender and race of each major's students are shown in Table I.

VI. RESULTS AND DISCUSSION

A. Sample Size

We first explored the impact that the number of semesters a student was enrolled in a major had on the size of our population of interest (Fig. 1). To ensure that students who had successfully graduated in that major did not negatively impact the interpretation of this figure, any student that graduated in fewer

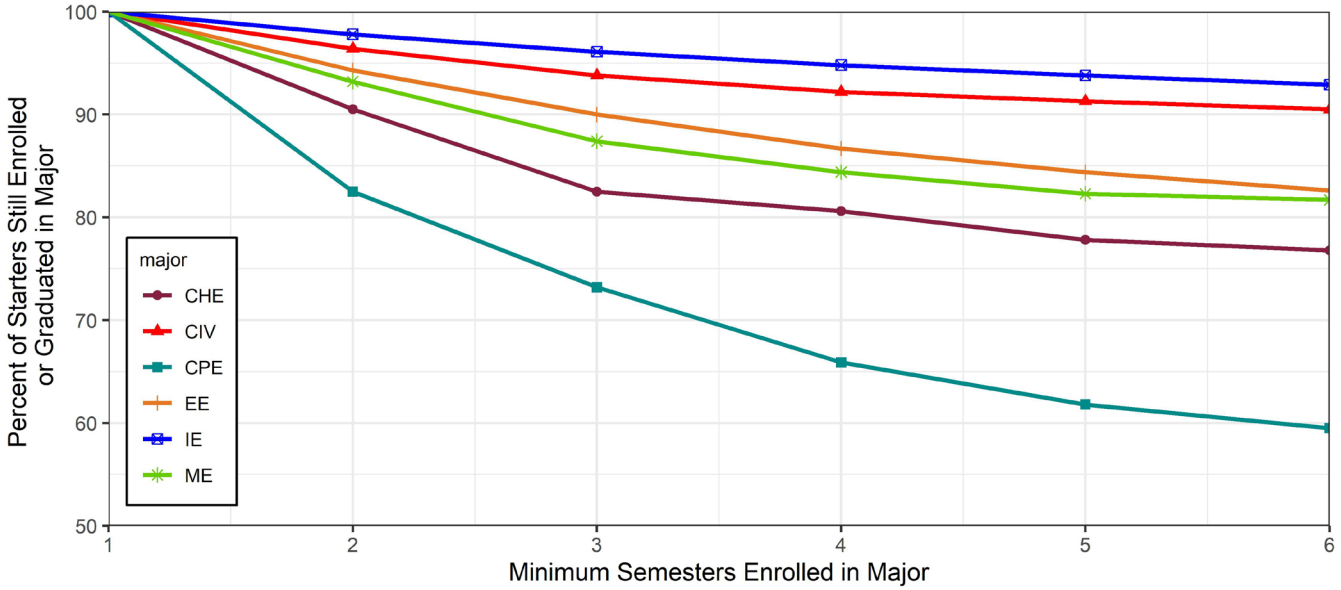

Fig. 1. The percentage of students still enrolled or graduated in a major after N semesters.

than 6 semesters continues to be included in the counts. Without these students, some majors, especially IE and CIV, appear to experience retention issues when in fact students are graduating early. Because this figure focuses exclusively on students who began their post-FYEP enrollment in the major plotted, all majors begin with 100% of students enrolled in the major. Because this plot is focused on retention of starters, the percentage of students enrolled can only decrease (except for a student who initially enrolls in the major, switches away, and then returns, but this scenario is exceedingly rare). As Fig. 1 shows, IE retains the largest percentage of its starters and CPE retains the lowest percentage of its starters of the six engineering majors studied.

While all six majors continue to experience some level of attrition throughout the six semesters plotted, the rate of attrition appears to decrease and "level out" at the third semester, except for CPE. By visual inspection, this is especially true of CHE. This begins to support our hypothesis of three semesters being required in an engineering major before a student can be considered an overpersister in that major.

B. Rate of Overpersistence

In order to compare the rate of overpersistence across different inclusion criteria, we created the graph shown in Fig. 2. The horizontal axis is the rate of overpersistence in the major and the vertical axis is the minimum number of semesters enrolled in that major. Colors indicate the different engineering majors and the shape indicates whether the rate presented is for students ever enrolled in the major or only students who started in that major. By definition, a student who started in a major was also ever enrolled in the major. As an example, students who start in Electrical Engineering and remain enrolled in the major for at least 3 semesters have a rate of overpersistence of 13.0%. Equation (1) shows the formula used to calculate the rate of overpersistence.

$$\text{rate of overpersistence} = \frac{\text{number who do not graduate in major within 6 years}}{\text{number of students in major and meet criteria}} * 100 \quad (1)$$

Comparing the minimum number of semesters required to be enrolled in order to be included in the sample of potential overpersisters, we can confirm that as the minimum length of enrollment is increased, the rate of overpersistence decreases. This is consistent with our hypothesis because if students who were only enrolled in a major for one or two semesters, who were likely just "trying the major out," are excluded, the percentage of students who graduate will increase.

If the minimum number of semesters enrolled in a major was selected to be only one or two semesters there is a trimodal split in the data – IE and CIV with the lowest rates of overpersistence; ME, EE, and CHE with the moderate rates of overpersistence; and CPE with the highest rate of overpersistence. When the minimum number of semesters a student must be enrolled in a major is increased to three semesters, we observe that the trimodal split collapses into a bimodal split with all majors grouped except CPE. While the magnitude of the gap between the two groups in the bimodal split does decrease with increasing time requirements, the rate of overpersistence in Computer Engineering is approximately double that of the next highest major at all time points. In other words, a greater minimum time of enrollment in the major after three semesters is not beneficial as a selection criterion. Exploring the impact of number of semesters enrolled in a major on retention rates as well as overpersistence rates indicate that our population criterion should be that students are enrolled in a major for a minimum of three semesters to be considered a potential overpersister.

This criterion addresses our research question to appropriately remove students who leave "early" (less than three semesters) and include students who switch majors "late" (after

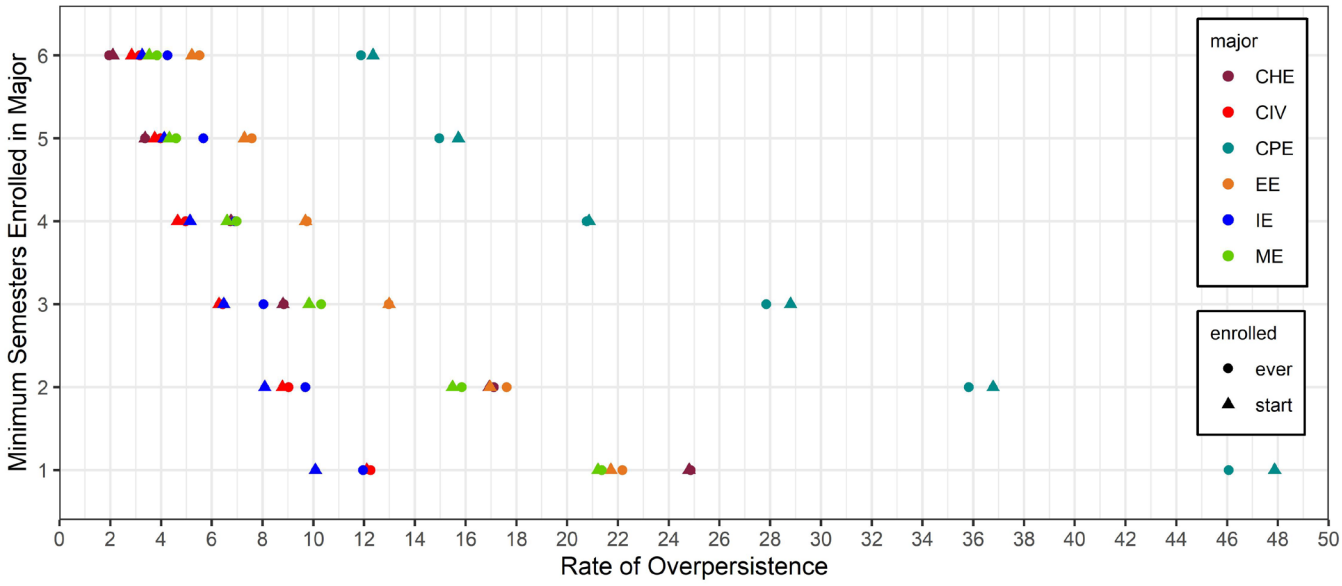

Fig. 2. The rate of overpersistence in six engineering majors as a function of time of enrollment in the major.

being enrolled in a major for three or more semesters). Students who leave a major without a degree after enrolling for three semesters or longer should be considered overpersisters. Many students leave after only one or two semesters in the major as seen in Fig. 1, and are now characterized as an "early departure". If a student is enrolled in a major for three semesters but later switches to another major, the student was not likely only "trying it out" but should be considered to have overpersisted in the major.

We can also note that students who are ever enrolled in a major generally have a similar rate of overpersistence as the students who started in those majors, regardless of the minimum number of semesters. However, despite being largely similar two patterns appear in the data. First, for CPE, students who start in the major generally have higher rates of overpersistence than students who are ever enrolled in the major. In other words, when you include students who switch to the major after enrolling in another major, the average rate of overpersistence for all students decreases slightly. Students who switch into CPE from another major are more likely to graduate within six years than those who selected it as their first major.

However, the opposite is true for students in IE where the rate of overpersistence for students who are ever enrolled in the major is higher than the rate of overpersistence when using only the students who started in the major. This means that a student who switches into IE is more likely to overpersist than a student who started in IE. Because overpersistence is determined based on whether or not a student graduated from the major within six years of matriculation, this difference in overpersistence in IE can likely be attributed to students switching to IE late in their academic careers and thus do not have sufficient time to graduate within six years of their matriculation. It is still possible that these students graduate within six years of their enrollment in IE, but that is the subject of future work. Further, it is also possible that students overpersist in a second engineering major, but our current investigation cannot make conclusions about that.

C. *Operationalization of Overpersistence*

Our results show that our conceptually-driven definition of a minimum threshold of three semesters in major is consistent with features of the empirical data. Compared to our previous operational definition, this allows us to include students who spend more than a year in the major before switching and exclude students who leave the major early, either by switching their major or leaving the institution (and hence do not overpersist). This more precise definition will help us identify characteristics unique to this phenomenon.

Because overpersistence considers whether or not a student has graduated in an engineering major within six years of matriculation to the institution, students who switch majors are at a higher likelihood of overpersistence in the second major because of a delayed start in the second major. Future work could include an adjusted timeline for students starting a second major, although the amount of time needed would be highly dependent on how many and which courses counted towards the new degree, and is beyond the scope of this paper. Therefore, we will restrict our samples of potential overpersisters to only include students who started in that major after completing the FYEP. This is consistent with our previous work.

Finally, we relaxed our requirement that students' final major must be the same as their first degree-granting major. Relaxing this criterion from our previous work allows us to include students who switch from a major, especially if the switch to another major comes many semesters after matriculation such that they could be considered an overpersister in the first major. Therefore, we will maintain the relaxation of this criteria and include students who switch from their initial degree-granting engineering majors to any other major. These students may still be excluded however if they are not enrolled in the engineering major for a sufficient number of semesters before making the switch to another major, whether inside or outside of engineering.

Enforcing these criteria excludes some students who are enrolled in each of the engineering majors. First, students who are enrolled in the major for only one or two semesters are excluded because we believe one academic year is a reasonable "trial" period. In our samples, between 56 and 225 students, depending on the major, do not meet this minimum enrollment threshold. These students do not fit with the conceptual definition of overpersistence and their exclusion is supported by the quantitative results presented. The number of students excluded in each major is presented in Table II.

The second and final inclusion criteria is that students' first degree-granting major must be in the major of interest. In other words, students who switch to the major after trying another engineering major are excluded. In our samples, between 49 and 221 students, depending on the major, do not meet this initial enrollment criterion. The number of students excluded in each major by criterion are presented in Table II. Note that in each major, between 19 and 36 students do not meet either criterion - they did not start in the major and they did not stay enrolled in the major for at least 3 semesters.

D. *Outcomes of Overpersistence*

Using our definition, students who do not graduate from their first degree-granting engineering major within six years of matriculation to the university are considered overpersisters if they spent at least three semesters in that major, were enrolled full-time during their first term, and were not a transfer student. While this is a binary classification at face value with the other

TABLE II. IMPACT OF INCLUSION / EXCULSION CRITERIA ON SAMPLE SIZE

	Students Ever Enrolled in Major	**Students Not Enrolled for ≥ 3 Sems.**	**Students Not Starting in the Major**	**Students Not Meeting Either Criteria**	**Students Included in Sample**
ME	1,590	225	100	36	1,301
CIV	1,061	85	127	26	875
IE	816	56	221	33	572
EE	607	76	119	27	439
CHE	545	106	49	19	409
CPE	509	140	87	27	309

option being to graduate within six years, as shown in Fig. 3a, students who overpersist can have three mutually exclusive outcomes. The outcomes for overpersisters are shown in Fig. 3b.

The first group of students (Fig. 3b; green) are those who change from their first degree-granting engineering major and graduate in any other major within six years; this category includes students switching to other engineering majors as well as majors outside of engineering. Because the institution being studied offers an FYEP, students who switch from their first degree-granting engineering major after three or four semesters can still graduate in a six-year time frame from any other engineering major following a traditional coursework schedule because each major only requires three years after the FYEP. Our goal is to help students most at risk of overpersistence consider making the switch earlier.

The second, smaller group of overpersisters (Fig. 3b; purple) are students who change from their first degree-granting major but do not graduate within six years of matriculation to the institution. This group is different from the first group at the surface, but may not be qualitatively different because both groups are overpersisters in their first majors. Just because these students have not graduated within six years of matriculation does not imply that they also overpersisted in a second major, only that they did not graduate within six years from matriculation. This could be due to spending many semesters overpersisting in their first major or switching to a major outside of engineering that required additional years of study which pushed the student beyond the six-year window. Like the previous group, our goal is to help these students make their decision to change majors earlier in their academic careers.

The last group of students (Fig. 3b; red) are those who have not changed their major and have not graduated within six years of matriculation. These students do not make timely progress toward their degrees and would likely benefit from additional major exploration. Some of these students could still graduate in their first major, but would be doing so more than six years after matriculation. Delays could be due to a stop-out in their education, additional terms on co-op that delay graduation more than the standard one year, or difficulty in particular courses that require students to repeat them. Some of these students may feel that they have already put too much into a particular program to change course [21] and effectively turn a blind eye to alternate degree paths that may have been a better fit for them. They may even get stuck in their first major if their GPA drops too low for them to be accepted into a different major. Our goal is to

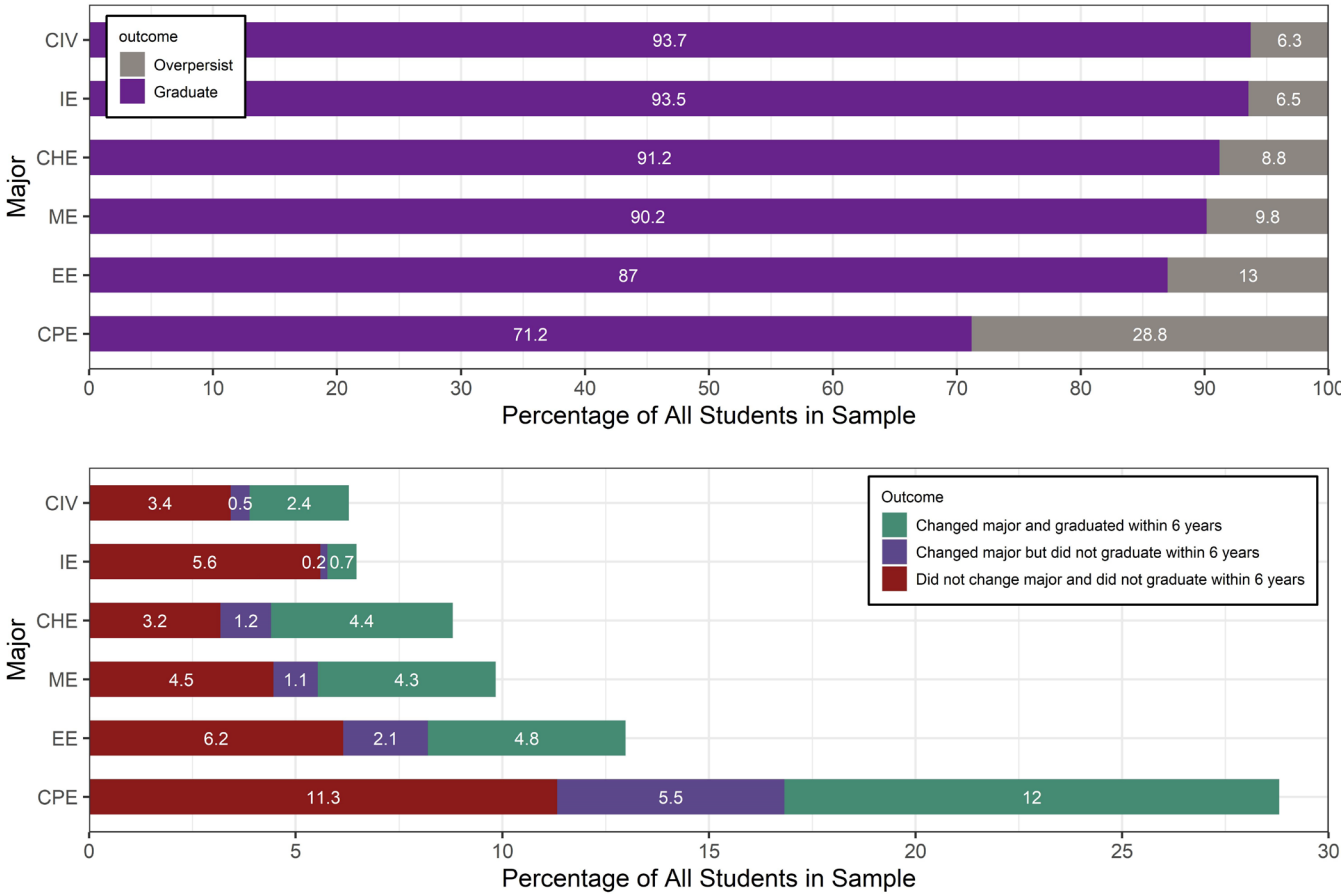

Fig. 3. (a; top) The rate of overpersistence for six engineering majors using inclusion criteria of (i) starting in the major and (ii) remaining enrolled for at least three semesters.

(b; bottom) The outcomes of overpersisters for six engineering majors; the sum of each bar in (b) is equal to the corresponding rate of overpersistence in (a).

identify these students early (especially those that are struggling with coursework) and provide the decision-making support that they need to make progress.

Students in CPE clearly have the highest rate of overpersistence. While we cannot say what causes CPE to have a considerably higher rate of overpersistence compared to the other majors, we can look at where those who leave CPE go. As seen in Fig. 3b, 16.8% of students (52 students) who start in CPE do not graduate in any major within six years of matriculation. These students could still be enrolled in CPE or another major or could have left the institution. 12% of students (37 students) do graduate in another major within 6 years. The most common majors for the students who switch and graduate are Electrical Engineering (16 students) and Computer Science (8 students); this is consistent with the literature which reports students switching between Computer and Electrical Engineering [22]. Three students also leave for each of Industrial Engineering and Mathematics. Other destinations for one or two students each are Computer Information Systems, Graphic Communications, Mechanical Engineering, Management, and Modern Languages.

VII. Conclusions

The research question we desired to answer in this paper considered how overpersistence could be redefined and operationalized to exclude students who leave the institution "early" and include students who switch majors "late." For an institution that offers an FYEP, we have concluded that a student should be classified as an overpersister in a major if they enrolled in their first degree-granting major for at least three semesters and then did not graduate in that major within six years of matriculation, assuming the student was first-time-in-college and enrolled full-time.

A student who does not meet the minimum threshold of three semesters in the major could be “trying the major out” or otherwise determine that the major is not a good fit for them and quickly switch to another major. They do not require interventions aimed at resolving overpersistence. Conversely, students who remain in a major for many semesters and then eventually switch majors are in need of interventions aimed at resolving overpersistence and should be identified. If a student is enrolled for three or more semesters, there is a fair assumption that the student has enough information to commit to graduate in that major. Therefore, if the student switches after more than three semesters enrolled, we classify the student as an overpersister in their first major.

We believe these results will be useful for researchers and practitioners seeking to identify alternative paths for success for students who are at risk of overpersisting in a major by providing them better support. Additionally, programs and institutions can use this definition to identify overpersisters and find common attributes among students that indicate overpersistence in their programs, which is the focus of our future work. After identifying these attributes, which could include lower grades in certain courses, programs and institutions could provide students with success strategies to proactively prevent overpersistence in the program. Advisors will also be able to use these indicators to help students at an individual level.

VIII. Future Work

The definition of overpersistence presented here will be used with institutional data to identify indicators of overpersistence using historical data. The indicators of overpersistence could include performance on standardized admission tests, performance in certain courses, or GPAs for certain semesters, among other things. With these indicators of overpersistence, we can begin to identify alternative pathways for success for these students using their recent peers’ paths. Because we know that some of the students who overpersisted in each of the engineering majors studied found a pathway to success, we will use their paths as a starting point to help develop models for future students to follow.

In the work presented, we do not distinguish whether a student leaves the major or the university voluntarily or involuntarily. Certain policies, including GPA requirements and course repeat limits may prohibit students from taking a path they want or force students off a path on which they would otherwise continue. Academic standing of overpersisters should be considered in future work.

References

[1] G. Lichtenstein *et al.*, “Should I Stay or Should I Go? Engineering Students’ Persistence is Based on Little Experience or Data,” in *Proceedings of the American Society for Engineering Education Annual Conference & Exposition*, 2007.

[2] M. W. Ohland, S. D. Sheppard, G. Lichtenstein, O. Eris, D. Chachra, and R. A. Layton, “Persistence, Engagement, and Migration in Engineering Programs,” *J. Eng. Educ.*, vol. 97, no. 3, pp. 259–278, 2008.

[3] O. Eris *et al.*, “Outcomes of a Longitudinal Administration of the Persistence in Engineering Survey,” *J. Eng. Educ.*, vol. 9, no. 4, pp. 371–395, 2010.

[4] E. Godfrey, T. Aubrey, and R. King, “Who Leaves and Who Stays? Retention and Attrition in Engineering Education,” *Eng. Educ.*, vol. 5, no. 2, pp. 26–40, 2010.

[5] M. K. Orr, C. E. Brawner, S. M. Lord, M. W. Ohland, R. A. Layton, and R. A. Long, “Engineering Matriculation Paths: Outcomes of Direct Matriculation, First-Year Engineering, and Post-General Education Models,” in *Proceedings of the IEEE Frontiers in Education Conference*, 2012.

[6] E. Seymour and A-B. Hunter, Eds. *Talking About Leaving Revisited: Persistence, Relocation, and Loss in Undergraduate STEM Education*. Cham, Switzerland: Springer, 2019.

[7] S. M. Lord, M. W. Ohland, R. A. Layton, and M. M. Camacho, “Beyond Pipeline and Pathways: Ecosystem Metrics,” *J. Eng. Educ.*, vol. 108, no. 1, pp. 32–56, 2019.

[8] G. Ricco, I. Ngambeki, R. A. Long, M. W. Ohland, and D. Evangelous, “Describing the Pathways of Students Continuing in and Leaving Engineering,” in *Proceedings of the American Society for Engineering Education Annual Conference & Exposition*, 2010.

[9] J. L. Paulson, R. L. Kajfez, and K. M. Kecskemety, “Examining Engineering Students’ Major Selection: Developing Baseline Quantitative Results to Investigate Major Selection and Change,” in *Proceedings of the IEEE Frontiers in Education Conference*, 2016.

[10] K. M. Ehlert, M. L. Rucks, B. A. Martin, and M. K. Orr, “Predictors of Matriculation in Intended Major in a First-Year Engineering Program,” in *Proceedings of the American Society for Engineering Education Annual Conference & Exposition*, 2019.

[11] M. K. Orr, C. E. Brawner, M. W. Ohland, and R. A. Layton, “The Effect of Required Introduction to Engineering Courses on Retention and Major Selection,” in *Proceedings of the American Society for Engineering Education Annual Conference & Exposition*, 2013.

[12] H. M. Matusovich, R. A. Streveler, and R. L. Miller, "Why Do Students Choose Engineering? A Qualitative, Longitudinal Investigation of Student's Motivational Values," *J. Eng. Educ.*, pp. 289–303, 2010.

[13] National Academy of Engineering, "Changing the Conversation: Messages for Improving Public Understanding of Engineering," National Academies Press, Washington, DC, 2008.

[14] T. T. Yuen, C. Saygin, H. Shipley, H.-D. Wan, and D. Akopian, "Factors that Influence Students to Major in Engineering," *Int. J. Eng. Educ.*, vol. 28, no. 4, pp. 932–938, 2012.

[15] J. C. McNeil, P. A. Miller, and J. J. Saleem, "Influential Factors on Selecting an Engineering Major in a First-Year Course," *J. Prof. Issues Eng. Educ. Pract.*, vol. 145, no. 2012, pp. 1–8, 2019.

[16] E. Seymour and N. M. Hewitt, *Talking About Leaving: Why Undergraduates Leave the Sciences*. Boulder, CO: Westview Press, 1997.

[17] M. K. Orr, R. K. Anderson, and M. L. Rucks, "Work in Progress: Developing a Procedure for Identifying Indicators of 'Overpersistence,'" in *Proceedings of the American Society for Engineering Education Annual Conference & Exposition*, 2017.

[18] M. W. Ohland, M. K. Orr, R. A. Layton, S. M. Lord, and R. A. Long, "Introducing 'Stickiness' as a Versatile Metric of Engineering Persistence," in *Proceedings of the IEEE Frontiers in Education Conference*, 2012.

[19] A. M. Penner and R. Willer, "Men's Overpersistence and the Gender Gap in Science and Mathematics," *Socius Sociol. Res. a Dyn. World*, vol. 5, pp. 1–17, 2019.

[20] R Core Team, "R: A Language and Environment for Statistical Computing." R Foundation for Statistical Computing, Vienna, Austria, 2020.

[21] C. E. Brawner, S. M. Lord, R. A. Layton, M. W. Ohland, and R. A. Long, "Factors Affecting Women's Persistence in Chemical Engineering," *Int. J. Eng. Educ.*, vol. 31, no. 6, pp. 1431–1447, 2015.

[22] S. M. Lord, R. A. Layton, and M. W. Ohland, "Multi-Institution Study of Student Demographics and Outcomes in Electrical and Computer Engineering in the USA," *IEEE Trans. Educ.*, vol. 58, no. 3, pp. 141–150, 2015.