The Effects of Nudges on Students' Use of the Diagnostic Assessment and Achievement of College Skills

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Abstract
The purpose of this study is to examine the effects of nudges on online college students' use of the Diagnostic Assessment and Achievement of College Skills (DAACS), a suite of free, online assessments, feedback, and resources designed to optimize student success in college. The results indicate that the nudges had an effect on students' completion of the DAACS and on accessing the feedback. The effectiveness varied by type of nudge and the order in which a series of nudges was sent. Simply sending the nudges did not have a direct effect on academic outcomes, but students who responded to one series of nudges were more successful than those who did not.

Keywords: nudges, college readiness, assessment, academic success

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Identifying and addressing the preparedness of newly enrolled college students is one of the most pressing issues in higher education today (Fay et al., 2017; Mokher et al., 2019; National Center for Public Policy and Higher Education & Southern Regional Education Board, 2010). Seventy-five percent of all high school seniors are unprepared for post-secondary coursework in mathematics, and 63% are unprepared for coursework in reading (National Assessment of Educational Progress, 2019). Over half of all 2019 high school graduates nationwide took the ACT. Of these, almost 40% failed to meet any of the four ACT College Readiness Benchmarks (ACT, 2019).

Unfortunately, traditional methods of bolstering college readiness skills have been shown to be ineffective, unnecessary for the majority of students, and associated with negative outcomes (Jaggars & Stacey, 2014). A different approach to enhancing college readiness is to offer newly enrolled college students the opportunity to assess their levels of readiness and apply feedback to become better prepared on their own. The Diagnostic Assessment and Achievement of College Skills (DAACS) system was developed with this purpose in mind (Vanderslice-Barr, 2020).

The Diagnostic Assessment and Achievement of College Skills, or DAACS, is a suite of open source, online assessments and supports (both technological and social) designed to help students prepare for the rigors of college (https://daacs.net/). Students use the DAACS website by taking four assessments, including mathematics, reading, writing, and self-regulated learning. They receive instant results on the assessments, along with individualized feedback and links to free online resources designed to help them fill in gaps in their knowledge and skills. Students who use the DAACS tend to have better academic outcomes than those who do not (Bryer et al., 2019), but not all students fully use it by reviewing their feedback and accessing related resources. In this paper, we report on the effectiveness of various behavioral nudges that encourage students to take the assessments and read the feedback.

What is the DAACS?

DAACS has four major components: (1) diagnostic assessments of students' readiness for college in terms of self-regulated learning (SRL), reading, writing, and mathematics; (2) instant, automated, customized feedback with recommendations and links to open educational resources (OERs) that help students address deficiencies; (3) information that enables academic advisors to help students address deficiencies identified by the assessments; and (4) predictive models that identify students at risk as well as the specific risk factors. The first three components are designed to directly influence student functioning, while the fourth is intended for institutional use. Taken together, the components align with the strategies recommended by the What Works Clearinghouse (WWC; Bailey et al., 2016) for supporting postsecondary students, with the exception of providing monetary incentives (Table 1).

Table 1

WWC Strategies for Postsecondary Students in Developmental Education, and DAACS Features

	WWC Strategy	Instantiation in DAACS
1	Use multiple measures to assess postsecondary readiness	Diagnostic assessments of students' SRL, reading, writing, and mathematics, followed by feedback, recommended strategies, and links to OERs
2	Require regular participation in enhanced advising activities	Access to DAACS dashboards and results by trained academic advisors
3	Offer students performance-based monetary incentives	Not applicable
4	Compress developmental education	Access to feedback, recommended strategies, and links to OERs enables students to engage in self-directed learning to prepare for college-level work
5	Teach students how to become self-regulated learners	SRL and writing assessments assess SRL, support students in making concrete improvement plans, and link to the online SRL Lab (https://srl.daacs.net)
6	Implement comprehensive, integrated, and long-lasting support programs.	Assessments of key soft skills such as SRL; integration into new student orientation and advising; freely available to students

The immediate feedback students receive upon completing the assessments and the related links to OERs are designed to promote self-directed learning. Consistent with the design intentions, findings from a randomized control trial at two institutions of higher education (n = 21,381) indicated that the DAACS is helpful to students who used the feedback and resources. Students who not only took the assessments but also clicked on the feedback (presumably to read it) were significantly more likely to complete their first six months of coursework on-time and were significantly more successful in earning credits than were the students who only took the assessments (Bryer et al., 2019). These results suggest that DAACS could be beneficial to those students who might not already be inclined to use it. In response, we developed nudges in the form of emailed encouragement for students to take advantage of the DAACS assessments, feedback, and resources.

DAACS Nudges

Nudge theory gained prominence after the publication of Thaler and Sunstein's book entitled *Nudge: Improving Decisions about Health, Wealth, and Happiness* (2008). According to their theory, which is grounded in behavioral economics, people make decisions based on trade-offs between costs and benefits. In the context of education, for example, making the decision to pursue a college degree involves a trade-off between costs (effort, time, and money) and benefits (future earnings). Nudges to take action can "alter people's behaviors in a predictable way without forbidding any options or significantly changing their economic incentives" (Thaler & Sunstein, 2008, p. 6), and break down barriers to success (Damgaard & Nielsen, 2018). Given the pressing need to help a large number of students navigate online learning without a commensurate increase in institutional resources, nudges provide an inexpensive way to encourage students to use tools that could be beneficial to them, such as the DAACS.

Taking the DAACS assessments and using the feedback and resources is a relatively small investment of effort and time that can result in substantial profit in terms of academic success (Bryer et al., 2019). If students are not aware of the benefits, however, they are unlikely

to invest the time. A nudge could encourage them to spend time on improving their academic skills and solidify their investment in their education. The goal of this study was to prompt (or nudge) students to complete the DAACS assessments and read their feedback. We did so by sending emails with personalized encouragements to students who either had not yet completed the DAACS assessments or had taken the assessments but not reviewed the feedback.

Theoretical Framework

Since the popularization of the concept, researchers have examined the effects of nudges on outcomes and behaviors in different domains, including education. The studies have a variety of foci, including setting default options, framing interventions, peer group manipulations, deadlines, goal-setting, reminders, social comparison, informational nudges, basic assistance, skill boosting, extrinsic motivation, social belonging, identity activation, and mindset (Damgaard & Nielsen, 2018). The nudges used in this study are most closely related to reminder, social comparison, and informational nudges, each of which are briefly reviewed next.

Reminder Nudges

Reminders are a type of nudge that prompts students to turn their attention to a particular problem or task, gives them easy access to information, and/or reminds them of the benefits of completing a task (Damgaard & Nielsen, 2018). Research has demonstrated the efficacy of reminder nudges for a variety of academic outcomes. In two separate experimental studies, Castleman and Page (2015, 2017) designed interventions to increase college enrollment for high school students by sending them text message reminders of the tasks they needed to complete before starting college. Both of these studies found a positive effect on college enrollment (3% and 7% increases, respectively), but for one of the studies (2015), this effect was limited to students who did not have as much access to support for college planning in high school and who were less prepared for college matriculation upon high school graduation than other students.

The effects of reminder nudges have also been demonstrated in the completion of financial aid applications, conference presentations, and course assignments. Castleman and Page (2016) found significant experimental effects of reminders sent to community college students to refile their financial aid applications (a 12% increase compared to control group students), especially for low-achieving students. Page et al. (2020) also found quasi-experimental evidence that personalized text messages sent to 7,500 high school students about their financial aid filing status was associated with increases in filing and college enrollment. Another experimental study using reminder nudges found that they increased the number of graduate students who submitted presentations to an academic conference (Unkovic et al., 2016). Across two experimental studies, Motz et al. (2021) found that sending reminders about upcoming assignment deadlines to students in online courses increased their on-time assignment submissions and grades.

The research on reminder nudges suggests that they can encourage students to take the steps necessary for enrolling in college. However, some studies on reminder nudges have produced null results (e.g., Bird et al., 2019; Dobronyia et al., 2019), and there is a lack of research on whether reminder nudges can increase students' engagement in behaviors that could help them improve their success while in college (see Motz et al., 2021, for an exception). To

test their effectiveness in the college context, all of the nudges designed for this project include a reminder component. For one set of nudges, the reminder is for students who have not yet completed the DAACS. For the other set of nudges, the reminder is for those who have completed the DAACS to return to the website to review their results and feedback.

Social Comparison Nudges

Social comparison nudges provide information about others' behavior or performance to change the nudged person's behavior or performance in the desirable direction. For example, Thaler and Sunstein (2008) described a study in which tax delinquent individuals in the United Kingdom were told that nine out of ten people pay their taxes on time, and the recipients of the nudge were among the few who had not yet done so. This resulted in a 15% increase in payment within 23 days. There has also been research on the effectiveness of social norms nudges in education. For example, applicants for Teach for America (TFA) who were admitted into the program were given information in their admissions letter about the high percentage of applicants who joined TFA, and were significantly more likely to join than a control group of students who were not given this information (Coffman et al., 2017). Another study by Eyinck et al. (2019) found that sending students in an Introductory Psychology class a message with a descriptive norm that provided information about what other students did was more effective for improving students' learning outcomes than sending them a message with an injunctive norm that provided information about what students should do.

Other studies test the effect of nudges that provide information about the performance of other students. These studies provide mixed evidence of effectiveness. For example, when nudges are provided in a way that compares students' performance to other students, some studies find a positive effect (e.g., Tran & Zeckhauser, 2012), while other studies find a negative effect (e.g., Azmat et al., 2019). Similarly, when students' performance as compared to other students is made public (e.g., posted online for other students to see, or being given an award for their grades), there is sometimes a positive effect (e.g., Tran & Zeckhauser, 2012) and sometimes a negative effect (e.g., Wagner & Riener, 2015). Damgaard and Nielsen (2018) suggest that relative performance feedback, rather than just social norm information, can have a de-motivating effect by subtly conveying to high-performing students that they do not have to try as hard and discouraging lower performing students from trying at all. They suggest that providing students with enough time to change their behavior in a productive way can make performance nudges work more effectively.

One study navigated the potential negative impact of relative performance feedback by providing information about the performance of students who exhibit certain behaviors to nudge those students toward more beneficial behaviors. In an experiment with over 24,000 students in a Massive Open Online Course (MOOC), Martinez (2013) sent an e-mail nudge about how students who procrastinate tend to perform worse than students who do not. This nudge was sent before the last quiz was due, rather than earlier in the course, which would have given students more time to change their behavior, as suggested by Damgaard and Nielsen (2018). Still, the nudged students were 17% more likely to complete the course than a control group.

We decided to test the effectiveness of two different types of social comparison nudges on students' completion of the DAACS (hereafter referred to as Completion Nudges). For both of these nudges, we used descriptive norms (i.e., describing what other students actually do), which Eyinck et al. (2019) found are more effective for improving students' learning outcomes than injunctive norms (i.e., describing what should be done). With one of the nudges, we used a simple social norms nudge similar to Coffman et al. (2017), in which we inform students that the majority of students have completed the DAACS, and that they are in the small minority of students who have not. The other nudge was designed to test the effect of providing information about performance in a manner similar to Martinez (2013), by informing students how much more successful are students who have completed the DAACS, and informing them that they are in the small minority of students who have not. As per Damgaard and Nielsen's (2018) suggestion, these nudges were sent soon after students enrolled in college, in order to provide enough time for them to take the DAACS and become better learners. This nudge has elements of a social comparison nudge, since it provides information about the benefits of DAACS on other students' performance, and also elements of an informational nudge, which is described next.

Informational Nudges

Informational nudges aim to improve outcomes by providing information about people's behavior and ability, or by encouraging them to overcome behavioral barriers that might impede their success (Damgaard & Nielsen, 2018). Studies have found positive effects of these types of nudges on a variety of academic outcomes. Some of these studies provide generic, non-personalized information to students. For example, providing information to students about plagiarism (Dee & Jacob, 2012), procrastination (Martinez, 2013), grit (Alan et al., 2019), and strategies for persisting in college (Bettinger & Baker, 2014) has been linked to improvements in those areas and relevant outcomes such as math performance (Alan et al., 2019) and college graduation (Bettinger & Baker, 2014). However, some studies have found very small or null effects of informational nudges on outcomes such as students' use of a website to find out more about a college in Michigan and their financial aid process (Hyman, 2019), and college enrollment by high school students (Gurantz et al., 2020).

Another study using a personalized informational nudge asked students in MOOCs to write about how they plan to complete the course and finish their assignments on time (Yeomans & Reich, 2017). This resulted in a 29% increase in course completion compared to control students. However, students who were immediately nudged to review what they wrote and adhere to their plan were not any more successful than students who simply responded to the prompt. DAACS uses a similar, personalized prompt for its diagnostic writing assessment, in which students are prompted to reflect on their self-regulated learning survey results and commit to using the strategies included in the feedback. For this study, we used nudges that encouraged them to review the feedback on their strengths and weaknesses in terms of self-regulated learning, as well as a nudge that encouraged them to review what they wrote about SRL for the writing assessment. We expected this nudge to be more effective than the one used by Yeomans and Reich (2017) for three reasons: (1) our writing assessment prompt had students write about their SRL survey results and feedback for improving their learning; (2) students were nudged

months after they wrote their essay for the writing assessment, as opposed to immediately after writing; (3) the nudge was included in a series of three nudges.

Design Principles and Research Questions

Yi (2019) recommended three design principles for nudges, each of which were considered in the creation of the DAACS nudges: Nudges should (1) serve as a connection between students and services that are available to them that they are not yet using; (2) address students' specific challenges and cognitive barriers; and (3) be brief and carefully timed, since the efficacy of nudges diminishes with exposure. In light of these design recommendations and the research on various types of nudges, as well as the purposes and features of DAACS, we created two types of nudges—Completion Nudges and informational Review-the-Feedback Nudges—with two or three variants each. The purpose of this study is to determine the effect of these nudges on students' use of DAACS and its feedback. Our investigation is guided by the following research questions:

1. Do Completion Nudges increase rates of completion of the DAACS assessments? If so, which type of nudge (social norms or performance) has the largest effect on completion?
2. Do students who had already completed the assessments login to the DAACS website when they receive a series of three informational Review-the-Feedback Nudges (strength, weakness, writing)? If so, which sequence of nudges has the greatest effect on the number of logins?
3. Do nudges have an effect on students' first-term course completion? If so, which nudges have the largest effect?
4. Of the students who received a nudge, is responding to it associated with an increase in first-term course completion? If so, which nudges have the strongest association?

Method

Participants

The study sample included incoming undergraduate students at Excelsior College, a private, nonprofit, online liberal arts college comprised of three schools (Undergraduate Studies, Graduate Studies, and Nursing) that offers over 40 programs in business health sciences, liberal arts, nursing, public service, and technology. Excelsior College serves predominately non-traditional, first-generation college students with an average age of 34. All newly enrolled students are given access to the DAACS as part of the college's online, asynchronous orientation. Although students are encouraged to complete the orientation, there are no consequences for not completing it. As a result, many students take the DAACS assessments, but many others do not.

Between April and December of 2019, 9,959 students enrolled at the institution. Two samples were selected from this pool of students for this study: Students who did not complete DAACS within three weeks of enrolling (n = 5,130) were selected to receive a Completion Nudge to complete the assessments. The second sample included students who completed DAACS (n = 1,302) and were to receive a series of Review-the-Feedback Nudges.

To comply with ethical standards, students who were less than 18 years of age were omitted from our sample, as were students who opted out of the study. Our final sample sizes for the Completion Nudges and Review-the-Feedback Nudges groups were n = 5,057 and n = 1,255, respectively. Demographics of the two samples are provided in Tables 2 and 3. Tests of equality between the treatment and control groups for both the Completion Nudges and Review-the-Feedback groups revealed trivial or no differences in demographic variables.

Table 2
Sample Demographics for Completion Nudges Group

		Control		Performance Nudge		Social Norms Nudge	
		(n)	(%)	(n)	(%)	(n)	(%)
Gender	Male	880	51%	934	55%	916	55%
	Female	845	49%	767	45%	753	45%
	NA	1	0%	0	0%	0	0%
Ethnicity	White	1094	63%	1073	63%	1032	62%
	Black or African American	277	16%	270	16%	267	16%
	Hispanic	220	13%	218	13%	219	13%
	Asian	54	3%	57	3%	50	3%
	Two or more races	57	3%	62	4%	67	4%
	American Indian or Alaska Native	11	1%	7	0%	7	0%
	Native Hawaiian or Other Pacific Islander	9	1%	10	1%	10	1%
	Unknown	4	0%	4	0%	17	1%
First Generation	No	922	53%	899	53%	880	53%
	Yes	390	23%	372	22%	375	22%
	NA	414	24%	430	25%	414	25%
Active Military	No	1112	64%	1066	63%	1062	64%
	Yes	614	36%	635	37%	607	36%

		Control		Performance Nudge		Social Norms Nudge	
		(n)	(%)	(n)	(%)	(n)	(%)
Income	≥ 120,000	152	9%	135	8%	139	8%
	< 100,000	100	6%	85	5%	106	6%
	< 120,000	96	6%	103	6%	78	5%
	< 25,000	154	9%	158	9%	155	9%
	< 35,000	149	9%	152	9%	150	9%
	< 45,000	165	10%	156	9%	152	9%
	< 55,000	184	11%	173	10%	154	9%
	< 70,000	180	10%	194	11%	174	10%
	< 85,000	148	9%	137	8%	172	10%
	NA	398	23%	408	24%	389	23%

Table 3
Sample Demographics for Review-the-Feedback Group

		Control		St.We.Wr.		We.Wr.St.		Wr.St.We.	
		(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Gender	Female	110	38%	128	41%	135	40%	128	38%
	Male	182	62%	186	59%	201	60%	210	62%
Ethnicity	White	188	64%	198	63%	213	63%	220	65%
	Black or African American	49	17%	33	11%	43	13%	36	11%
	Hispanic	33	11%	50	16%	51	15%	54	16%
	Two or more races	9	3%	13	4%	19	6%	11	3%
	Asian	6	2%	12	4%	5	1%	12	4%
	American Indian or Alaska Native	2	1%	5	2%	1	0%	1	0%
	Native Hawaiian or Other Pacific Islander	2	1%	1	0%	2	1%	3	1%
	Unknown	3	1%	2	1%	2	1%	1	0%
First Generation	No	113	39%	112	36%	137	41%	134	40%
	Yes	45	15%	59	19%	46	14%	67	20%
	NA	134	46%	143	46%	153	46%	137	41%
Active Military	No	161	55%	172	55%	188	56%	199	59%
	Yes	131	45%	142	45%	148	44%	139	41%
Income	≥120,000	12	4%	22	7%	15	4%	23	7%
	< 100,000	12	4%	14	4%	14	4%	20	6%
	< 120,000	18	6%	13	4%	14	4%	19	6%
	< 25,000	19	7%	11	4%	14	4%	16	5%
	< 35,000	19	7%	18	6%	15	4%	16	5%
	< 45,000	13	4%	24	8%	23	7%	20	6%

	Control		St.We.Wr.		We.Wr.St.		Wr.St.We.	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
< 55,000	24	8%	20	6%	28	8%	25	7%
< 70,000	30	10%	32	10%	39	12%	32	9%
< 85,000	19	7%	22	7%	25	7%	32	9%
NA	126	43%	138	44%	149	44%	135	40%

Note. St = Strength Nudge; We = Weakness Nudge; Wr = Writing Nudge.

Design and Procedures

Two randomized controlled trials were conducted concurrently to examine the effects of two Completion Nudges and three Review-the-Feedback Nudges, sent to students via e-mail. As described above and in Table 4, Completion Nudges were designed to deliver a social norm or a performance nudge to students who had not completed any of the DAACS assessments within three weeks of initially being enrolled in the orientation course. As an open enrollment institution, new students were added to this study on a weekly basis. Each week, new students were randomly assigned with equal probability to one of three conditions: (1) a control group that did not receive any email nudges (n = 1,725), (2) a treatment group that received a Performance Nudge (n = 1,686), or (3) a treatment group that received a Social Norms Nudge (n = 1,646). There is no attrition from the study because once students were assigned to a group, their outcomes were observed.

Table 4

Description and Content of DAACS Nudges

Nudge Type	Description	Full Text of Nudge
Completion Nudges for Students to Complete the DAACS Assessments		
Social Norms Nudge	Uses social norms to encourage students to complete the DAACS assessments.	*"Over 80% of college students at participating universities have completed the DAACS. You are currently in the small minority of people who have not yet completed it. Please consider completing the DAACS, after which you will be given results and helpful feedback on how to become an efficient, successful learner."*
Performance Nudge	Uses the likelihood of improved performance to encourage students to complete the DAACS assessments.	*"College students who use the DAACS are 1.5 times more successful than those who have not. You are currently in the small minority of people who have not yet completed it. Complete the DAACS now to learn about your strengths and weaknesses*

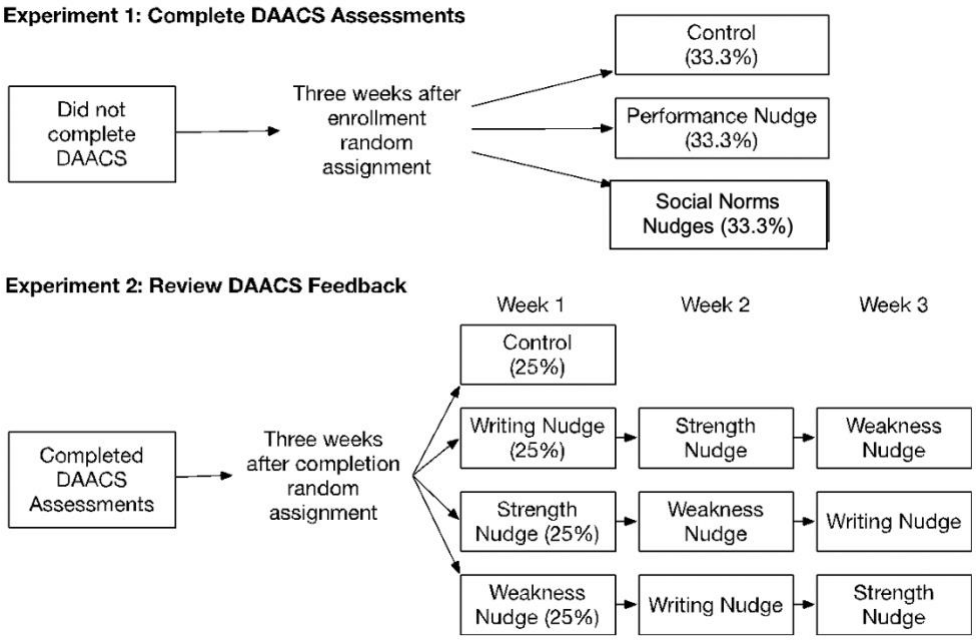
Nudge Type	Description	Full Text of Nudge
		and discover ways to become a better learner."
Informational Review-the-Feedback Nudges for Students Who Already Completed DAACS		
Writing Nudge	Asks students about how well they are following through on what they committed to regarding improving their SRL in their essays for the DAACS writing assessment. Includes a link to their essay so they can remind themselves of what they said they would do.	*"You recently completed the DAACS writing assessment, in which you committed to improving your self-regulated learning. If you have followed through on the strategies you committed to using in your essay, bravo! If you have not, click here to reread your essay to remind yourself of the strategies you committed to using. Click here to review strategies related to becoming a self-regulated learner."*
Strength Nudge	Encourages students to keep up the good work on a sub-domain they scored high on, and directs them toward strategies to continue to improve or in case they find themselves slipping in regards to that sub-domain.	*"You recently completed the DAACS self-regulated learning survey, and were given results and feedback on your individual strengths and weaknesses. Your results indicated that you scored high on [a scale, e.g., motivation, strategies, metacognition]. Congratulations—this is an important asset that will help you as you continue your studies. If you'd like to read more about [the scale], or if your skills in this area have slipped since you first took the survey, click here."*
Weakness Nudge	Encourages students to review feedback on a subscale on which they scored poorly, and directs them toward strategies to continue to improve in regards to that scale.	*"You recently completed the DAACS self-regulated learning survey and were given feedback about areas in which you could improve. Your results for planning indicate that you will perform better in college if you try new strategies. Click here to learn about strategies for [a subscale]."*

Review-the-Feedback Nudges were designed for students who had already completed the DAACS SRL and writing assessments to encourage them to review their feedback.

These students were randomly assigned to either the control group (n = 292) or one of three treatment groups that received a different sequence of three nudge messages: (1)Strength.Weakness.Writing Nudge (n = 307), Weakness.Writing.Strength Nudge (n = 329), and Writing.Strength.Weakness Nudge (n = 327). These three nudges were sent to students over the span of three consecutive weeks. Figure 1 provides an illustration of the design and Table 4 contains the full text of the nudges.

Figure 1

DAACS-nudges Research Design



Data Sources

Behavioral and academic outcomes were collected to address our research questions.

Behavioral Outcomes

Students' completion of the DAACS assessments and their opening of the feedback and OERs were used as behavioral indicators before and after they received nudges. For the Completion Nudges group, students who completed the DAACS self-regulated learning and writing assessments within 14 days of when they received the nudge were considered to have responded to the nudge; those who completed the DAACS assessments after 14 days, or never completed the assessments, were considered to have been nonresponsive.

Students in the Review-the-Feedback Nudges group received a series of three nudges. Students who logged in to view the DAACS results and resources within four weeks of receiving the first nudge (one week after the third nudge was sent) were considered to have responded to the nudge; those who logged in later or did not log in at all were considered to have been nonresponsive.

Academic Outcomes

First semester course completion was the dichotomous indicator of the academic outcome. That is, students who successfully completed at least three credits by the end of their first semester were deemed successful; students who did not were deemed unsuccessful.

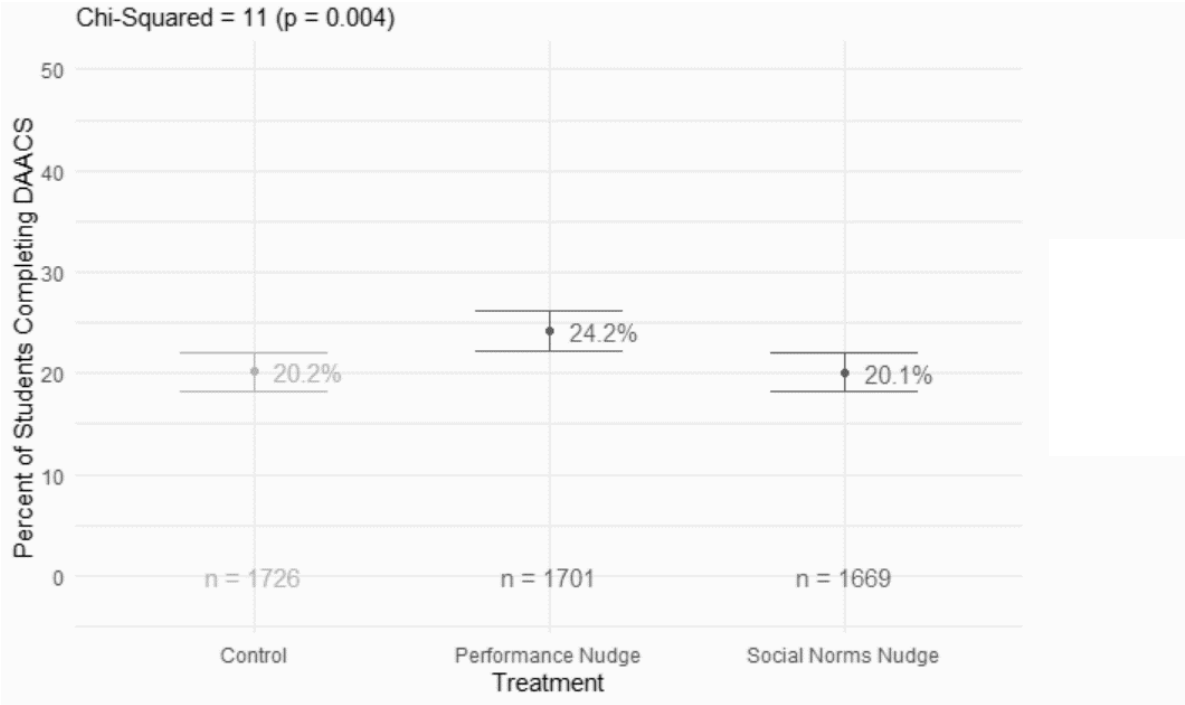
Results

Research Question 1: Do Completion Nudges increase rates of completion of the DAACS assessments? If so, which type of nudge (social norms or performance) has the largest effect on completion?

A chi-square goodness-of-fit was performed on the Completion Nudges group to determine whether the two treatment and control groups resulted in equal completion of DAACS. Completion of DAACS among the three conditions was not equally distributed, X^2 (2, N = 5,096) = 10.999, p < .01. Post-hoc analysis of between group differences revealed that the Performance Completion Nudge resulted in a significantly higher completion rate than the Social Norms Completion Nudge and the control group. There were no significant differences between the Social Norms Completion Nudge and the control group (Figure 2).

Figure 2

DAACS Completion for Completion Nudges Groups

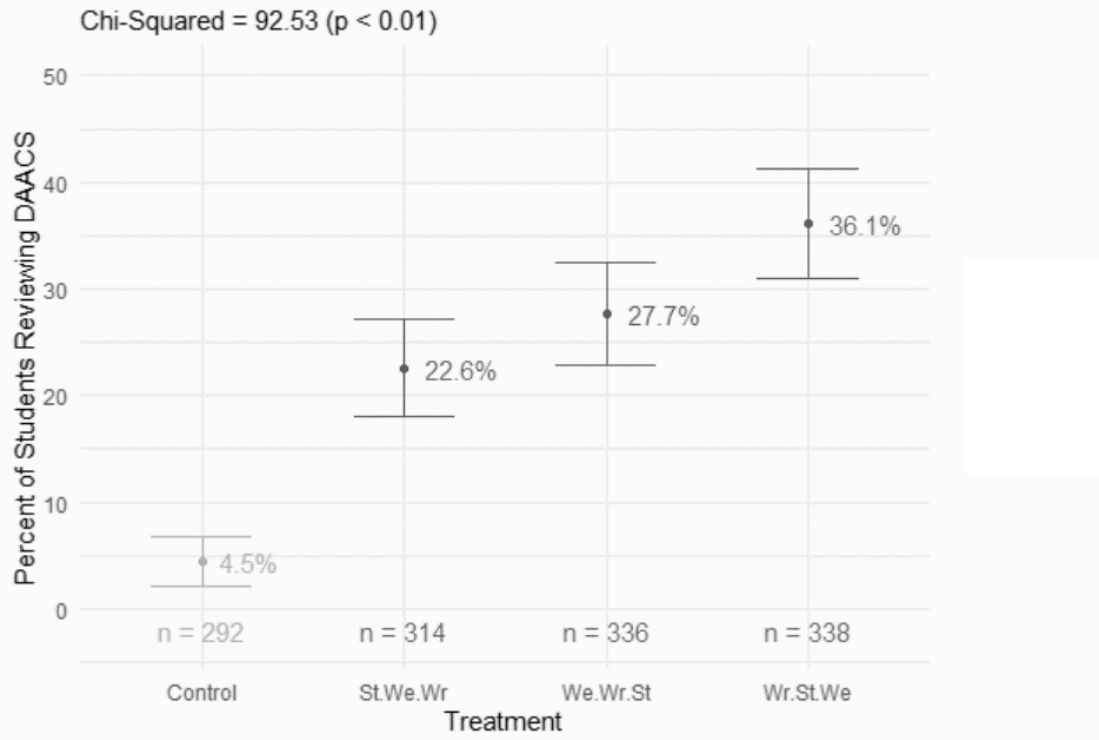


Research Question 2: Do students who had already completed the assessments login to the DAACS website when they receive a series of three informational Review-the-Feedback Nudges (strength, weakness, writing)? If so, which sequence of nudges has the greatest effect on the number of logins?

A chi-square goodness-of-fit was performed to determine whether the three treatment and control groups resulted in equal percentage of students reviewing their DAACS feedback. The

percentage was not equally distributed across the four groups, X^2 (3, N = 1,280) = 92.53, p < .001. Post-hoc analysis indicated that the Writing.Strength.Weakness series of nudges (36.1% reviewed the feedback) and Weakness.Writing.Strength series of nudges (27.7% reviewed) outperformed Strength.Weakness.Writing. (22.6% reviewed) series, as well as the control group (4.5% reviewed; Figure 3).

Figure 3
DAACS Feedback Reviewed for Review-the-Feedback Nudge Groups



Note. St.We.Wr. = Strength.Weakness.Writing; We.Wr.St = Weakness.Writing.Strength; Wr.St.We. = Writing.Strength.Weakness

Research Question 3: Do nudges have an effect on students' first-term course completion? If so, which nudges have the largest effect?

DAACS Completion Nudge Group. A chi-square goodness-of-fit was performed to determine whether students' behavioral response to a Completion Nudge increases their first term course completion. The percentage was equally distributed across the three groups, with 51.4% of the Control group (n = 888), 54.0% of the Performance Nudge group (n = 919), and

52.9% of the Social Norms Nudge group (n = 883) completing their first term course, X^2 (2, N = 5096) = 2.29, p = .32. Although there are slight differences in the percentages of students who successfully completed three credits during their first semester, students who received a Completion Nudges are statistically comparable to the students who did not.

Review-the-Feedback Nudge Group. A chi-square goodness-of-fit was performed to determine whether students' behavioral response to the Review-the-Feedback Nudges increases their first term course completion. The percentage was equally distributed across the four groups, with 53.8% of the Control group (n = 157), 49.0% of the Strength.Weakness.Writing Nudges group (n = 154), 49.4% of the Weakness.Writing.Strength Nudges group (n = 166), and 53.6% of the Writing.Strength.Weakness Nudges group (n = 181) successfully completing three credits during their first semester, X^2 (2, N = 1,280) = 2.51, p = .47. That is, the course completion of students who received the Review-the-Feedback Nudges is comparable to students who did not.

Research Question 4: Of the students who received a nudge, is responding to it associated with an increase in first term course completion? If so, which nudges have the strongest association?

Completion Nudge Group. A chi-square goodness-of-fit was performed to determine whether students' behavioral response to the Completion Nudge was associated with an increase in their first term course completion. The percentage was not equally distributed across the two groups, with 69.3% of the Responded-to-Nudge group, and 49.0% of the Did-Not-Respond-to-Nudge group completing their first term course completion, X^2 (1, N = 3,370) = 95.70, p < .001. That is, students who completed the DAACS assessments in response to the nudge were more likely to earn three credits during their first semester than students who did not. Furthermore, the group of students who responded to the performance nudge had slightly more success with first term course completion (72.2%) as compared to the group of students who responded to the social norms nudge (65.7%), and this difference approached statistical significance X^2 (1, N = 746) = 3.466, p = 0.06.

Review-the-Feedback Nudge Group. A chi-square goodness-of-fit was performed to determine whether students' behavioral response to the Review-the-Feedback Nudge was associated with an increase in their first term course completion. The percentage was equally distributed across the two groups, with 53.1% of the Responded-to-Nudge group, and 49.7% of the Did-Not-Respond-to-Nudge group completing a first term course, X^2 (1, N = 988) = .83, p = .364. This means that the course completion rates of students who responded to the Review-the-Feedback Nudge by accessing their DAACS feedback is comparable to the students who did not.

Discussion

The purpose of this study was to examine the effects of nudges on a sample of largely non-traditional, online students' use of the DAACS assessments and feedback, and on their first semester course completion. The results indicate that some nudges had an effect on students' completion of the DAACS assessments and accessing the feedback. We sent two different nudges to students who had not yet completed the DAACS. The Social Norms nudge informed

students of the high percentage of students who have completed the DAACS, and the Performance nudge informed students of the success previous students have had after using DAACS. Both nudges included a statement that the student was "in the small minority" of students who had not yet completed the DAACS. The Performance nudge had a positive effect on students' completion of the DAACS compared to a control group, while the Social Norms nudge did not.

This finding is consistent with the literature on reminder nudges, which suggests that reminding students to complete a task can have a positive effect on a variety of outcomes (Castleman & Page, 2015, 2016, 2017; Unkovic et al., 2016). The finding that the Performance Nudge outperformed the Social Norms Nudge is not surprising, given the mixed evidence in the literature of effectiveness of social comparison nudges. While both nudges pointed out that a student was "in the small minority," the Performance Nudge also provided motivational information ("students who use the DAACS are 1.5 times more successful than those who have not"). As a result, it might have behaved more like an informational nudge than a social comparison nudge.

The results of this study also suggest that nudges that encourage students to review the DAACS feedback increase the rate of logging in to view the feedback. We tested three nudges that served as reminder and informational nudges, randomizing the order in which these nudges were sent. Although the Review-the-Feedback nudges increased students' viewing of feedback in any order, the most effective order was the one that began with the writing nudge, which encouraged students to review the brief essay they wrote for the writing assessment about their SRL survey results and plans for becoming more self-regulated. This finding is consistent with the literature on informational nudges, which demonstrates that giving students information about their behavior and ability or how to overcome behavioral barriers has a positive effect on academic outcomes (Damgaard & Nielsen, 2018). We speculate that the series of nudges that began by encouraging students to review their own essays was most effective because it was inherently personal: the vast majority of students wrote earnest essays about their plans to become better self-regulated learners (Akhmedjanova et al., 2019), which suggests that they might have found a reminder to reread what they wrote particularly motivating.

Finally, we tested whether any of the nudges influenced an academic outcome, namely first-term course completion. We found that none of the nudges resulted in significantly different outcomes than the control groups. Thus, although the nudges had an effect on immediate behaviors (completing the DAACS, clicking on the feedback), they did not have an effect on a complex, relatively long-term academic outcome. Although feedback has a well-established influence on learning (Lipnevich & Smith, 2018), it is clear from these findings and the nudges literature that people can be compelled to engage in a discrete behavior through nudges but changing a chain of behaviors over long periods of time to increase performance is difficult.

However, there were significant differences in first-term course completion between students who were sent a Completion Nudge and responded to that nudge and students who did not respond. While we cannot determine causality from this finding, since we had no control

over who responded to the nudge, this finding implies that the DAACS can be beneficial to those who use it. It might seem obvious that students who seek out resources to improve their college success will be more successful, whether the intervention is effective or not. However, in this study students who were sent Completion Nudges were those who had not completed the DAACS when first asked to do so, so this finding cannot be explained simply in terms of compliance or motivation. We speculate that the Completion Nudges did what nudges do best: remind people to do something beneficial that they have put off.

Interestingly, students who received and responded to the performance nudge were more likely to be successful than students who received and responded to the social norms nudge. Although this difference was only marginally significant, it is consistent with our other finding that the performance nudge was more effective at getting students to complete the DAACS than the social norms nudge. Again, the promise of improved performance provoked more of the desired response than did social comparison.

There are a few limitations to this study. First, our sample consisted only of students from one online college, most of whom were nontraditional in terms of age and number of transfer credits. Thus, the findings from this study are not generalizable to traditional students in traditional educational institutions. Second, although we found significant effects of a series of nudges that encourage students to review their feedback, we cannot determine which of the three individual nudges (writing, strengths, weaknesses) was most effective, since they were all sent to all treatment students at some point. The reasoning behind sending all three nudges was that we were primarily concerned with increasing students' use of the DAACS in a way that would maximize its effectiveness. This reasoning worked, as the nudges did have an effect on how frequently students accessed the DAACS feedback, and we were able to determine which ordering of the nudges was most effective. However, future research should isolate these three nudges to determine their relative effectiveness.

Another limitation of this study is the outcome used to measure academic performance. Since Excelsior College utilizes a pass/fail system, we were only able to operationalize academic performance as whether or not students successfully completed at least three credits by the end of their first semester. Thus, the outcome measure we used might have operated as a measure of persistence rather than of performance. Since the nudges were aimed at increasing students' performance, rather than their persistence, future research should investigate the effects of nudges on more traditional measures of academic performance, such as grades or GPA.

We also acknowledge the criticism made by Hertwig and Grüne-Yanoff (2017) that nudges are paternalistic. While we acknowledge that nudges can be perceived as coercive and undermining autonomy, we argue that the nudges employed for the DAACS encourage students to make choices for themselves that can increase their chances of success without restricting their autonomy. All of the nudges, and the DAACS itself, encourage students to regulate their own learning, and thus are more aligned with what Hertwig and Grüne-Yanoff (2017) call educative nudges or "boosts", which "seek to foster people's cognitive and motivational competences" (p.

981), rather than non-educative nudges, which simply aim to change people's behavior without a corresponding improvement in skills or competencies.

The use of nudges has increased in popularity over the last several years because they offer a cost-effective way of encouraging individuals to engage in specific behaviors. Results from this study contribute to this body of research by investigating the efficacy of a variety of new nudges created specifically for online learning and DAACS, and which aim to use aspects of nudges that have worked in previous research while avoiding or improving on aspects which have not worked. That is, we found that nudges are effective in prompting students to engage in specific academic activities, while also revealing that not all nudges perform equally. Nudges that combined features of reminder, social comparison, and informational nudges were more effective than nudges that only provided information about social norms. In addition, students who were nudged to review their academic strengths, weaknesses, and the SRL strategies they planned to use were more likely to do so than students who did not receive these nudges. These effects varied based on the order in which the nudges were sent, with the suggestion to review a self-authored essay about self-regulated learning being the most effective lead nudge.

When designing an educational tool for online students, having faith that "if you build it, they will come" might not result in students using the tool to its full advantage. Although previous research has demonstrated the benefits of using the DAACS on students' college success (Bryer et al., 2019), many students choose not to use it, perhaps because they do not see it as worthy of their time. Some students likely made a rational decision not to use it, as their DAACS results indicated that they were well prepared for college. For the majority of students, however, the DAACS identified gaps in their knowledge and skills that needed to be addressed. This study shows that students can be prompted to take the DAACS assessments and access the related feedback by sending low-cost, automated, and personalized nudges via email. To abuse an old adage, our next step is to determine how to not only get the horse to water and make it drink, but also to make it absorb that water in a way that makes it useful. That is the work of instructional design, and perhaps beyond the scope of a nudge.

Declarations

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

The authors assert that approval was obtained from an ethics review board (IRB) at Excelsior College, 7 Columbia Circle, Albany, NY 12203, USA.

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