

Factors impacting completion of pre-class assignments in Physics, Math, and Behavioural Sciences

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Abstract: Pre-class assignments are effective at increasing student learning, but only if the students complete them. This project investigated the impact of the number of points assigned and the instructor use of the responses on students' completion rates, motivation to complete the assignments, and perceived value of the assignments. Participants were primarily freshmen students enrolled in several sections of core courses in Physics, Math, and Behavioural Sciences. While points showed a significant influence on completion rates overall, good instructor use with fewer points could match completion rates when a large number of points was allotted. Instructor use also significantly impacted the value students indicated for the assignments as well as their level of motivation to complete them.

Key words: JiTT Pre-class Assignments Motivation

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Introduction

Instructors across several departments at the US Air Force Academy use pre-class assignments to help students prepare for class with the goal of using class time more effectively. Pre-class activity is in contrast to traditional homework problems, which are assigned after the material has been covered in class and serve to reinforce the material already learned. Pre-class assignments are a core component to the Just-in-time-teaching (JiTT) approach (Novak and Patterson, 1998). More specifically, when JiTT is used, the students turn in their pre-class work (also called pre-flights) prior to class using an electronic submission process. Instructors read the responses before class in order to learn which concepts students already understand well and which concepts might need additional attention. Student responses can also be used to tailor class via more focused discussions, illustrating different perspectives, or dealing with misconceptions. The use of the pre-flight process has been extensively studied and shown to be effective when the pre-class activities are closely linked to learning objectives and incorporated in a meaningful way into the classroom activities (eg Cookman, Mandel, & Lyons, 1999; Simkins & Maier, 2004). Pre-class assignments also encourage students to continuously interact with the material rather than simply reviewing before an exam, which should enhance learning.

However, the benefits of pre-class assignments are realized only if students actually complete the assignments. Completion rates have been reported to be influenced by the points awarded to the assignments (eg Simkins & Maier, 2004). The three departments involved in this study (Math, Physics, Behavioural Sciences) allotted different amounts of points to the pre-class

assignments. However, we believed that other factors may also influence completion rates. For example, even with 40% of the grade dedicated to pre-class assignments, Cookman, et al. (1999) found that there was an upper limit to the amount of effort that the students were willing to put into the assignments. Explaining the JiTT process and its benefits also impacts student attitudes toward the pre-class assignments (Camp, Middendorf & Sullivan 2010).

In order to better understand the variety of factors that might influence student completion of the pre-class assignments, we reviewed several theories of motivation. Two useful sources that summarize several motivational theories with respect to student learning behaviours are *McKeachie's Teaching Tips* with Marilla Svinicki (Ch 11), and Svinicki's book *Learning and Motivation in the Postsecondary Classroom*. We specifically considered how different course factors under an instructor's control might influence student motivation and perceptions of the pre-class assignments.

One widely familiar motivational theory proposes that motivational factors are intrinsic or extrinsic. That is, motivation can be influenced by internal value given to the goal as well as by external rewards. The use of points and course grades are most often categorized as extrinsic motivators. For practical reasons, students care about points, because points impact grades, and grades impact graduation, graduate school admissions, and future job opportunities. Intrinsic motivation is often deemed to be under the student's control, and largely based on interests and experiences a student brings to the course. Students can show a mixture of both intrinsic and extrinsic motivations for a single course.

A second, widely researched approach to understanding student motivation is the achievement goal theory. Three goal types observed in students are learning-oriented, performance-oriented, and work-avoidance. Learning and performance goal-oriented students have different characteristics (Seifert, 2004). Learning-oriented students tend to believe that intelligence is malleable, challenges represent opportunities to increase knowledge, effort is linked to success, and they generally show more positive affect while learning new tasks. In contrast, performance-oriented students are concerned about appearing incompetent, believe that intelligence is fixed, and show more task avoidance for challenging tasks. Failure tends to lead learning-oriented students to try new strategies but cause performance-oriented students to dislike and avoid the tasks. Work-avoidance students have similarities with performance-oriented students in that they tend to avoid challenging tasks and may feel less competent to complete the task; however, an additional characteristic is that they perceive the task as having little meaning (Seifert, 2004).

We believed that there would be several factors under an instructor's control that might moderate how students of various goal orientations perceive pre-class assignments. To start, instructors control how the pre-class assignments are presented to the students. In other words, on the syllabus and during class sessions, instructors have opportunities to clearly explain and reinforce the value of completing pre-class assignments. Such explicitness should help foster intrinsic motivation, and help engage work-avoidance students who otherwise might view the assignments as "busy work." Camp et al. (2010) reported a large increase in engagement the second semester they incorporated JiTT due to more clearly explaining and reiterating the learning benefits of the JiTT process.

Also under an instructor's control is the numbers of points allotted to the pre-class assignments. However, we argue that the use of points not only leverages extrinsic motivations,

but also indicates value of that activity / product, which might serve to enhance intrinsic motivation. Other influences on intrinsic motivation can also be under an instructor's control. For example, while some students might enter a class with strong intrinsic motivation based on perceived relevance of the subject matter, instructors can foster intrinsic motivation through their use of examples that demonstrate application of the material beyond the classroom or by making connections to student interests. With respect to pre-class assignments, the type of question (eg content regurgitation versus personal reflection) might differently tap student connection with the material. Unfortunately, through the design of their course or how they present the material, instructors can also decrease a student's intrinsic motivation for learning the material.

The use of pre-class assignments might also be viewed differently by learning-oriented compared to performance-oriented students. An instructor who obviously modifies lesson content and activities based on student pre-flight responses indicates that student learning is a primary focus of the course. This could serve to enhance the likelihood that students adopt a learning-oriented approach. However, pre-class assignments might be perceived as threatening by performance-oriented students because, to some extent, they require that students work with new material with which they might not yet be comfortable. These fears can be moderated by clarity of instruction and by offering questions at different levels of difficulty so that all students should show some success. If instructors highlight answers in class, performance-oriented students might experience anxiety that their response won't be shown as a good example, or even worse, be highlighted as an example of a misconception. However, if they do feel comfortable with the material, they will enjoy the opportunity for attention.

We believed that all types of students would be demotivated when an instructor requires the pre-class assignments, but then does not seem to use the responses in any meaningful way during class or provide individual feedback to the students about their responses. Such lack of use and feedback may be interpreted as meaning that an instructor places low value on the student effort or that the assignments are not connected to course goals. Ultimately, students may come to believe that the pre-class assignments are a waste of their time, and completion rates will drop. This might especially be true if the amount of time needed for completion is longer, as students will not prioritize the assignments, and in turn, not set aside enough time to complete them.

Background, Design, and Hypotheses

The current study took place over two semesters (fall 2009 and spring 2010). The goal of the study was to better understand factors that influenced student completion rates for pre-class assignments in core courses (primarily freshman level) in Math, Physics, and Behavioural Sciences. Each department incorporated pre-class assignments in different ways, and these pre-existing differences provided an opportunity to investigate several factors without intruding on the current course designs.

In Physics, students were assigned three or four multiple choice and short answer questions for each lesson. Across the semester, the pre-class problems comprised 20% of the course grade. All assigned problems were required and all were submitted online so that instructors could skim responses before class in order to tailor class sessions. The questions

were specifically designed to probe known bottlenecks in learning, and thus, were somewhat challenging. The problems were addressed in class unless all or most of the students answered the question correctly, and it was rare to give individual feedback.

In Math, one pre-class problem was assigned for each lesson, and there were no points associated with completion. Students were told that the problems were required, but that they should do them without credit. The rationale for this was two-fold. First, the work of completing pre-class assignments supported the learning process was thus something good for students to do. Secondly, a mark of a good officer is that s/he does his/her duty. Preparing for class is a duty. Thus as officers-in-training, students should complete pre-class work to develop habits of good officers. While a subset of the pre-class work was done online and thus could be previewed by instructors prior to class, most of the pre-class problems were worked out on paper and brought to class. In class, students were often asked to show their work on the white board at the beginning of class and feedback would be given on that product.

In Behavioural Sciences, students were given two or three questions for each lesson and they were required to answer one of them. Student responses were required to follow a four-component structure that reinforced the acquisition of content and the development of critical thinking skills. Personal opinion and examples were encouraged in the responses. During the fall semester no points were given for the completion of the pre-class questions. In the spring, responses were allotted 10 % of the course grade. During both semesters, there was much instructor variance on how the responses were used in class and whether or not individual feedback was given.

In order to investigate factors influencing pre-class assignment completion rates, we used end-of-semester feedback forms to gather the following information from students: the percentage of pre-class assignments they completed, the average amount of time it took them to complete the assignments, and a rating of instructor use of the responses ("good use" exemplified by instructors referring to the responses during class, obviously modifying lesson content and activities based on responses, or meaningful feedback given to students regarding their responses). We also asked students how much credit would be necessary to allot to the pre-class assignments in order to motivate them to complete at least 90% of the pre-class assignments.

We had several initial hypotheses based on the previous research and motivational factors outlined above. First, we expected higher completion rates when points were allotted for the assignments. We also hypothesized that as time needed for completion increased, there would be a decrease in completion rates, and that better instructor use would be related to higher completion rates. Finally, we hypothesized that more points for completion would be desired by Physics and spring semester Behavioural Sciences students (because they were accustomed to receiving points), as time for completion increased, and as good instructor use decreased.

These end-of-semester feedback forms were used in all three departments during the fall semester and in the Behavioural Sciences course during the spring semester. During the spring semester we were able to collect additional data to more explicitly investigate perceptions of value and reported student motivations. On the end-of-semester form an additional set of questions asked students to rate their agreement with whether or not the pre-flight assignments helped them prepare for exams, get more out of the textbook, prepare for

class discussions, and structure their study time. We also used a separate pre-post survey to investigate the relationship between student perceived value of and motivation for engaging in the different components of the JiTT process. Four components were identified: reading before class, completing the pre-class questions, attending class due to instructors tailoring the class session based on responses, and attending class to participate in discussion based on responses to the questions. We expected that good instructor use would increase perceived value and motivation. We also expected that poor instructor use would have a more detrimental impact on motivation than perceived value, especially for pre-class reading and questions, because the learning benefits should be less strongly linked to the instructor.

Procedure

Following approval by the institutional review board, we disseminated the fall end-of-semester feedback forms in all sections of freshmen Physics courses ($N = 683$), Calculus I (mostly freshmen, $N = 805$), and those sections of the Introduction to Behavioural Science that incorporated the pre-class assignments (all freshmen, $N = 318$). The questions contained closed-ended scale responses asking them to indicate the percentage of pre-flight assignments that they had completed during the semester, how much time they took to complete a typical pre-flight assignment, their agreement with whether or not their instructor had made good use of the pre-flight responses (with a examples given of good use), and what percentage of points would be necessary to lead them to complete 90% of the pre-class assignments. During the spring semester, Introduction to Behavioural Sciences students ($N = 318$) answered the same end-of-semester questions, plus the additional questions that asked them to rate their agreement with whether or not the pre-flight assignments helped them prepare for exams, get more out of the textbook, prepare for class discussions, and structure their study time.

The spring semester Introduction to Behavioural Sciences students also completed a pre- and post-semester survey focused on their perceived value for and motivation to engage in the four components of the pre-flight process. These components were 1) Prior to each class period, students review the material to be covered in class that day, 2) Prior to each class period, students answer questions about the material to be covered during that class period, 3) Instructors review pre-flights before class and structure class lecture and activities based on pre-flight responses, and 4) During class, time is regularly set aside for students to discuss the content material and the pre-flight responses. Using 5-point Likert scales (with 1 being completely disagree, 3 being neutral, and 5 being completely agree), students indicated whether or not they believed each JiTT component would help / helped them better learn and understand the material, and whether or not they were / had been motivated to complete that component or attend class in order to participate in that component.

Results and Discussion

Data were first examined to determine the impact of the number of points allotted for completion of the pre-class assignments; see Figure 1. As hypothesized, a one-way ANOVA revealed a significant influence for the number of points, $F(3, 2118) = 243.73$, $p < 0.001$. Post-

hoc analyses revealed a significant increase in completion as points were increased (no difference between Math and Behavioural Sciences in the fall, both giving 0% of the course grade for completion, and then a significant increase as 10% of course grade was given in the spring semester Behavioural Sciences course, $p < .01$, and then an additional significant increase when 20% of the course grade was given in Physics, $p < .05$).

Unlike what was hypothesized, there were higher completion rates associated with more time being taken to complete the assignments, $r(2120) = .101$, $p < .001$. This relationship was probably driven by the influence of points, as points significantly influenced the amount of time students reported spending to complete the pre-class assignments, $F(3, 2109) = 23.24$, $p < 0.001$. Physics ($M = 2.05$) and Behavioural Sciences students in the spring ($M = 2.03$) took significantly more time ($p < .01$), than students in Math ($M = 1.7$) and fall semester Behavioural Sciences students, ($M = 1.8$), where ratings of 1=0-30 mins, 2=30-45 mins, and 3 = 45-60 mins. The lack of difference within the two pairs of courses could indicate that students set aside a consistent amount of time to complete such assignments if they were allotted points, and a lesser amount of time if they were not allotted points. Alternatively, it could indicate that the instructors designed the assignments to be completed in approximately the same amount of time (between 30 and 45 minutes), and students were more likely to take that much time if given points for completion. Supportive of our hypothesis, more time being taken to complete the assignments was significantly related to students desiring more points for 90% completion, $r(2102) = 0.14$, $p < .001$.

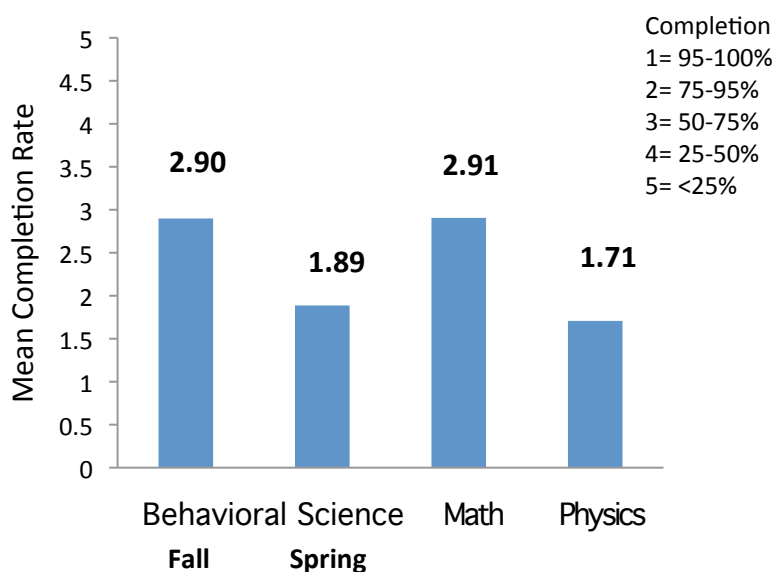


Figure 1. Completion rates for the four courses as a function of number of points allotted for completion: Behavioural Science fall semester = 0% of the course grade, Behavioural Science spring semester = 10% of the course grade, Math = 0% of the course grade, and Physics = 20% of the course grade. Note that lower values indicate higher percent completion (see legend).

Importantly, instructor use of pre-class assignment responses also significantly impacted student completion rates, although points moderated the effect. Data from the fall semester

revealed significant correlations between good instructor use and completion rates for Math and Behavioural Sciences (both giving 0% of course grade for completion of the assignments; $r(803) = .14, p < .001$ and $r(316) = .20, p < .001$, respectively). However, no relationship was seen between instructor use and completion rates in Physics, which allotted 20% of the course grade to completion of the assignments. Of great interest was how the shift in allotted points in Behavioural Sciences would affect this relationship. Would we still observe an influence of instructor use once students received 10% of the course grade for completion of the pre-class assignments? The data revealed that, yes, good instructor use of responses significantly influenced completion, $r(316) = .13, p < .05$.

The above patterns of results suggest that a relatively large number of points can overwhelm the impact of instructor use, but that a more moderate number of points combined with good perceived instructor usage can significantly increase completion rates. There are pros and cons of both scenarios. Assigning a large number of points serves as a powerful extrinsic motivator, and puts less pressure on instructors to take the time and effort to review responses and adjust lessons based those responses. However, most instructors will report a desire that students engage in behaviours not just for the points (more closely related to a performance orientation), but rather, for the opportunities those behaviours provide to support learning (more closely related to a learning/mastery orientation).

Thus, the question arises, "what level of instructor use of pre-class assignment responses might be necessary to yield completion rates equivalent to those seen when 10% and 20% of the course points are allotted to completion?" Figure 2 shows student pre-class assignment completion rates as a function of student ratings of instructor use. Note that data are sorted purely by individual student ratings of use. Thus, each data point has multiple instructors in it due to variance in ratings across students for each individual instructor. These data suggest that, when no points are given, even the best perceived instructor use of student responses cannot lead to the completion rates seen when 10% or 20% of course points are given. More encouraging is the fact that there are essentially no differences in completion rates for the 10% and 20% groups as long as students agree or are neutral in their beliefs that instructors are putting their responses to good use.

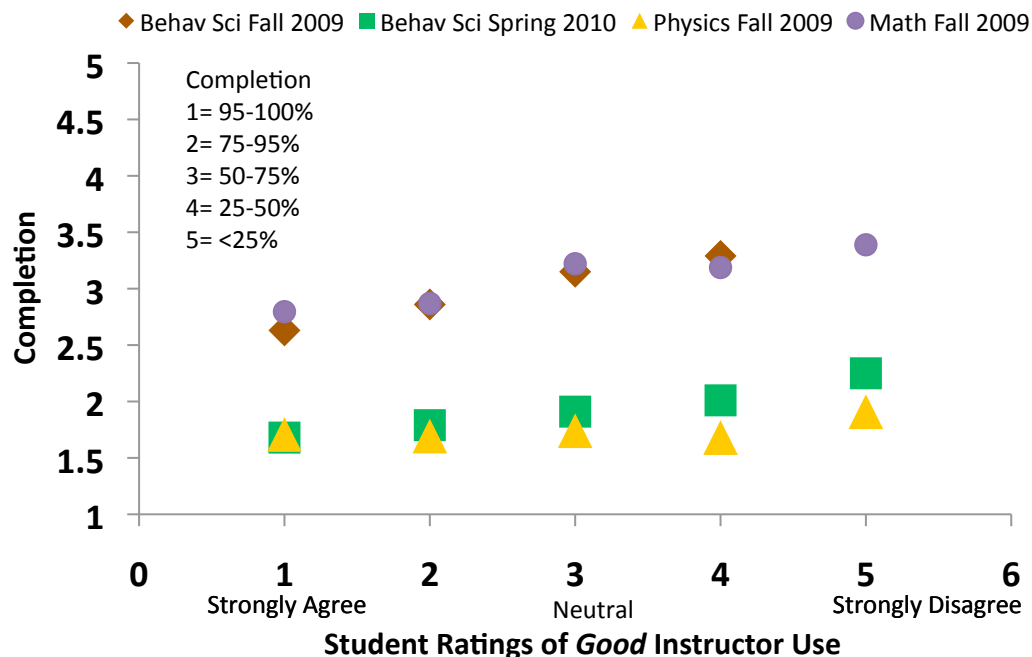


Figure 2. Impact of perceived instructor use of pre-flight responses on student completion rates based upon course. Math and fall semester Behavioural Sciences (zero points for pre-flight completion) had significantly lower completion than Physics (20% of grade) and spring semester Behavioural Sciences (10% of grade). Ratings of instructor use correlated significantly with completion for all courses except Physics. Behavioural Sciences was able to match completion rates to Physics by allotting 10% of points and achieving at least neutral agreement of good instructor use.

What might be underlying this observed impact of instructor use of responses? Responses to the additional questions on the end-of-semester feedback form for the spring Behavioural Sciences course suggest that instructor use can significantly impact student perceptions about benefits of the pre-class assignments. More specifically, good instructor use significantly correlated with perceptions that the pre-class assignments helped students prepare for quizzes and exams, $r(315) = .20$, $p < .001$, get more from the textbook, $r(315) = .14$, $p < .05$, prepare for class discussions, $r(315) = .19$, $p < .001$, and structure their study time, $r(315) = .23$, $p < .001$. Not surprisingly, the more strongly students agreed that the pre-flights benefitted them in these areas, the higher the completion rates.

The above perceived benefits suggest that good instructor use might increase student value for the pre-class assignments, which might in turn serve as a motivating factor, hence the increased completion rates. The pre-post survey during the spring semester allowed us to more deeply investigate value and motivation for the four JiTT components (read before class, do pre-class assignment, instructor use responses to modify lesson, instructor use responses to stimulate discussion). Overall, both pre- and post-semester, students tended to more strongly agree that the four components of JiTT were valuable for learning the material, than they agreed that they were motivated to actually engage in the component activities.

Most interesting was the result that, at the beginning of the semester, there were no significant differences in value or motivation perceptions across instructors, but by the end of

the semester there *were* significant differences, $F(4, 35) = 6.86, p < .001$. Data were transformed into difference scores (post-pre) and correlated with instructor use. Good instructor use of pre-flight responses significantly correlated with increases in perceived value, and vice versa, $r(3) = .90, p < .05$. There was a marginal effect on motivation in the same direction, $r(3) = .86, p < .07$.

We had originally hypothesized a more substantial effect of instructor use on motivation than value, especially for reading before class, because that behaviour is likely to have been reinforced prior to college (and hence become an more internalized value. However, it is also likely that students had learned through experience that they often can do well in classes even if they do not read ahead of time, and thus, their value of that behaviour might depend more strongly on instructor use. More specifically, although instructors often desire that students read ahead and come prepared, a vicious cycle frequently occurs such that instructors cover basic material in class because many or most of their students haven't read it beforehand. Students who have read ahead often get frustrated and stop doing so, and pretty soon only a handful continue. JiTT helps address this issue, so that instructors can skip coverage of basic concepts that students can get on their own if they spend some time preparing, and class time can be used more effectively to cover more complex concepts. Based on this logic, it makes sense that instructor use would have a meaningful effect on student perceptions of value, even for a well-prescribed learning behaviour such as reading before class.

Summary

So, what have we learned? First, as expected, points influence the completion rates as well as the amount of time students report spending on the pre-class assignments. However, not only points matter. Instructor use of pre-class assignment responses can also significantly impact completion rates, perceived value of the assignments and JiTT process components, and student motivation. These two factors interact, in that the influence of instructor use was not observed for our highest level of points, ie in Physics, where 20% of the course grade was allotted to pre-class assignments.

While in some cases it might be optimal to remove the influence of instructor use of responses in order to increase student completion of pre-class assignments, there have been some cautions. For example, Cookman, et al. (1999, p. 20) state "Depending on what percentage of the course grade the JiTT component counts, it will drive students who are concerned about good grades. Many students will rise to the work load demanded, even if they resent it." Returning to theories of motivation, students can be motivated in many ways. Relying on a single motivational influence will be less likely to effectively motivate all students, and only relying on an extrinsic factor such as points may also increase the likelihood that students develop performance-oriented goals rather than learning-oriented goals.

Extrinsic motivation can be very powerful, however, so for new or unfamiliar tasks (such as pre-class assignments and the JiTT process in freshmen-level courses), it can initially be beneficial to use external rewards such as points to encourage the new behaviours (McKeachie & Svinicki, 2010). But, ultimately, we usually want students to engage in learning behaviours for reasons beyond those solely due to points. Thus, we also need to make the task meaningful and of value, by promoting the development of intrinsic motivation.

Our data from the course that allotted 10% of the course grade to the completion of pre-class assignments (Behavioural Sciences spring semester), suggests that an ideal balance can be struck. In this case, as long as instructors were reasonably good with respect to using student responses, the high completion rates seen in Physics could be matched. Of interest is whether or not even fewer points could also lead to such high completion rates. We were not able to investigate other levels of points in our current study, but Simpkins and Maier (2004), found 80-90% completion rates when they assigned 5-10% of the course grade to pre-class assignments in an Introduction to Economics course. Of course, there may be some disciplinary differences in the need for certain amounts of points. Although both the Physics and Behavioural Sciences courses in our study were required core courses and had a wide variety of freshmen students enrolled, it is possible that the influence of points might differ for the two courses due to the type of content or preconceived notions students might have about the two disciplines.

The ideal number of points might also vary due to factors other than discipline. The vast majority of students who participated in this study were freshmen, and the courses were core courses. How well might these findings generalise to more advanced students and non-core courses? Casual conversations with undergraduate students often reveal that they view many of the core courses as necessary evils to be endured, which indicates low levels of intrinsic motivation. However, they report being excited about and more deeply engaged in majors courses, which they are more likely to take as they advance through their degree requirements. Thus, it seems reasonable that the use of extrinsic motivators could be reduced in more upper-level, majors courses.

A final point to address is that there are additional recognized influences on motivation that were not examined in the current study. For example, autonomy and self-determination influence motivation, as people tend to be more motivated to complete tasks over which they have some choice and control. As instructors, we can design the questions and course so that students have more or less autonomy, such as whether or not students get to choose which pre-class questions to answer. By having some ability to choose which questions to answer, they are able to select those with greater relevance to them, and thus, experience greater motivation to spend more time on the question and answer it more thoughtfully. This type of option was used in Behavioural Sciences, where the pre-class questions were styled as short essays where students would respond using content material as well as personal reflection. In Math and Physics, each pre-class question tapped a different concept, and thus, students were not given a choice about which to answer. In the future we could manipulate this factor and investigate its impact on completion rates.

In sum, while the use of pre-class assignments can enhance learning and the effective use of class time, the benefits are only realised if students complete the assignments. This study shows a strong, interacting effect of the awarding of points and instructor use of responses on pre-flight completion rates. A combination of fewer points and good instructor use led to the same levels of completion as a much higher number of points (where instructor use did not influence completion rates). When making course design decisions such as the number of points for assignments, instructors might consider how to incorporate influences from a variety of motivators.

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ⁱ Note: The opinions expressed here are those of the authors and do not necessarily represent the official policies of the United States Air Force or the Air Force Academy.