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Unlocking Student Motivation: Development of an Engineering Motivation Survey

Mr. Philip Reid Brown, Virginia Tech

Philip Brown is a Ph.D. candidate in Virginia Tech's Department of Engineering Education. He has a B.S. from Union College and a M.S. from Duke University, both in Electrical Engineering. His research interests include informed career decisions, mixed methods research, motivation and learning theories and intervention development.

Dr. Holly M Matusovich, Virginia Tech

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Abstract

Student motivation is an important part of a student's engagement in learning. Researchers and educators across broad educational contexts have identified and investigated a variety of specific motivation-related constructs related to learning. However, few studies have developed and tested survey instruments for measuring motivation constructs within engineering education in a valid and reliable way. This study describes the development and piloting of such a survey, situated in expectancy-value theory, through numerous steps of validity and reliability testing. The survey items consist of 35 Likert scale questions measuring attainment value, interest-enjoyment value, utility value, cost and expectation of success for students obtaining a degree in engineering. Initial development of the survey was based on previously published instruments measuring expectancy-value constructs, as well as consultation with two experts on motivation research and one expert on survey development. The survey was piloted with 219 engineering students at a large public university located in the mid-Atlantic United States. Validity of items was confirmed by factor analysis. Resulting internal consistency ratings using Cronbach's alpha produced scores higher than 0.70 in all cases, suggesting that the survey reliably measures theory constructs. Ultimately, this instrument will be useful to the engineering education community because of its potential to concisely measure all of the expectancy-value constructs (task values and expectancy of success) in engineering students. Motivation can be compared to other data such as persistence rates and measurements of career goals to better understand the decisions that students make about their engineering education and career by measuring such connections.

Introduction

Research continues to show that engineering loses talented capable individuals to other majors and careers.[1-5] Out-migration is highest after the first year but research shows that people leave engineering majors throughout the undergraduate cycle, and even as practicing professions. Moreover, due to the rigid nature of engineering curricula and requirements for professional practice, in-migration into engineering majors is limited. While some reports have suggested focusing on engineering retention primarily because there is a shortage of engineers[6-8], we argue for focusing on retention as a means to help students make informed decisions about engineering as a career choice, which includes the decision to obtain an engineering degree. For example, viewing out- and in-migration in light of developmental theories, such as Arnett[9], it is not surprising that students move between academic fields and majors as they determine what type of work they want to do long-term. In fact, career exploration is an important part of identity development.[10-12] Unfortunately, many of the people who leave engineering programs and fields report a poor fit[1-2] with engineering for a variety of reasons. This is concerning, as researchers also report that students do not actually understand what type of work they might do as engineers even into their fourth year of academic study.[13-14] This leads to questions about the type of information students need to make an informed choice about engineering as a career choice.

To begin addressing this gap, we need to understand the factors that contribute to students' choices to enter and remain in engineering programs to degree completion. Therefore, in this paper, we discuss the development of a survey instrument designed to measure student motivation to obtain an engineering degree. This survey was developed to be a tool for concisely measuring multiple motivation constructs. We broadly situate our study in motivation theory as such theories are designed to explain choices to engage in action or not.[15] Specifically, we situate our study in expectancy-value theory[16-18] which has a history of research applications related to persistence and career choices[19-20] and particularly among engineering students.[21-22]

The survey was developed by consulting existing surveys measuring different constructs in expectancy-value theory in a variety of situations. While some items from these surveys were taken and modified to fit the context of engineering, many new items were also created. These new items were developed by consulting original literature on expectancy-value theory. Validity was checked by consulting experts and through factor analysis of pilot data. Specifically, three experts were consulted in the development of survey items: one expert in survey development, and two experts in motivation theories with specific experience in theory development and the application of expectancy-value theory. Factor analysis was performed on pilot data collected from 219 undergraduate engineering students. Factors were found to align with originally defined constructs. Internal consistency was performed on each factor, with Cronbach's α values found to be above 0.70.

The survey developed in this study provides an important tool for future research. It provides for a valid and reliable method for measuring motivation to obtain a degree. Future research could implement this survey in order to compare the motivation of different populations of students, or connect existing expectancy-value constructs to theorized influencing factors such as career goals.

Background and Framework

Motivation, in its most basic terms, can be defined as the desire to participate in a task[15] and motivation theories attempt to explain how such desire is developed and enacted. For example, motivation theories address such constructs as goals[22], internal and external sources of desire[2], values related to a task, the expected outcome of a task[16-18] and belief about one's ability to perform a task.[24] To clarify our terms, we consider a theory is a big-picture idea of how a phenomenon works (expectancy-value theory offers an explanation of the entire process of choosing to perform a task) and a construct to be a single, measureable component of a theory (e.g., self-efficacy).

The pursuit of a career in engineering and the completion of an engineering degree can both be thought of as tasks, and research around them lends itself to motivation theories. Applications of motivation theories to tasks that are ultimately relevant to career choice include studies using motivation to study enrollment and persistence in engineering programs[21,26], student motivation in different curricula[27], student learning habits[28], student confidence in performing a task[29]career plans and values placed on a task[30], and student perceptions about their education.[22]

Within the motivation theories, our study specifically situated in expectancy-value theory (EVT)[16-18] for two reasons. First, EVT was developed in part to explain academic program enrollments and ultimately career choice.[31] Second, EVT contains both ability constructs (such expectancy of success) and importance constructs (such as interest). These types of constructs exist in other motivation theories, though some theories focus more on one aspect than another.

Expectancy of success is how well an individual thinks they will perform on the task in question. This construct has been shown to be similar to self-efficacy, which is an individual's belief in their ability to complete a task.[32] As the two can be difficult to separate, our survey asks questions about both and groups them together. Task value is made up of four constructs: attainment value, how participating in a task is consistent with one's sense of self; interest value, how enjoyable a task is to an individual; utility value, how useful the performance of a task is to an individual; and cost, which is how much performing the task takes away from an individual.

While Eccles & Wigfield[17, 25] have implemented survey instruments measuring expectancy-value constructs in the past, Eccles[18] notes that the ideas behind these constructs have evolved and include broader concepts than these surveys have measured. For example, a survey used in a study by Eccles & Wigfield[25] measured the attainment value that children have for attaining competence in mathematics with three items, asking children whether the effort put forth to be competent was worthwhile, whether being good at math was important, and whether getting good grades in math was important. However, Eccles[18] has more recently defined attainment value as how a task is important to one's sense of themselves and who they want to be. While the abovementioned questions may measure an aspect of that importance to their current selves, they do not address any importance to what children think they want to be. This is not to say that the survey items did not accomplish their stated goal of measuring attainment value. Instead, it highlights that there are evolving ideas within constructs, and previously existing instruments may not address ideas that were added more recently to the definition of a construct.

Another potential issue with reusing existing instruments is difference in context. Change in context has the potential to affect how a survey instrument, or items from that instrument, function.[33] In a different context, the items could actually have different meanings. Therefore, while questions measuring the attainment value that children have for exceling in mathematics could be modified to ask undergraduate engineering students about their motivation to obtain a degree, this change in wording does not necessarily produce a direct match in meaning. While the first could be interpreted as obtaining a skill, the second could be perceived as a life-choice. Such changes could significantly alter how well questions function, and thus affect the reliability with which it measures that construct.

Li, McCoach, Swaminathan & Tang[22]highlight some potential issues that can arise in creating a new set of survey items. Their study created a survey intending to measure expectancy-value task values for engineering students in the generally stated task of "being engineers". In the process of validating the survey items through factor analysis, the authors found that the way some items grouped into factors did not align with constructs that they originally intended to measure. As a result, they analyzed attainment value and intrinsic value together because items from those constructs grouped together into the same factor. Such a finding could be the result of context: perhaps, for the specific situation they were studying, these two values are the same. However, there is also the possibility that items were not worded carefully enough to be able to differentiate between these two values.

From our search of the literature, we concluded that more work is needed to develop an EVT-related survey to measure motivational factors contributing to choices to pursue engineering degrees.. We therefore set about building on existing instruments to develop a valid and reliable survey. Consistent with our framework and overall goal of developing a survey instrument, this study is guided by three research questions: 1) What aspects of existing EVT survey items should be included in a survey designed to measure student motivation to obtain an engineering degree motivation? 2) How should items be worded or reworded to fit the context and constructs being measured? 3) How valid and reliable is the instrument that was developed?

Survey Development

Item Creation

As previously mentioned, we started developing our survey by drawing on existing surveys. We used some items from the Eccles & Wigfield[25] and Jones, Paretti, Hein & Knott[30](which adapted Eccles & Wigfield), survey instruments but significantly adapted the wording to fit our context. . These include items 1, 7 and 8 in Appendix A. Some of the items developed by Li, McCoach, Swaminathan & Tang[22] on interest value, cost & utility value were also considered and rewritten, including items 4, 5, 14,15, 27, 28 and 29 in Appendix A. New items were also written. In the adaptation and development of items, definitions from recent publications overviewing research conducted with EVT constructs were closely consulted in order to ensure that items fit within the intended meaning of each construct.[18] All items were reworded or written with respect to a seven-point Likert scale ranging from strongly disagree to strongly agree.

To enhance different aspects of the validity of the new items prior to piloting, three experts were also consulted during this process. One expert, a professor of educational psychology at a large public university in the southern United States, has numerous publications on the development and implementation of motivation theories. Another expert, a professor of engineering education at the same university, has conducted and published research related to implementing expectancy-value theory constructs in an engineering education setting. These experts were consulted as an additional way of maintaining construct and content validity.[33, 34] A third expert, a professor of education at a different university in the southern United States, has taught classes and conducted research on the development of survey instruments. This expert was used to help guide the wording of survey in order to help maintain face validity[33], and also helped to suggest some methods taken to measure validity and reliability in this paper.

The resulting survey items are shown in Appendix A, grouped by their associated construct. Five items are associated with interest value, seven items with attainment value, seven items with utility value, seven items with self-efficacy/expectation of success, and nine items with cost for a total of 35 items. Once these items were finalized in expert consultation, they were piloted to conduct further validity and reliability tests. Note that the online survey also contained demographic questions and questions about engineering careers that we are not considering or discussing in this paper.

Pilot Testing

The survey was piloted over the course of two semesters on first year engineering students enrolled in common first year engineering courses at a large public university in the southern United States. The survey was implemented on Survey Monkey one semester and Qualtrics the next, but no other questions or circumstances were changed between semesters. A researcher not affiliated with classes in which the students were enrolled sent an email request for students to voluntarily participate in the survey, and the survey itself reiterated that participation was voluntary and that students could withdraw at any time. All survey protocols were IRB approved. A total of 219 students completed the survey across those semesters out of approximately 1500 possible respondents. Only surveys that were filled out completely were considered

Pilot Data Analysis

Pilot results were analyzed using factor analysis. Factor analysis consists of the process of dividing individual items into groups, called factors, that each explains a portion of the total variance of results.[35] Within the topic of factor analysis, there is a wide selection of different methods and tools that can be used, each with situational usefulness. For the actual process of factoring, one must consider between a probabilistic method for factoring (Maximum Likelihood), or a non-probabilistic method (like Principal Component Analysis or Principal Axis Factoring). While probabilistic factoring provides a measurement for goodness of fit, or how well the factors fit the observed data, it also requires that data is normally distributed to be calculated properly. Non-normal data can affect the interpretability and usefulness of results. In order to determine normality, data was visualized item by item via a histogram of Likert scale scores. As data is on a seven point Likert scale, it is inherently non-normal, being a non-continuous, discrete distribution. However, some studies still assume normality if histograms display an approximation of the characteristic bell-shaped curve of a normal distribution.[36] Visual observation in this study did not show an approximate bell-curve, and data was assumed to be non-normal. In choosing between non-probabilistic factoring methods, Costello & Osborne[36] argue that principal axis factoring (or principal factoring) is a robust choice, which led us to choose that as our factor extraction method.

The result of factor extraction is often front loaded: a great deal of variance is often explained by one or two factors containing a large number of items, while a lesser amount is explained by factors containing fewer items. In some applications where the reduction of the dimensionality of data is desired, this is preferable. However, in survey development and validation, we are often looking for items to be spread more evenly across factors. To accomplish this, a method known as factor rotation is conducted, where items are rotated in the factor space and assigned to new factors without reducing the total amount of variance explained by all of the factors combined. In choosing a method of rotation, we considered whether we expected factors to be correlated or uncorrelated. In the case of uncorrelated factors, an orthogonal rotation method is a good option, while correlated data calls for an oblique (nonorthogonal) rotation. In our study, task values and expectation of success are all components of a person's motivation to perform a task. Therefore we expect that factors will be correlated, and chose an oblique rotation method accordingly.

Costello and Osborne[36] discuss ways that researchers often choose the number of factors to analyze in factor analysis, noting that while many are accepted, none are inherently correct. To compensate for a choice that could seem arbitrary, we perform factor analysis twice choosing two different methods for choosing the number of factors. In the first method, we analyze the scree plot of our data, which Costello and Osborne[36] suggest as a good choice. This plot, shown in Figure 1, is the eigenvalue of the factor versus the factor number, with the total number of factors equal to the number of items analyzed. One accepted method of choosing the number of factors to use is to look for a discontinuity, or kink, in the plot, and use every factor *before* the kink. In this case, we find a kink in the plot between 5 and 6 factors and choose to perform factor analysis with five factors.

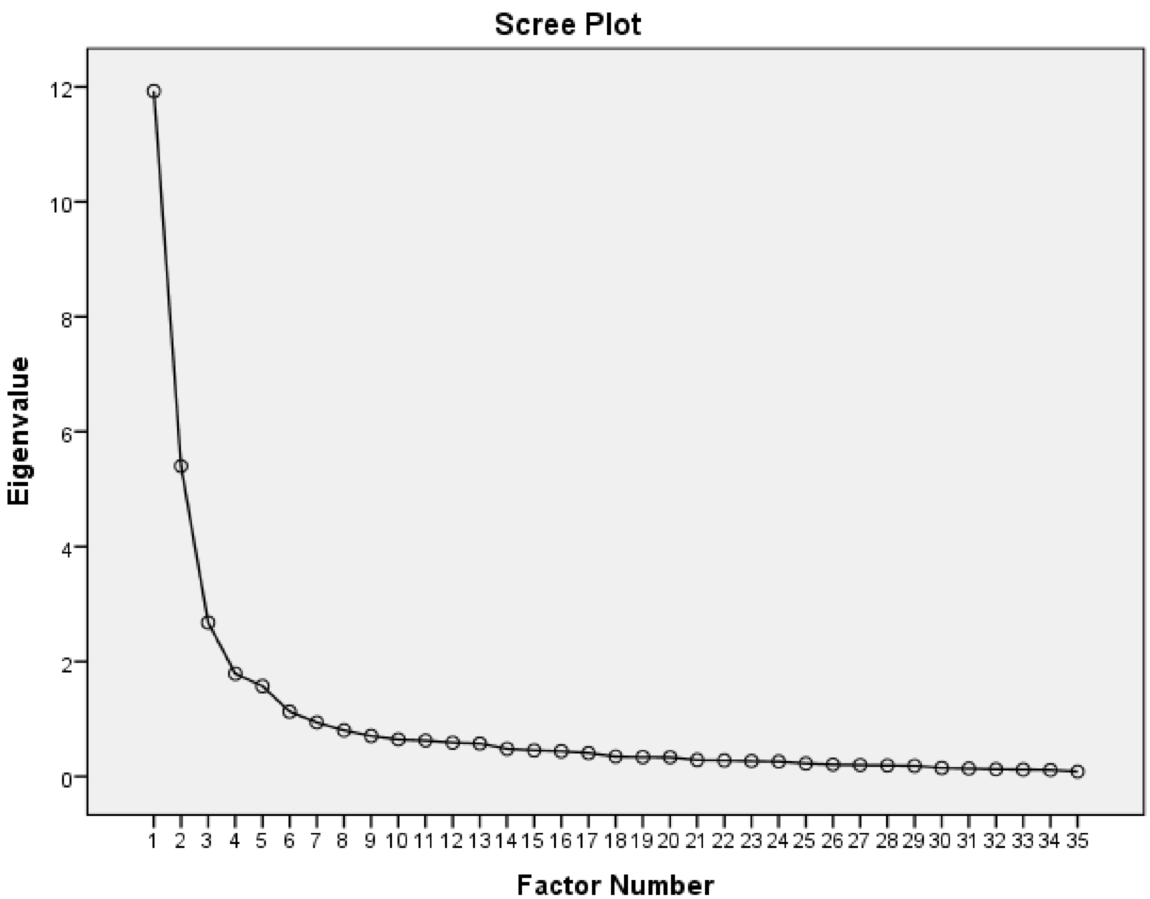

Figure 1: Scree Plot of Factors

Another method for choosing the number of factors is by examining the percent of total variance explained. Table 1 shows a table of each factor, with its eigenvalue, the associated percent of total variance explained (the eigenvalue over the sum of eigenvalues), and the associated cumulative percentage of total variance. This table was cut off at variables that explain 1% or more of the total variance to save space. Some conventions suggest choosing factors such that all of the factors have an eigenvalue of one or greater, while others suggest choosing a number of factors that explain a certain amount of the total variance.[22, 36, 37] Costello & Osborne note that these methods are generally less accurate, especially those using the eigenvalue rule.[36] To find an approximate middle ground between these two rules of thumb, we chose seven factors for our second factor analysis, which chooses factors that explain more than 70% of the variance and have eigenvalues of approximately one (0.941) and greater.

Table 1: Eigenvalues and Percent of Variance

Factor	Eigenvalue	% of Variance	Cumulative %
1	**11.927**	**34.078**	**34.078**
2	**5.401**	**15.432**	**49.509**
3	**2.678**	**7.651**	**57.161**
4	**1.788**	**5.108**	**62.269**
5	**1.572**	**4.493**	**66.762**
6	**1.128**	**3.224**	**69.985**
7	**.941**	**2.687**	**72.672**
8	.803	2.295	74.968
9	.705	2.014	76.982
10	.645	1.842	78.824
11	.626	1.790	80.614
12	.587	1.678	82.292
13	.573	1.638	83.931
14	.479	1.370	85.300
15	.454	1.297	86.598
16	.439	1.255	87.852
17	.407	1.163	89.016

Tables 2 and 3 show the results of the first factor analysis with rotation. Rotation of factors produces two different matrices: the pattern matrix and the structure matrix. The pattern matrix shows how well each item predicts each factor (similar to a regression), while the structure matrix shows how well each item correlates to each factor. On the right side of each table, the construct originally associated with the item is shown for reference. Values lower than 0.5 are blanked to make the tables easier to view.

Examining the pattern matrix for five-factor analysis, items originally from interest and attainment value are found to predict Factor 1, a portion of the cost questions predict Factor 2, self-efficacy/expectation of success questions predict Factor 3, the remaining cost items predict Factor 4, and a portion of the utility value questions predict Factor 5.

The structure matrix reveals that interest and attainment value items, along with one utility value item, are correlated with Factor 1, Factors 2 and 4 retain their association with different cost items, and Factor 3 remains associated with self-efficacy/expectation of success, along with one item each of interest and attainment, while Factor 5 is correlated with an array of items from attainment and utility.

Tables 4 and 5, similar in layout to Tables 2 and 3, show the pattern and structure matrices for the factor analysis run with seven factors. Once again, we see items from cost breaking up and predicting two factors (2 and 6), and self-efficacy/expectation of success predicting a factor (3). Items from attainment and interest that originally predicted the same factor in five-factor analysis split up, with interest items and one attainment item predicting a factor (1) and attainment items and one utility item predicting another (7). The remaining factors are predicted by two utility items each (4 and 5). The structure matrix reveals that interest, attainment and utility items combine to correlate with two factors (1 and 7), while the remaining constructs split up in a similar manner to the pattern matrix.

Reliability measurements were conducted through the Cronbach's α test for internal consistency. While values of 0.80 and above are generally regarded as reasonable for this test[33], surveys are sometimes considered sufficiently reliable with values of 0.70 or even slightly below.[25] If we simply perform reliability measurements on our survey items broken down by original construct, we find that interest value items have a score of 0.900, attainment value scores 0.877, utility value scores 0.828, self-efficacy/expectancy of success scores 0.910 and cost scores 0.893. Looking at some of the more distinctive factor breakdowns, we find that the two cost factors (2 and 4 in five-factor analysis) score 0.915 and 0.910 respectively, while the factors that were each predicted by two utility-value items each in seven-factor analysis (4 and 5) had scores of 0.761 and 0.797 respectively. Table 6 shows factor-specific reliability breakdowns for the five-factor analysis, containing only items with values of 0.5 or greater in Table 2.

Discussion

This study aimed to explore three research questions. The first was: What aspects of existing EVT survey items should be included in a survey designed to measure student motivation to obtain an engineering degree motivation? To address this question, we examined surveys that have used expectancy-value theory in engineering education, along with original expectancy-value theory surveys developed by Eccles & Wigfield.[17, 22, 25, 30] Items from these surveys were then compared to current construct definitions from expectancy-value theory[18], and adapted if they still fit within those definitions and the context of the survey.

To answer the second question, "How should items be worded or reworded to fit the context and constructs being measured?", new and old items were compared to expectancy-value literature in order to maintain consistency with construct definitions. Experts in motivation theories were also consulted to further this consistency with constructs.

The final question, "How valid and reliable is the instrument that was developed?" was addressed in a number of ways. The methods discussed in the above paragraphs contributed to construct and content validity, while consulting a third expert in survey development helps preserve face validity. Further validity was gained through factor analysis. We conclude that our

Table 2: Pattern Matrix, Five Factors

Item	Factor 1	2	3	4	5	Construct
1	.722					Interest
2	.847					Interest
3	.776					Interest
4	.597					Interest
5	.845					Interest
6	.790					Interest
7	.578					Attainment
8	.729					Attainment
9						Attainment
10						Attainment
11	.510					Attainment
12						Attainment
13						Utility
14					-.536	Utility
15						Utility
16					-.765	Utility
17					-.685	Utility
18					-.650	Utility
19						Utility
20			.865			SE/Exp
21			.865			SE/Exp
22			.779			SE/Exp
23			.861			SE/Exp
24			.734			SE/Exp
25			.662			SE/Exp
26			.569			SE/Exp
27				-.661		Cost
28				-.621		Cost
29				-.725		Cost
30		.579				Cost
31		.558				Cost
32		.897				Cost
33		.930				Cost
34		.701				Cost
35		.852				Cost

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

Table 3: Structure Matrix, Five Factors

Item	Factor 1	2	3	4	5	Construct
1	.723					Interest
2	.890					Interest
3	.858		.518			Interest
4	.563					Interest
5	.835					Interest
6	.831					Interest
7	.740		.507			Attainment
8	.810					Attainment
9	.650				-.580	Attainment
10	.702				-.658	Attainment
11	.731				-.693	Attainment
12	.507					Attainment
13	.662				-.628	Utility
14					-.587	Utility
15					-.599	Utility
16					-.832	Utility
17					-.660	Utility
18					-.714	Utility
19	.543					Utility
20			.861			SE/Exp
21			.818			SE/Exp
22			.830			SE/Exp
23			.880			SE/Exp
24			.762			SE/Exp
25			.752			SE/Exp
26			.600			SE/Exp
27				-.745		Cost
28				-.715		Cost
29				-.763		Cost
30		.662				Cost
31		.681		-.566		Cost
32		.873				Cost
33		.926				Cost
34		.759				Cost
35		.853				Cost

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

Table 4: Pattern Matrix, Seven Factors

Item	Factor 1	2	3	4	5	6	7	Construct
1	.728							Interest
2	.644							Interest
3	.648							Interest
4	.592							Interest
5	.819							Interest
6	.637							Interest
7								Attainment
8	.531							Attainment
9								Attainment
10							-.611	Attainment
11							-.777	Attainment
12								Attainment
13							-.630	Utility
14				-.656				Utility
15				-.788				Utility
16								Utility
17					-.791			Utility
18					-.703			Utility
19								Utility
20			.827					SE/Exp
21			.834					SE/Exp
22			.731					SE/Exp
23			.838					SE/Exp
24			.719					SE/Exp
25			.652					SE/Exp
26			.607					SE/Exp
27						.809		Cost
28						.702		Cost
29						.706		Cost
30		.556						Cost
31		.572						Cost
32		.913						Cost
33		.933						Cost
34		.736						Cost
35		.872						Cost

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

Table 5: Structure Matrix, Seven Factors

Item	Factor 1	2	3	4	5	6	7	
1	.753							Interest
2	.847						-.704	Interest
3	.836						-.623	Interest
4	.586							Interest
5	.860						-.535	Interest
6	.802						-.625	Interest
7	.681						-.641	Attainment
8	.762						-.648	Attainment
9	.564						-.669	Attainment
10	.580						-.804	Attainment
11	.582						-.904	Attainment
12							-.556	Attainment
13	.541						-.784	Utility
14				-.703				Utility
15				-.862				Utility
16				-.637	-.602		-.572	Utility
17					-.823			Utility
18					-.789			Utility
19	.559							Utility
20			.854					SE/Exp
21			.816					SE/Exp
22	.501		.825					SE/Exp
23			.882					SE/Exp
24			.764					SE/Exp
25			.746					SE/Exp
26			.617					SE/Exp
27						.835		Cost
28						.772		Cost
29						.747		Cost
30		.668						Cost
31		.697				.597		Cost
32		.876						Cost
33		.922						Cost
34		.776						Cost
35		.857						Cost

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

Table 6: Cronbach's α Scores (5 Factors)

Factor				
1	2	3	4	5
0.928	0.915	0.829	0.91	0.716

survey measures five constructs from expectancy-value theory: attainment value, interest value, utility value, cost and self-efficacy/expectation of success, and cost. Cost's breakdown into two factors could be contextual: the questions asked here about cost were of a more specific nature than previously constructed survey mentioned here. As the items in both factors still fit the definition of cost, and because items from other constructs did not load onto these factors, we conclude that both factors are simply different aspects of the cost construct. Self-efficacy and utility value generally broke down into theirown factors, and while attainment value and interest were more difficult to separate, we argue that there is sufficient rationale to keep them as different constructs as well.

Li et al.[2] also encountered difficulties with original item constructs not completely aligning with factors. In that study, the authors noted that items originally in attainment and intrinsic value combined into a single factor. Both factor analyses performed in this study show that items originally written from those two constructs tend to be associated with the same factors in prediction and correlation (pattern and structure matrices). However, factor analysis with 7 factors show that those items can predict different factors. As the construct definitions for interest (enjoyment of a task) and attainment (the task fitting in with one's sense of self) are of similar nature, this is not entirely unexpected. Also note that, in seven factor analysis, interest value items were generally more strongly correlated with one factor (Factor 1, Table 5), while attainment value items were generally more strongly correlated with the other (Factor 7, Table 5). These results, combined with the measures taken to preserve validity in survey development, suggest that these items can still be used to measure their intended constructs.

Li et al. also observed utility value splitting into two factors which they labeled individual and societal utility. While five-factor analysis places most utility value items into the same factor for prediction, we also see a split in prediction in seven-factor analysis. The two items that most predict each factor are related to money and work for Factor 4 and society and opportunity related to Factor 5, respectively, representing a similar breakdown to the one seen in Li et al.[22] However, as the method used to select the number of factors in five-factor analysis (scree plot) is generally considered more accurate than the method used in seven-factor analysis (eigenvalues and % of variance)[36], we interpret the overall results of factor analysis as showing that most utility value questions can be used to describe the same factor. Two of the items (13 and 19) developed for utility value did not strongly predict that construct in either factor analysis, and were found to be more correlated with factors that contained items from others constructs, and will likely be excluded in future research. The remaining utility value questions produce a Cronbach's α of 0.792.

In both factor analyses, we also observed a breakdown of items associated with cost, with items breaking down into the same factor predictions each time. The item breakdown shows that items 27-29, which ask about difficulty of a task and effort, break down into predicting one factor, while items 30-35, asking about removing things that an individual enjoys or making an individual less healthy, break down into predicting the other factor. This breakdown, while not expected, makes sense in terms of the wording of the items. The fact that this breakdown hasn't been reported before could be the result of our survey asking more detailed questions about cost relating to different aspects of that construct (or possibly two sub-constructs). However, as no other items were associated with these factors, we conclude that the items as a whole are a valid measurement of cost.

In both factor analyses, self-efficacy/expectation of success questions was found to predict the same factor. When combined with measures taken in survey development, we take this as evidence that these items all measure the same construct.

All internal constancy scores with items grouped original constructs were above 0.8. As noted above, the exclusion of two possibly faulty items from utility value takes this value to 0.792 for that construct. While some item groupings from factor analysis produce lower values of internal consistency, those values are still above 0.700. Thus, our survey can measure each construct with reasonable reliability.

The primary limitation of our study is the sample, which is limited in both size and scope. Our response rate of slightly less than 15% means that our sample population may not be representative of the population of students that the survey was sent to. Unfortunately, because of how data collection was conducted, it is not possible to know exactly how the population of non-responding students differs from the students who responded to the survey. Our study also only draws from a population of first year engineering students at a single academic institution, enrolled in a specific introduction to engineering curriculum, and may not be an accurate representation of all engineering students.

While there are a number of ways to assess validity, we argue that we have done enough to show that our survey is valid on a number of fronts. Moskal, Leydens & Pavelich[38] discuss four types of validity: construct validity, content validity, criterion validity and consequence validity. Construct validity is how well an instrument measures a construct, and whether that construct is measured with sufficient depth. In this study, we show this type of validity through adapting and developing multiple questions per construct, aimed at measuring different aspects of how those constructs were originally defined and consulting experts whether those items match the constructs they were intending to measure. Finally, further construct validity is shown through factor analysis.

Content validity is how much an individual's responses to certain items reflect the construct the items intend to measure. Messik[39] notes that construct and content validity are typically shown through similar methods. Thus, the methods discussed for construct validity above also help to show content validity. However, future work could improve content validity of this survey by interviewing students who have responded and matching their interpretation of items to the intended meaning of items.

Criterion validity is how well a measurement correlates with an event that such a measurement is intended to predict. No steps were taken to show criterion validity in this study, as no assumptions were made about the relationship of the constructs measured to any other events a respondent might be going through. If, in future research, such an assumption is made, steps will need to be taken to show criterion validity.

Finally, consequence validity is whether an item avoids context-related differences in how users will respond. For example, set of items that uses words that illicit race may cause differences in response based on race. To address this type of validity, we ensured that items remained neutrally worded so as not to illicit responses based on anything outside of experiences in engineering. However, we did not consider the effect that initial demographic questions may have had on responses, and will likely do so in future work.

In this paper, we have discussed the development of a survey that measures students' motivation to obtain an engineering degree. Through steps taken in survey development and in pilot data analysis, we conclude that the survey items can be used to measure constructs within expectancy-value theory. However, we believe validity and reliability testing should continue. This survey will be used in future work relating student motivation to obtain an engineering degree to other factors that are possibly related to that decision, including career goals, to better understand the decisions that students make about their engineering degree and career.

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Appendix A

Interest Value

1. I find engineering coursework interesting.
2. I like engineering.
3. Solving challenging engineering problems is rewarding.
4. I like design projects.
5. Engineering is exciting.
6. Engineering is an intellectually rewarding field of study.

Attainment Value

7. The amount of effort it will take to get my engineering degree is worthwhile to me.
8. Being good at solving engineering-related problems is important to me.
9. Getting an engineering degree is essential to being the person that I want to become.
10. I am becoming an engineer by working towards my degree.
11. I want to become an engineer.
12. I am an engineer.

Utility Value

13. An engineering degree is useful to my career plans after graduation.
14. Engineers make a lot of money.
15. An engineering degree leads to good working opportunities.
16. Obtaining an engineering degree will make my life better.
17. Having an engineering degree gives a person higher status in society than other undergraduate degrees.
18. A person that holds an engineering degree has more opportunities to succeed.
19. Through my engineering coursework, I learn things that are useful to me in my everyday life.

Self-Efficacy/Expectation of Success

20. I am confident in my ability to complete basic math and science requirements for an engineering degree.
21. I am confident in my ability to excel in basic math and science requirements.
22. I am confident in my ability to excel in my current engineering coursework.
23. I am confident in my ability to excel in future engineering coursework.
24. Compared to other students, I expect to do better than average in my engineering coursework.
25. I believe I can learn the necessary skills to obtain an engineering degree.
26. I have the necessary skills to obtain an engineering degree.

Cost

27. Engineering programs are difficult.
28. Engineering is a tough career.
29. Earning an engineering degree takes a lot of effort.
30. Getting an engineering degree takes me away from things I enjoy.
31. I am often stressed out by coursework.
32. My coursework prevents me from being physically healthy.
33. My coursework prevents me from being mentally healthy.
34. I am often exhausted after completing my coursework.
35. I have little time to do anything but my coursework.