A Preliminary Exploration of the Role of Surveys In Student Reflection and Behavior

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Introduction

Surveys often are used in educational research to gather information about respondents without considering the effect of survey questions on survey-takers themselves. Does the very act of taking a survey influence perspectives, mindsets, and even behaviors? Does a survey itself effectuate attitudinal change? Such effects of surveys, and implications for survey data interpretation, warrant close attention. There is a long tradition of research on surveys as *behavioral interventions* within political science and social psychology, but limited attention has been given to the topic in engineering education, and higher education more broadly.

Recently the engineering education community has started to examine the potential effects of assessment techniques (including surveys) as *catalysts for reflection*. In March 2014, the Consortium to Promote Reflection in Engineering Education (CPREE), representing a two-year collaboration amongst 12 campuses, was established to promote "a broader understanding and use of reflective techniques in engineering education."[1] CPREE's formation suggests a growing recognition of reflection as an important and underemphasized aspect of an engineer's education. CPREE defines reflection as "exploring the meaning of experiences and the consequences of the meanings for future action" and emphasizes the importance of taking action as a result of ascribing meaning to experiences.[1] Surveys may be one of several tools that may create opportunities for reflection; others include "exam wrappers" and "homework wrappers" that encourage students to explore how they feel about an assignment or task as part of making meaning of it[2,3] (and stimulating the kind of reflection that can lead to action).

The current study bridges these two frameworks of behavioral interventions and reflection to consider the "extra-ordinate" dimensions of survey-taking and explores how survey participation may (1) support students' reflection on past experiences, meaning-making of these experiences, and insights that "inform [their] path going forward,"[1] and (2) be associated with students' subsequent behaviors. We first review a broader literature on the interventional effects on surveys in political studies and social psychology, after which we present the results obtained from including an optional reflection question at the end of an engineering education survey. We conclude that educators would benefit from considering the range of potential impacts that responding to questions may have on students' thoughts and actions, rather than treating surveys as neutral data collection devices when designing their research.

Previous research on the effects of survey taking

If we consider taking a survey as an experience in itself, we must then consider how this experience might impact the subsequent thinking and behavior of participants. For example, a request to rate one's preferences during an experience in a context that is either positive or negative may influence a participant's preferences in the moment and persist into their memory-based evaluations. Pocheptsova and Novemsky induced neutral

or positive moods in study participants with short stories, and found that those who rated paintings while in a better mood also preferred them five days later.[4] However, the influence of the story-induced positive mood on painting ratings did not persist if participants were not asked to rate the paintings during the initial viewing experience in which the mood was induced.[4] Emotional reactions can also initiate reflection, and previous research has even suggested using emotional language to pose reflection questions to students in order to help them recall and reflect on critical learning moments[5]

Such studies indicate that surveys, which often incorporate evaluation, might make even artificially induced changes in thinking due to context persisting over time. Such changes, in turn, could have an effect on subsequent actions: there is a long tradition of research in social studies from the early 1940s onwards on how the experience of taking a survey may influence the response of a participant in subsequent surveys, due to changes in reporting or behavior.[6] This phenomenon is called 'panel conditioning' or an 'interview effect'. Changes in behavior may be explained by the idea that "a prior interview may alert the respondent to some element of their own behaviour or circumstances that prompts them to act in a way they would not have acted otherwise."[6] Panel conditioning has been found to be particularly salient when surveys deal with a topic that the respondent knew little about previously.[7]

Panel conditioning is often cited in political science studies as both a potential intervention and as a potential source of error due to making the sampled population increasingly less representative of the overall population, especially as related to voter registration and turnout following election interviews. In a landmark study in 1968, Clausen investigated why a study of voting behavior including both a pre-election and post-election interview indicated a significantly higher voting rate than the overall recorded rate of the 1964 election. Although he found some of the discrepancy to be due to misreporting (i.e., participants reporting voting when they had not) and to sampling error, he also proposed a short-term 'stimulus hypothesis' to explain the remaining discrepancy: interviews awakened the least interested subjects' interest and sense of duty enough to inspire them to vote in the related election.[8]

Traugott and Katosh expanded on this study for the 1976 election. They verified the official voting records of participants in two survey studies to determine to what extent the higher reported voting rate they observed was due to real differences in voting behavior between the sample and the overall electorate rather than misreporting or sampling error.[9] They found that the validated voting rate for citizens who participated in the ongoing politically focused study (interviewing participants pre- and post-election in 1972, 1974, and 1976) was higher than the national average, providing evidence for the interview effect. Additionally, participants responding to their third election study were significantly less likely to misreport voting behavior than were those responding for the first time, suggesting a possible benefit to survey quality in panel studies, to be taken in consideration, along with the confounding factor of altered behavior.

To extend Clausen's research, Traugott and Katosh also investigated the 'stimulus hypothesis' as compared to two alternative hypotheses about the cause of the interview effect proposed in 1973: a 'self-concept hypothesis' and a 'alienation reduction

hypothesis.'[10] Both involved changes in the individual's psychological attitudes due to the personal contact of the interview. To test this effect, political self-efficacy and political alienation were measured on each survey; taking additional surveys did not change either measure, so these hypotheses were rejected. Traugott and Katosh concluded that there was an interview effect and it was caused by Clausen's stimulus hypothesis, as supported by the cumulative effect of interviews increasing the behavior of voting. They warn of the importance of considering the interview effect, stating that "The data collection method represents a potential source of contamination to the very relationships which it is being used to measure."[10]

Indeed, there are multiple potential sources of both potential errors and changes to consider. In a 1980 study, self-predicted rates of behavior of a surveyed population were found to differ from the rates of behavior demonstrated by a control population, with surveyed participants self-predicting engaging in more socially desirable behaviors than the control group actually performed. However, these self-predictions seemed to translate into subsequent actual increases in the socially desired behaviors compared to participants who were not asked to predict their behavior in advance. Thus the act of self-predicting seemed to produce a sub-population with at least temporarily different rates of behavior than their non-surveyed peers[11].

Although researchers using the earliest versions of panel studies were most concerned with the effects of in-person interviews, the prevalence of online surveys has raised questions of whether these less personal measures still have an appreciable effect on participants. In a 2016 paper, Struminskaya addressed the growing concern in the social sciences about panel conditioning as a source of error in terms of sample generalizability to a larger population [12]. However, she focused on whether participants' responses changed due to learning the rules and structure of the survey, and intentionally used a series of surveys on various topics. Although she concluded that there was little evidence of favorable panel conditioning and no evidence of unfavorable conditioning, her results are not generalizable to potential conditioning effects of learning the *material* contained in an online survey[12] leaving open important questions about attribution of attitudinal changes over time.

Perhaps most intriguing for educators, some studies intentionally investigate the use of interviews or surveys as a type of intervention. For example, a study employing low to high monitoring of participants in a coffee-production training program for farmers in Rwanda found that closer monitoring of participants led to improved participation and performance levels, especially for farmers who were the least engaged before monitoring[13]. Although the authors call this the 'monitoring effect,' it describes a similar phenomenon as what is called panel conditioning in the political and social sciences. It also provides a more direct link between questions (about the farmers' understanding of best-adoption practices for their crops) and practices (whether they adopt these practices and how often they attend training sessions). This study gives evidence that the experience of responding to surveys can influence actual behavior, lending additional credence to the assertion that panel conditioning can lead to real changes in behavior rather than changes in reporting unaccompanied by behavioral change.

A recent meta-analysis of "question-behavior effect" by Wood and colleagues frames it as a low-cost intervention that is therefore relevant despite its small effect sizes in adult populations.[14] They note that self-prediction questions have a larger impact on behavior than intention questions, both of which have a greater impact than questions related to goals[14]. Additionally, they conclude that prediction or intention questions have the greatest impact on action "when the behavior is socially desirable or does not involve risky behavior, when the behavior is easy to perform, and when students are the participants."[14] The authors suggest further research to understand the causes of different types of question-behavior effect and to determine how to effectively harness it to create societally important changes, such as blood donation, where a small difference goes a long way[14].

Summary and research questions for the current study

This small cross-section of literature from the fields of political science, social science, and social psychology illustrates that surveys and interviews can, under certain conditions, influence subsequent thinking and behavior and thus serve as an intervention. In the current study, we attempt to extend these ideas to an engineering education survey context, and explore the specific possibility that survey-taking both affords reflective opportunity and may have behavioral correlates and implications. We draw from the panel conditioning literature as well as the more recent efforts in engineering education to promote reflection to frame the following exploratory research questions:

- To what extent can a survey with a reflection-prompting question inspire engineering students to consider new ideas, or different thinking, about their engineering education, i.e., to *reflect* on their educational experiences and make meaning of these experiences?
- To what extent can this reflective opportunity be associated with *intentions to act* in new or changed ways?
- To what extent can engaging in this reflective opportunity be associated with willingness to respond and response rates in *subsequent surveys*?

Methods

In order to explore reflective and behavioral implications of survey-taking, the current study investigates open-ended comments that students self-reported at the end of a recent engineering education survey. We gathered our data from the Engineering Majors Survey (EMS), a study of engineering students from a nationally representative sample of 27 U.S. engineering schools. The EMS is intended to follow junior and senior engineering students from their undergraduate education into their career. So far the first ("EMS 1.0") and second ("EMS 2.0") waves have been administered, one year apart, with additional follow-up surveys planned. The EMS asks a variety of questions about engineering students' past academic and extracurricular experiences, confidence performing various skills, and plans for their future careers. A major goal of the EMS is to collect information about students' innovation-, entrepreneurship-, and engineering-related interests and plans. An optional, open-ended question was included at the end of EMS 1.0: "*To what extent did this survey inspire you to think about your education in new or*

different ways? Please describe". The present study is based on the analysis of responses to this question, hereafter referred to as the "reflection question".

From the 7,197 participants who completed EMS 1.0, fully 2,375 participants opted to respond to the closing reflection question. Based on their content, responses were categorized as either

- *non-responses* if the response did not provide any meaningful reference to either the 'extent' or 'please describe' aspect of the reflection question (such as "N/A", "meow", or "it's ok")
- *non-substantive responses* if the response referred only to the 'extent' part of the reflection question – (such as "Greatly" or "Very little.")
- *substantive responses* if the response answered the 'please describe' portion of the reflection question in any meaningful manner. In these responses, the 'extent' was sometimes explicit and sometimes implied.

This categorization scheme resulted in a total of 85 non-responses, 327 non-substantive responses and 1,963 substantive responses.

The demographics of the participants reporting substantive responses were compared to the overall demographics of the survey by Pearson's chi-square test of goodness of fit. Responses missing demographic data in a given category were excluded from the analysis of that category, as the demographic questions were also at the end of the survey so students who did not reach the demographics questions were also likely not to reach the reflection question. We used a significance level of $p \leq .01$. Due to the large sample size, we also calculated the Cramer's V effect size measurement for statistically significant distributions, with $V > .10$ (small effect), $V > .30$ (medium effect), and $V > .50$ (large effect).

Analyses of the current data indicated that men were more likely to respond than were women ($df = 1$, chi-sq $= 7.5$, $p < .01$, $V < .1$) and that under-represented racial/ethnic minority (URM) students were more likely to respond than were non-URM students ($df = 1$, chi-sq $= 23.5$, $p < .0001$, $V < .1$), although for both differences, the effect size was very small. Despite this relatively modest degree of demographic difference between the reflection question and non-reflection question survey takers, and the large absolute number of reflection question survey takers, we treat the reflection question sample as an exploratory sample, non-generalizable to all of our EMS 1.0 respondents, much less a nationally representative population of engineering students, but suggestive of possibilities in this population.

Focusing on the subset of substantive responses (n=1,963) among the 2,375 reflection question survey takers, we used an inductive, iterative approach to thematic analysis to categorize the content of these responses[16]. In the first step, we applied codes to each substantive response as a whole. We started by looking for *themes that described the type of comment in response to the reflection question*. We developed three separate coding schemes – one for the *type of change in thinking* reported within the substantive responses, a second for the *topics* that participants reported thinking about, and a third for the type of *emotional reaction* described, if any, shown in Table 1 (next page).

Table 1: Coding Schemes applied to 'Substantive' responses

Scheme 1: Type of Change in Thinking *(mutually exclusive categories)*	
No Change	This code is the equivalent of 'to no extent.' The respondent does not seem to have been affected by the survey and is thinking in exactly the same way that they were prior to taking the survey.
	"*I am pretty clear on what I want to do or what I think I want to do, so not much."*
Affirming/ Revisiting	The respondent did not report new or different thought, but seemed to be thinking more about topics they had previously considered. This code could roughly translate into 'to some extent.'
	"I had already thought about my future in engineering so it just made me reaffirm my goals."
New or Different	The respondent specified thinking about a new topic or thinking in a different way (i.e. 'more deeply'). If the respondent mentions a topic without specifying having thought about it before, 'new or different' is assumed because of the wording of the question. This roughly translates into 'to a great extent.'
	"I realized I haven't really stepped out and looked at what Engineering opportunities the University gives me!"

Scheme 2: Topic *(categories not mutually exclusive)*	
Undergraduate Education	The respondent describes a reaction to a school related experience, including an evaluation of its quality, what the student has gained from it, and/or goals to be performed during undergraduate studies.
	"It has made me think about some of the opportunities available to me as an engineering student, particularly in student-led extracurricular activities, that I could be taking advantage of."
Graduate Education	The respondent mentions continuing studies beyond undergrad, including graduate school, getting a second undergraduate degree or doing 'research' after their undergraduate studies.
	"It reminds me to think more about deciding on which specific masters program to pursue."
Career	The respondent describes plans, goals, or thoughts about their (future) career. It also includes reference to 'being an engineer' as well as any reference to a respondent's resume.
	"It made me think about all the other options available to us engineers - career paths which do not directly involve "hard" engineering, so to speak."
Engineering Education	These are comments about how the respondent views education/ engineering education as a whole, more broadly than their own education, including suggestions for improving engineering education, complaints about common practices, and comments about the usefulness of education.
	"I had not realized how many different programs I had attended as a kid that led me to make the choice of entering engineering. Getting young kids involved in these types of programs seems to be an essential part of growing up an engineer."
Innovation and Entrepreneur-ship	The respondent mentions innovation and entrepreneurship keywords such as: 'innovation,' 'entrepreneurship,' 'start my own business,' 'start-up.'
	"I am pretty new to getting involved in the world of social entrepreneurship, but I was surprised to realize how much I really care about it. Just came up with an idea too!"
Self-Awareness	Responses that show self-examination and responses that show self-consciousness were both considered as 'self-awareness.' This includes self-focused metacognition, an awareness of why one acts or thinks the way one does, and insights into one's own beliefs, confidence, or expectations.
	"The survey somewhat helped me realize which skills I'm strong or weak in."
Scheme 3: Emotion *(mutually exclusive categories)*	
Positive	Any hopeful, excited, content, curious, or pleased emotion.
	"I've always thought of myself as an innovator. This survey makes me hopeful, as an engineer, that more engineers are thinking of starting their own companies and exploring their ideas."
Negative	Any negative emotional reaction, including afraid, disconcerted, nervous, challenged, overwhelmed, and regretful.
	"It didn't. I think I made a mistake going into engineering but it's too late to change now."
Neutral	The respondent does not indicate a specific emotional (positive or negative) reaction.
	"The survey more or less confirmed the feelings I already understood about my future and current education"

The categories identified in the *topics* scheme were not mutually exclusive (i.e., a respondent's comments could contain more than one topic, or no topic), while the categories identified in the *type of change in thinking* and *emotional reaction* schemes were each mutually coded in a mutually exclusive manner.

We then observed that many students indicated they were taking the insights they reported gaining via the survey and intending to apply it to future action. We categorized such responses as Active/Motivational, based on Nuttin's description of an Active/Motivational Time Perspective[17]; we treated Active/Motivational responses as

deeper evidence of "reflection" per CPREE's expanded definition: "Reflection is not simply about examining and thinking deeply about an experience, but also using that information to look forward, to plan the future. Action refers to steps taken as a result of the meaning that has been ascribed to the experience."[1] We again used inductive thematic analysis to categorize all *active/motivational* responses into more detailed, descriptive categories based on their content, but chose to split responses into multiple goals and code each goal independently rather than coding each response as a unit. Therefore, while each goal was only given one code, a single student response sometimes had multiple codes applied. The goals were then grouped into six overarching topics that largely corresponded with the six topic codes in Table 1 (Scheme 2). The exception was that since making a goal is often a form of self awareness, the *self awareness* code was replaced with a code called *no specific context given* with a categorization corresponding to goals that did not specify any of the other five contexts.

Once all responses had been coded, we used Pearson's chi-squared test to find any significant differences in code occurrence by demographic qualities of the students, as well as to evaluate whether variations in the distribution according to one coding scheme were associated with a second coding scheme (i.e., if emotional reactions differed by topic). Finally, we compared whether those who had provided a substantive response were also more likely to have indicated willingness to take part in future studies (per a research permission question at the end of the EMS, on a survey page prior to the reflection question) than were students who did not respond or provided a non-substantive response, as well as the persistence of any difference to actual completion of the follow-up survey. This last step was taken primarily to begin to explore the possibility of behavioral correlates of survey taking, based on the panel conditioning and related literature discussed above. We note that our non-experimental data do not allow for causal inferences about these relationships, however.

Results

Focusing on the substantive responses, we first report both the self-reported type of change in thinking by topic and emotional responses by topic. We then look in more detail at the subset of substantive responses showing an active/motivational mindset.

Type of change, topic, and emotion in response

Of the 1,963 participants providing a substantive response, 61% reported *new or different* ideas (1201/1963), 22% reported *no change* (427/1963), and 17% *affirmed or revisited* ideas. There were no significant differences by gender. Students just starting their college programs, e.g., freshmen (n= 52) and sophomores (n = 252), were significantly more likely to have *new or different* thoughts (df=3, chi-sq=17.6, $p<.001$, V = 0.095), as were URM students (n= 832) (df=1, chi-sq=33.0, $p<.001$, V=0.13), compared with students in later cohorts and non-URM students, respectively. That said, the Cramer's V values indicate a very small effect size for cohort and a small effect size for URM status.

Self-awareness and *undergraduate education* were the two categories responses were most commonly coded for, totaling at 559 and 448 responses, respectively (see Table 3

(below)). The topic category of *undergraduate education* and the *career* category had the highest proportions of responses of the *new or different* type of thought category (82% and 79%, respectively). For example, students made the following remarks about their own undergraduate education and career (descriptive codes per Table 1 are included in parentheses):

> *"It blew my mind. I am [a] senior and I have done so many things during college and yet this survey made me think that [I] haven't done enough. I could've done so much better..."* (New or Different/ Undergraduate Education/ Self-Awareness/ Negative)

> *"I am often reminded, as I was with this survey, that I could be doing a lot of good with my engineering experience. Even if I am unable to do the world a lot of good and get paid for it, I will always be looking for volunteer opportunities and ways to help. "* (Affirming-Revisiting/ Career/ Positive)

While all of the topic categories had predominately neutral responses, negative emotional responses were more numerous than positive emotional responses in most categories. (Table 3, below).

Table 3: Type of Thought and Emotional Reactions by Topic

note: some responses were coded with multiple topics and some did not fall into any topic category

Topic	Number of responses by topic	Percent of topical comments also coded as *new or different*	Percent of topical comments also coded as *negative emotion*	Percent of topical comments also coded as *positive emotion*	Percent of topical comments also coded as *neutral emotion*
Self-Awareness	559	66.37%	15.60%	9.10%	75.30%
Undergraduate Education	448	81.92%	25.00 %	6.90%	68.10%
Career	386	79.27%	9.60%	7.80%	82.60%
Innovation/ Entrepreneurship	309	74.76%	6.10%	6.80%	87.10%
Graduate Education	88	76.14%	4.50%	3.40%	92.00%
Engineering Education	60	65.57%	33.30%	5.00%	60.70%
Total	***1963***	***61.18%***	***11.40%***	***7.80%***	***80.80%***

Responses coded as *undergraduate education* were significantly more likely to show a negative emotion, with a small effect size (df=2, chi-sq= 108.5, p<.001, V=.23) Responses coded as *engineering education* were also significantly more likely to show a negative emotion, with a small effect size (df=2, chi-sq=29.7, p<.001, V=.12). To illustrate, the following responses were categorized as negative emotional responses within undergraduate education or engineering education:

> *"Honestly, this survey helps me realize that although I am almost fully certified to be a biomedical engineer, I still know almost none of the skills necessary to be successful (specifically in the business and building aspects) and not one of my studies or professors has ever inspired me to want to learn."* (New or Different/ Undergraduate Education/ Negative)

> *"It made me feel that the education system is good at teaching basics (only if it can keep the students attention) but in its attempt to show how everything joins together in the end it fails spectacularly."*(New or Different/ Engineering Education/ Negative)

Innovation and entrepreneurship had proportionately equal *positive emotion* responses and *negative emotion* responses in aggregate, and was significantly less likely to be *negative* and more likely to be *neutral* than expected, albeit with a very small effect size (df=2, chi-sq=11.0, p<.01, V=0.07). *Self-awareness* surpassed *innovation and entrepreneurship* as the topic category with the highest proportion of *positive* rather than *negative* or *neutral* responses, with responses coded for *self-awareness* being significantly more likely to show a *positive emotion* with a very small effect size (df=2, chi-sq=16.6,p <.001, V = 0.09). Positive emotions were also expressed in relation to undergraduate education and careers:

> *"This survey helped me realize a lot of soft skills and goals I have acquired throughout my education that I will be able to use in the future in my career"* (New or Different/ Undergraduate Education/ Career/ Self-Awareness/ Positive)

> *"It helped me think about the other areas on engineering I should pursue, other than design work. Although I may not be great at design does not mean I cannot be a great engineer or engineering project manager."* (New or Different/ Career/ Self-Awareness/ Positive)

Insights into potential future actions

A total of 336 *active/motivational* responses were identified from the 1,963 substantive responses to the reflection question (17%). The distribution of goals is shown in Table 4.

Table 4: *Active/ Motivational* Goals

Topic	*Descriptive Code*	*Number of self-reported goals*
Undergraduate Education	join extracurricular activities	65
	utilize undergraduate resources	26
	communicate with faculty	21
	develop skills	21
	diversify experiences	18
	get an internship	11
	do research	9
	improve academic performance	6
	apply knowledge	5
	take specific classes	5
	make major change	3
	Total	**190**
Innovation and Entrepreneurship	starting a company	20
	engage in innovation	13
	design, creation and innovation activities	8
	Total	**41**
Career	prepare for career	11
	talk with others about career	9
	look for specific qualities in a job	8
	expand job search	4
	join engineering committee/society	3
	get a job/make money	3
	apply undergraduate education to career	8
	Total	**46**
Graduate Education	attend graduate school	8
Engineering Education	change the educational system	5
No specific context given	take steps to achieve future goals	33
	plan more for future	25
	think more about new concepts	21
	improve myself	13
	motivated for future	13
	keep learning	7
	figure out interests	6
	Total	**118**

There were no significant differences in goals by gender, but similar to reporting *new and different* thoughts, students who were earlier in their college careers were significantly more likely to show an *active/motivational* mindset than were students in later cohorts, although with a very small effect size (df=3, ch-sq=15.6, p<0.01, V=0.08), as were URM students compared with non-URM students, with a small effect size (df=1, chi-sq=24.8, p<.001, V=.11). A majority of goals fell under the *undergraduate education* category, with *join extracurricular activities* being the goal stated in the largest number of responses (n=65). The second most common goal did not have a specific context, but was generically focused on *taking steps to achieve future goals* (n=33). Additional goals included *communicating with faculty* (n=21), *starting a company* (n=20), and *looking for specific qualities in a job* (n=8), and *changing the education system* itself (n=5).

Turning to the possibility of behavioral correlates around survey-taking, students with a *substantive* response to the reflection question had 3.2 times the odds of giving permission for follow-up than did all other respondents (df=1, chi-sq=371.5, p<.0001, V=0.24, OR=3.2). However, among the group that agreed to further contact, there was no significant difference in actual response one year later to the follow-up EMS 2.0 survey between those EMS 1.0 respondents who gave a substantive response to the "reflection question" and those who did not.

Discussion and Implications

The current study set out to explore whether a survey could have an effect on participant thoughts, reflection, and even behavior, instead of being a "neutral" data collection instrument that it is often assumed to be. We found that a sizable proportion of EMS 1.0 respondents provided substantive comments to the final reflection question (27%), and a sizable proportion of these respondents self-reported thinking in new or different ways about topics that the survey addressed (61%), e.g., increased awareness of variety in employment opportunities, increased interest in campus resources, and new perspectives on faculty-student interactions. Among the topics discussed across nearly 2,000 comments, the proportions of students mentioning their undergraduate education, career, and/or innovation and entrepreneurship align with the focus of the survey and might be expected, although we note that the percentage mentioning innovation/entrepreneurship is actually smaller than we initially anticipated given the number of innovation/entrepreneurship-related questions on the instrument.

We also observed emotional reactions from some of the students, such as the following:

> *"It made me think about how screwed I am after I graduate, looking at how much experience, interest, confidence I don't have in what I do."*

Though our "reflection question" was not intentionally posed in emotional language, such emotional reactions may be taken as an indication of some meaning-making occurring as a result of the survey.[5] In addition to expressing positive or negative emotion about their undergraduate education, 17% of participants reported *active/motivational* goals, ranging from a desire to spend more time thinking about topics the survey brought up, to immediate plans to take advantage of opportunities, to developing skills and preparing for a career. Proportionately more of these goals related to students' undergraduate education

than to, for example, their career. The presence of *both* emotional reactions and the intended application of knowledge to future action, which CPREE identified as vital to the value of reflection,[1] further suggests that some students were engaging in meaningful reflection at the conclusion of the survey.

Interestingly, participants who provided substantive reflection responses were more likely to agree to take part in further studies, although there was no significant difference (among all students reporting "yes" to the permission question) when observing actual participation rates in EMS 2.0 one year later. We are not yet sure as to the implications of this finding for our follow-up sample (and causality, moreover, is not something we can establish in our data), but see the prospect of multivariate models to explore this finding more deeply. Of course, responding to our follow-up survey was the only behavior that we directly investigated in this study; there are many other behavioral associations to explore in future work.

Overall, while such observations on reflective and behavioral possibilities potentially linked with EMS's reflection question are grounded in over half a century of research on panel conditioning in political science and social psychology, as well as more recent work on evaluative tools as reflection, such possibilities have not yet been studied deeply in the engineering education community. We think it is important to consider the potential reflective and behavioral effects of surveys in a field where many such instruments meet the criteria of having potential impact on subsequent behavior[14] : engineering education survey participants are often *students*, *prediction questions* are often asked, and many *behaviors one might wish to promote*, from studying more to joining more engineering extracurricular activities to persisting in engineering, are socially desirable and/or relatively easy to perform. Additionally, prior research suggests that panel conditioning may introduce bias in follow-up surveys, so it is important for researchers to carefully consider how the questions they ask on one survey may influence respondent thinking and potentially make the sample less representative of the overall population as the study progresses.

We see at least three promising avenues for continued study. Our first avenue relates to the potential behavioral influences of EMS 1.0 on, say, participating in more or different types of extracurricular activities, and the ensuing implications for longitudinal data analysis. Put differently, for the subset of students inspired to engage in these activities after taking the survey, who then go onto actually do these activities (which we imagine is a small fraction of the subset), to what extent does this relationship "muddy" inferences about individual change (across all respondents) over time? Will this appreciably affect the statistical error in longitudinal models of action, as found in surveys of voting behavior[9]?

Second, we found that students from URM backgrounds were significantly more likely than were their peers to report new or different thoughts as well as make explicit goals in the reflection question, as were students earlier in their college careers, albeit with a very small effect size. We do not have a clear understanding of the reasons behind these differences, but generally take this to mean that not all students respond reflectively/emotionally to surveys in the same ways, and whether we want to understand

surveys as reflection opportunities and/or as catalysts for behavioral change, we need to disaggregate the data to search for trends by sub-group. There may be some student groups, in other words, for whom reflective or interventional aspects are more pronounced than they are for others, just as might be expected in the panel conditioning literature. We recommend deeper qualitative research (e.g., "exit poll"-type focus groups with survey respondents) to understand variation in survey experience.

Third, many students reflected on the experience of taking a survey in ways we would not expect. Although researchers often choose validated measures of topics they are studying for the express purpose of seeking differences in the student population, students may assign their own meaning to the choice of measures and how these measures are combined. For example, this respondent appears to consider the survey questions regarding preparedness for various aspects of engineering work as inclusive of most aspects of an engineering job:

> "*Although I enjoy the subject of engineering from an academic and pragmatic perspective, none of the types of activities described as taking place in a work setting were particularly appealing, so I may have to look harder to find something I want to do, in engineering or another field."*

Several other participants felt that questions regarding past experiences constituted what was important to put on a resume. We must be aware that surveys do not always prompt thinking in the direction that educators might intend, and may even have the opposite effect. Although reflection earlier rather than later in a student's pathway could be argued to be useful to the student, this is only true if the sentiment is not drawn from false premises. Therefore, we suggest that engineering education survey designers review how the totality of their survey portrays engineering, useful skills, or other constructs, and consider the potential impacts their survey may have on participants who view it as a source of expert information.

The ever growing pace and presence of technology have caused many to lament the lack of idle time to reflect on experiences. Indeed, several students echoed the sentiment of not having 'time to think' due to the rigorous demands of their engineering studies:

> *"[The survey] encouraged me to put more thought into my future plans; right now, I am very focused on my studies and don't have time to think about much else, but this survey made me realize that thinking about the future is important."*

It is important for educational researchers to be mindful of the reflective, behavioral, and interventional potential of surveys. On one hand, questions can be formulated to promote reflection and/or new thought, allowing the time the student invested to complete the survey to also serve as some much needed time for reflection. Additionally, our results suggest that there may be an association between reflection on the survey and at least openness to participate in subsequent surveys. On the other hand, researchers should also consider the potential error introduced by actual changes in the surveyed group in comparison to the overall population in order to understand the limitations of analysis of later surveys within panel studies. Additional qualitative research on how participants feel they have or have not been influenced by surveys can help researchers to understand the scope of this effect.

Acknowledgments

The EMS study was conducted with support from the National Center for Engineering Pathways to Innovation (Epicenter), a center funded by the National Science Foundation (grant number DUE-1125457) and directed by Stanford University and VentureWell, formerly the National Collegiate Inventors and Innovators Alliance (NCIIA). Funding was also received from the Stanford Vice Provost of Undergraduate Education (VPGE) and the School of Engineering in support of summer undergraduate research. The EMS research continues with funding support from the National Science Foundation (grant number 1636442).

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