Further Examination of the Engineering Students' Motivational Beliefs Scale

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Construct Validation of the Engineering Students' Motivational Beliefs Scale: Findings and Future Directions

Previous research has shown that engagement in a task is directly linked to a person's motivational beliefs[1]. Motivational theories have been incorporated into domains like psychology and education for decades in order to help explain student performance in many different areas [1][2][3]. Recently, researchers in engineering education have used the Expectancy-Value Theory of motivation to assess academic and achievement behaviors in students [4][5][6][7]. Specifically, motivation theories have been used to assess the probability of a student's intention to leave a given field or major [4][6]. Due to the attrition problem that affects about 50% of engineering students in universities across the country [8][9], the use of motivational theories could prove to be a useful tool in further exploring the attrition issue and finding answers. As part of a larger research program, the current study attempts to validate an instrument, the Engineering Students' Motivational Beliefs Scale (ESMBS), through the use of the Benson's Model of Construct Validation [10]. The development of the ESMBS is based on an Expectancy, Value, and Cost framework of motivation and assesses students' motivational beliefs in the context of engineering education [11]. Because preliminary data yielded mixed findings regarding the internal consistency of some of the subscales[11], the paper herein serves to show findings from a second administration of the instrument, along with inter-correlations between items and future directions for the development of the ESMBS, in attempts to further examine these psychometric issues. The researchers believe that a bigger sample size was needed in order to make any claims about the functioning of the ESMBS items, thus the need for a new larger study.

The Expectancy-Value Cost (EVC) model was created under the umbrella of the Expectancy Value Theory (EVT) of motivation, which has been a major theory for researching achievement related behaviors in many different educational domains [2][3]. EVT posits that motivation towards a specific activity or domain is driven by a person's expectations of obtaining a specific goal and the value that one ascribes to said goal [12]. The main components of EVT, *expectancy* and *value*, are believed to impact motivation and have shown to be very useful in research on academic behavior [13]. The first component, *expectancy*, refers to the expectancy that a person has for being successful at a given task. The second component deals with the *value* ascribed to the specific task, and can be broken down into four subcomponents; interest, attainment, utility, and its moderator, cost [14]. *Interest value* is described as having interest for engaging in a task or gaining a significant experience from being involved with a task. *Attainment value* refers to the importance that one places in succeeding on a task, while *utility value* is the usefulness of engaging in a task. Finally, *cost* is conceptualized as the effort associated with engaging in an activity. Cost, the divergent value subcomponent, was further broken down into loss of valued alternatives, perceived effort, and psychological cost [2]. *Loss of valued alternatives* was described as the loss of the ability to engage in other valued activities due to engaging in a specific activity. *Perceived effort* is thought of as the amount of effort that must be put forth to succeed in a task, and *psychological cost* refers to the anxiety for the potential failure associated with the task.

After years of utilizing EVT to study student motivation, researchers discovered that *cost* should actually be considered as a separate entity from value, as it greatly differs from the other value components and shares a unique relationship with motivation [3][15]. After further examination of cost and its relationship to both expectancy and value, it was found that there was no support, be it conceptual or empirical, to keep cost as a mediator of value [3]. Thus, the EVC model was created in an effort to further understand how cost influences motivation through a stringent framework grounded in motivation theories. Further work with cost has even shown a newer fourth subcomponent of cost, *outside effort cost*, which refers to the amount of effort needed to participate in activities unrelated to the target activity [16]. Interestingly, the effort cost components have been shown to be perceived differently depending on if the task was motivating or demotivating [16]. For example, with demotivating tasks, effort put forth is viewed as negative, while effort put forth for motivating tasks can be viewed as positive. This finding had significant implications for measuring cost, as this construct could be viewed differently depending on the context or on how the effort items are worded [3].

Research utilizing the EVC model has shown that each component has a specific relationship with both motivation, and the other components of the model [1][3][11]. Specifically, both expectancy and value are believed to be positively related to motivation and to each other, such that as expectancies increase, so do values [2]. Cost, in contrast, has been shown to share a negative relationship with expectancies and values. Thus, as costs increase, expectancies, values, and motivation has been shown to decrease [3][2]. While these relationships seem to have consensus within the domain of education, seminal researchers have actually proposed a curvilinear relationship between task difficulty, which refers to the effort and perception of the difficulty for a task, and other motivational constructs, meaning that small or large amounts of effort are paired with low motivation, while a medium amount of effort results in high motivation [2][12][14]. This relationship has been shown to hold true in certain situations and for specific individuals, such as the case of competitive athletes [17]. More recently, research within the field of engineering education suggests that cost, specifically effort and sacrifice, is sometimes positively related to motivation [5][7][11].

Motivation theories have gained popularity in engineering education research, specifically due to the contributions they make to predicting achievement related behaviors. Many engineering education researchers have attempted to create instruments utilizing EVT [6][4][18][7]. To the best of our knowledge, though, only the current research team has utilized EVC to create an instrument to measure students' motivational beliefs [11] and to call out cost and its multiple facets explicitly. Thus, while many of the EVT-based instruments have yielded interesting results, they do not incorporate the latest findings in regards to the cost construct, and therefore might not accurately be measuring all aspects of cost. The current study attempts to further develop the ESMBS, an instrument utilizing EVC to assess engineering student motivation, and to further explore the relationship between different motivational constructs and how they might behave in the context of engineering.

For this study, the Engineering Students' Motivational Beliefs Scale (ESMBS), an instrument assessing students' motivational beliefs, was administered to engineering students in attempts to continue the construct validation process. This instrument is grounded in an Expectancy, Value, and Cost framework, and contains questions that pertain to each aspect of this framework. For example, the ESMBS contains 3 questions assessing students expectancies for doing well in the major, 5 questions assessing students' perceptions of the value associated with the engineering major and profession, and 4 questions pertaining to students' perceptions of the costs associated with the engineering major.

I. Theoretical Framework for Construct Validation of the ESMBS and Previous Work

The ESMBS has been undergoing construct validation using the Benson's model. This specific model of construct validation is comprised of three different phases: substantive, structural, and external [10]. During the substantive phase, a literature review was conducted in order to theoretically and empirically define the constructs of expectancy, value, and cost, in the context of engineering education [11]. Items were then created using the operational definitions of each construct and content experts reviewed the items to ensure they applied to the specific context of engineering education. Next, two think-aloud procedures were conducted with engineering students for evaluating sources of response error. The items were edited based on the feedback of the content experts and students. The ESMBS was administered to a group of engineering students in order to move to the next stage of instrument development, the structural stage. Psychometric information was examined, including inter-correlations between each item and correlations between each item and its' respective subscale. This process allowed researchers to examine the consistency of the measure, although due to a small sample size conclusions about the functioning of the individual items could not be drawn. Finally, during the external phase of construct validation, the ESMBS items were correlated with a measure of student engagement to determine if the items were related as described by previous literature and theory to the construct of student engagement. It was found that items were not relating to student engagement as expected based on previous literature. The researchers believed that this could either be due to the small sample size used in the study, the wording of the questions in the ESMBS being misinterpreted, or the student engagement scale not measuring all of the factors that contribute to that construct [11].

II. The Current Study

In order to continue the effort to validate the ESMBS, a new round of the phases of the Benson's model was conducted, with a larger sample size. During this new administration, the substantive phase was focused on reviewing the literature again (summarized above) to determine if any new research in this area had been conducted. Due to the small sample size of the previous study and the inability to truly assess the internal consistency of the instrument, the research team decided to not modify any of the items at this point. The working definitions from the previous study that served as a base for the item are presented below (Table 1). Researchers believed that by conducting the same study with a larger sample size, we would be able to see if patterns that emerged in preliminary data would still hold true.

TABLE 1. Operational Definitions of the ESMBS constructs

ESMBS Construct	Working Definitions
Expectancy- General	The confidence that engineering students have in their current and future abilities to do well in the engineering major.
Value- General	Positive beliefs about engineering as a field of study and as a profession.
Value - Attainment	The importance students assign to being engineering students or becoming engineers.
Value - Interest	Level of interest students have for the engineering major.
Value - Utility	Usefulness that students grant to engineering as a major and as a profession.
Cost- General	Sacrifices in time and other resources students have to make in order to do well in engineering, including the drawbacks related to student involvement in the major.
Cost - Loss of valued alternatives	Sacrifices that students need to make in order to do well in the engineering major.
Cost - Effort related to engineering	Effort students require to allot to the engineering major related activities in order to do well in the major.
Cost - Effort not related to engineering	Effort or time expended in activities not related to engineering.
Cost - Psychological cost	The mental stressors associated with the major.

During the second round of the structural phase, the ESMBS was administered to a larger sample of engineering students, and intercorrelations between items were calculated in order to examine preliminary information regarding the structure of the ESMBS. Finally, during the second round of the external phase, the relationship between the ESMBS constructs and student engagement was evaluated in order to see if the constructs were related as expected.

III. Structural Construct Validation Phase – Psychometric Properties of the ESMBS

Psychometric properties of the ESMBS were examined using several statistical analyses, including Cronbach's alpha, item-to-item correlations, and item-to-subscale correlations. Pearson's correlations were used to determine the relationships between different items and between items and their corresponding subscales. Confirmatory Factor analysis was not conducted due to an inadequate sample size.

1) Participants and methods

For the current study, the ESMBS was administered to 101 engineering students at a mid-Atlantic University via an online survey using Qualtrics software. After removing 6 participants who either did not pass the manipulation check or did not take sufficient time to complete the survey, the final sample included 95 students, 27 of which were freshman, 9 were sophomores, 38 were juniors, and 21 were seniors. Of these 95 students, 72 were male and 23 were female. The manipulation check presented students with a list of engineering courses that they may have taken, with a check box next to each course. Students were given the instructions to ignore the boxes, and instead click the continue button at the bottom of the page. Students who did not follow directions and checked off any of the courses listed were categorized as not passing the manipulation check and were believed to have not fully read all directions in the survey. Students were emailed the link to the online survey (using Qualtrics) and were compensated a dining voucher, redeemable at any dining facility on campus, worth $10.50. After participants completed the survey, researchers checked for response bias, ensuring no one simply marked the same response throughout the survey. Researchers also ensured that each participant took sufficient time, minimum 5 minutes, to complete the survey.

2) Results and discussion

Prior to examining the relationships between the instrument's items and their respective subscales, the data was examined to determine normality. Suggested levels for skewness |2| and kurtosis |7| set forth by Finney and Distefano were met, as all ESMBS items fell within these acceptable ranges (Table 2)[19]. The normality of the data, along with the sufficient sample size, indicates that there was no need to conduct non-parametric analyses.

TABLE 2. Descriptive Statistics for ESMBS items

Item-Level Descriptive Statistics					
Items	***Range (actual)***	***M***	***SD***	***Skewness***	***Kurtosis***
Exp 1	4 - 7	5.51	1.08	-0.40	-1.26
Exp 2	3 - 7	5.42	1.11	-0.85	-1.01
Exp 3	2 - 7	5.09	1.08	0.65	-0.37
Value 1	3 - 7	6.25	1.00	-1.38	1.40
Value 2	2 - 7	5.82	1.31	-0.93	-0.09
Value 3	3 - 7	6.08	0.93	-0.89	0.43
Value 4	3 - 7	6.34	0.97	-1.43	1.26
Value 5	4 - 7	6.18	0.93	-0.84	-0.31
Cost 1	3 - 7	5.59	1.07	-0.45	-0.46
Cost 2	4 - 7	6.39	0.85	-1.48	1.64
Cost 3*	1 - 7	2.79	1.25	0.38	-0.22
Cost 4	3 - 7	5.39	1.15	-0.30	-0.82
* Cost item 3 is the only item negatively worded.					

To determine internal consistency for the items associated with the three constructs, expectancy, value, and cost, Cronbach's alpha was calculated. The internal consistencies for the ESMBS subscales were .83, .71, and .45 (expectancy, value, and cost). The expectancy subscale appears to meet the acceptable cutoff of .70 [20], while the value subscale just barely meets Kline's acceptable range. Cost, however, falls short of meeting the acceptable range, showing that the internal consistency for this subscale is unsatisfactory (Table 3). Interestingly, compared to the first administration of the scale, the internal consistency of value dropped from .87 to .71, though this subscale still meets the internal consistency cutoff. Cost, however, showed a significant drop in internal consistency, and went from being in the acceptable range (.71) to no longer having acceptable internal consistency (.45). With these results in mind, it is important to note that all cost findings for this study should be taken lightly and the low internal consistency of this subscale should be kept in mind while interpreting these results. The low internal consistency of cost could be due to a number of factors, which will be discussed below.

TABLE 3. Correlations between items and their respective subscale totals

Pearson's correlations between expectancy, value, and cost items and their subscale total			
Items	**Pearson's r_s (effect size r_s^2)**		
	Expectancy Total	***Value Total***	***Cost Total***
Expectancy1	.870* (**0.757**)	—	—
Expectancy2	.891* (**0.794**)	—	—
Expectancy3	.823* (**0.677**)	—	—
Value1	—	.753*(**0.567**)	—
Value2	—	.767* (**0.588**)	—
Value3	—	.636* (**0.404**)	—
Value4	—	.623* (**0.388**)	—
Value5	—	.618* (**0.382**)	—
Cost1	—	—	.665* (**0.442**)
Cost2	—	—	.621* (**0.386**)
Cost3	—	—	.435* (0.189)
Cost4	—	—	.772* (**0.596**)

** Statistically significant results at .01. Cohen's recommendation for categorizing ρ effect sizes for the social sciences: 0.1 is small, 0.3 is medium, and 0.5 is large* [21]. *Medium to large effect sizes have been bolded.*

In order to assess if the items were related as predicted by motivation theory, the researchers conducted intercorrelation analyses between items (Table 4). Items should be highly correlated with other items measuring the same construct, and moderately correlated with items pertaining to other constructs. As per previous literature, we would predict that the expectancy, value, and cost items would be more related to items in their own subscale in comparison to items from another subscale. When reviewing the intercorrelation matrix, we see that expectancy items have strong significant positive correlations with each other, indicating that these items might be measuring the same construct. In the case of the value construct, although many value items share significant relationships with each other these correlations are considered weak to moderate by Cohen's benchmarks (Table 4)[21]. Similar findings were observed during the first administration, where the majority of value items had positive correlations among each other. However, the correlations from the current administration are certainly weaker. In that sense, the current findings call for an evaluation of the value items to see if there are problematic items that are not truly representing the value construct. The need for an evaluation of the value items is further supported when observing the correlations between value and expectancy. Value items 1 and 2 are significantly related to most expectancy items, and these relationships are both positive and moderate. These relationships are consistent with previous findings from EVT research. In contrast, value items 4 and 5 share no significant relationships with the expectancy items, and value 3 is only significantly correlated with the first expectancy item. While the expectancy and value constructs should not share strong correlations, they should be at least moderately correlated with each other. During the first administration we could observe some of the patterns described here [11]. Specifically, although the correlations between the expectancy and value items were practically significant, only some of them were statistically significant. Furthermore, some of these correlations were even stronger than correlations observed within the value construct. This does not coincide with previous findings pertaining to EVT [1][3] and requires a revision of the items.

The cost items also produced interesting results, as most cost items were not significantly related, and some cost items had relationships that trend in the negative direction (Table 4). Cost item 2 and 3 even share a significant negative correlation (-.212), such that as efforts related to engineering increase, efforts not related to engineering decrease. These results were found after reverse scoring cost item 3, which was negatively worded. Without the adjustment of the item, we would expect a negative correlation between cost 2 and the other cost items, though since we did reverse score this item, these results are not consistent with previous literature. During the first administration of the survey a similar pattern emerged within the cost construct…

In terms of the relationship between the constructs, perhaps the most interesting finding pertains to cost items 1 and 2, which measure sacrifice and effort pertaining to engineering. These two items are positively correlated with all expectancy and all value items, though only some of these are statistically significant. This indicates that as sacrifice and effort increase, so do some aspects of expectancy for succeeding at a task and the value placed on the task. While this is not the norm for the majority of EVT and EVC research, this is not the first time such findings have been reported. Such findings have given rise to the argument that in some cases, and for specific individuals, a curvilinear relationship between cost and other motivational constructs may exist [11][12]. Cost items 3 and 4 were all negatively correlated with the expectancy items, as expected, although some of these relationships were not significant. This relationship shows that as outside effort and psychological cost increase, expectancies to do well decrease, though this relationship may not be statistically significant due to the low internal consistency of this subscale. Cost item 3 was also negatively correlated with all value items, as expected, though again, not all relationships were statistically significant. This again could be due to the low internal consistency of the cost subscale. Finally, only one of the value items, value 2, was negatively correlated with cost 4, though this relationship was not significant. The positive relationships between the cost items and the expectancy and value items appear to be problematic, as they do not match what theory would predict. These results should be taken lightly though, as there are psychometric issues with the cost subscale.

TABLE 4.
Inter-item Correlations

Pearson's Correlations of The ESMBS Items												
Items	***1.***	***2.***	***3.***	***4.***	***5.***	***6.***	***7.***	***8.***	***9.***	***10.***	***11.***	***12.***
1. Expectancy 1	1.000	–	–	–	–	–	–	–	–	–	–	–
2. Expectancy 2	.710**	1.000	–	–	–	–	–	–	–	–	–	–
3. Expectancy 3	.541**	.588**	1.000	–	–	–	–	–	–	–	–	–
4. Value 1	.304**	.326**	.243**	1.000	–	–	–	–	–	–	–	–
5. Value 2	.184	.257*	.237*	.554**	1.000	–	–	–	–	–	–	–
6. Value 3	.381**	.141	.150	.377**	.387**	1.000	–	–	–	–	–	–
7. Value 4	.170	.055	.121	.316**	.181	.309**	1.000	–	–	–	–	–
8. Value 5	.152	.153	.162	.293**	.330**	.129	.412**	1.000	–	–	–	–
9. Cost 1	.034	.067	.126	.308**	.137	.185	.134	.149	1.000	–	–	–
10. Cost 2	.073	.095	.063	.444**	.167	.373**	.310**	.165	.551**	1.000	–	–
11. Cost 3	-.521**	-.491**	-.553**	-.384**	-.375**	-.370**	-.143	-.077	-.098	-.212*	1.000	–
12. Cost 4	-.254	-.214	-.184	.145	-.807	.068	.232*	.123	.313**	.417**	.177	1.000
*Note: *p < .05, **p < .01*												

In terms of relationships between constructs, value items 1 and 2 are significantly related to most expectancy items, and these relationships are both positive and moderate. These relationships are consistent with previous findings from EVT research. In contrast, value items 4 and 5 share no significant relationships with the expectancy items, and value 3 is only significantly correlated with the first expectancy item. While the expectancy and value constructs should not share strong correlations, they should be at least moderately correlated with each other. Perhaps the most interesting finding pertains to cost items 1 and 2, which measure sacrifice and effort pertaining to engineering. These two items are positively correlated with all expectancy and all value items, though only some of these are statistically significant. This indicates that as sacrifice and effort increase, so do some aspects of expectancy for succeeding at a task and the value placed on the task. While this is not the norm for the majority of EVT and EVC research, this is not the first time such findings have been reported. Such findings have given rise to the argument that in some cases, and for specific individuals, a curvilinear relationship between cost and other motivational constructs may exist [11][12]. Cost items 3 and 4 were all negatively correlated with the expectancy items, as expected, although some of these relationships were not significant. This relationship shows that as outside effort and psychological cost increase, expectancies to do well decrease, though this relationship may not be statistically significant due to the low internal consistency of this subscale. Cost item 3 was also negatively correlated with all value items, as expected, though again, not all relationships were statistically significant. This again could be due to the low internal consistency of the cost subscale. Finally, only one of the value items, value 2, was negatively correlated with cost 4, though this relationship was not significant. The positive relationships between the cost items and the expectancy and value items appear to be problematic, as they do not match what theory would predict. These results should be taken lightly though, as there are psychometric issues with the cost subscale.

To more fully understand how the items across the three proposed subscales relate to one another, researchers would need a large enough sample size in order to conduct a confirmatory factor analysis. This analysis would allow the researchers to determine if the proposed three- factor model fit better than alternative theoretical models. Next, as this is the second time that these findings related to cost were obtained using this specific instrument, it may be important to maintain the hypothesis that cost might behave differently in the culture of engineering, and that not all costs are perceived as negative[11]. Specifically, related effort is not always been perceived as negative, as shown in qualitative research [15][22][23]. This positive interpretation of sacrifice and effort may hold true in the context of engineering, which, as previously described, is a culture that values hard work, and the effort needed to succeed [24][25]. People who are involved in engineering may see the loss of valued alternatives and the effort needed to succeed as necessary means to an end. They may believe that these costs are worthwhile in exchange for success within engineering. If this is the case, the research team may have to adjust these cost items to truly measure negative cost. On the other hand, further examining how the cost construct behaves in the context of engineering could provide useful information for both engineering educators and motivation theories.

3. Conclusions of the structural phase

This initial investigation into the structure of the ESBMS, gives us a preliminary understanding of how the items are functioning. In this case, the expectancy items are behaving as expected, have strong positive correlations with each other, and show good internal consistency. In comparison, the value items, though showing good internal consistency, only make Kline’s cutoff by a marginal amount. These items are also not correlated as expected, with some value items sharing moderate to large positive significant correlations, and others not being significantly correlated with the expectancy items, or with each other. For example, value items 4 and 2, and value items 3 and 5 do not share significant correlations with each other. These results are unexpected, as all value items should be strongly correlated with each other. Finally, the cost items present somewhat peculiar results and do not relate to each other and to the other items as predicted by motivation theory. Three of the cost items do share (Table 3) significant positive correlations with each other, as expected, but items 2 and 3 share a significant negative correlation, which was not expected. This, along with the positive relationships between some cost items with some value and expectancy items require further examination. The cost subscale also showed very low internal consistency, which could be due to a number of factors. First, as seen in table 3, cost item 3 has a much larger range (1-7) than the other items. This could mean that the students were not fully reading the questions and treated cost 3 as a positively worded item, instead of negatively worded. Future research should examine the construct of cost specifically in the context of engineering in order to better understand how this construct behaves in this specific culture. In addition, further investigation into the structure of the ESMBS, through the use of methods such as a confirmatory factor analysis should be the focus of future studies.

IV. External Construct Validation Phase – Correlations between ESMBS and Student Engagement

The last phase of the construct validation process is the external phase, in which the scores derived from the instrument under development are compared to other theoretically related constructs to determine if the scores relate in theoretically predicted ways. In this case, EVC literature supports a theoretical relationship between the expectancy, value, and costs constructs and the construct of student engagement. During the first administration of the survey, findings did not provide much external validity to the scale [11]. Specifically none of the correlations between the EVC items and student engagement were statistically or practically significant, in opposition with previous literature. Given the small sample size utilized during the first administration, the research team preferred to conduct a new administration with a larger sample size before making decisions based on the initial findings.

1) Participants and methods

Researchers used a sample of 95 engineering students to examine whether ESMBS subscale scores correlated with student engagement scores in theoretically predictable ways. The data used for this investigation is the same as the data utilized for the structural phase. All participants and methods are the same as those outlined above in the Structural Construct Validation Phase. In addition to the ESMBS, students also completed the *Student Engagement Survey (SE).* To assess student engagement, researchers selected 14 questions from the National Survey of Student Engagement [26]. These questions were designed to measure specific aspects of student engagement, such as collaborative learning, cognitive development, and personal skills development [27]. As described in the previous study conducted on the ESMBS, the SE has been determined to have good reliability, with the alpha reliability being 0.84 [27]. In the previous study, the SE questions were modified to pertain to the entire engineering major, instead of only applying to one class [11]. For example, instead of reading, "As a student, about how often have you done each of the following?", the question now read "As an *engineering student….".* In the current study, the ESMBS subscale scores were correlated with the SE scores using Pearson correlations.

2) Results and discussion

The correlation between student engagement and expectancy scores was statistically significant, though it was not practically significant (Table 5). For this specific student engagement survey, high scores represent higher levels of cognitive level, personal skills and development, and cooperative learning, which all would be expected to lead to students with high confidence and high expectancies for doing well. Thus, the low strength of the relationship between expectancy and student engagement is unexpected. More research will need to be done to see if these results are representative of engineering students as a whole.

Student engagement was found to have statistically significant correlations with all subscales of value (utility, interest, attainment, and total), though only two of these subscales (attainment and total) had practical significance, which was small. The strengths of these relationships are relatively weak, which again was not expected given the theoretical relationship between value and student engagement. Theoretically, one would predict that students who are engaged would find engineering to be more useful, would have more interest in engineering, and would feel like they gain more from engineering than those not engaged.

TABLE 5. Correlations between ESMBS items and Student Engagement

Correlations of student engagement with expectancy, values, and costs		
	Correlation (Pearson's r_s)	***Effect size (r_s^2)***
Expectancy	.279**	0.078
Value: Attainment	.462**	0.213
Value: Interest	.315**	0.099
Value: Utility	.419**	0.176
Value: Total	.511**	0.261
Cost: Loss valued	.297**	0.088
Cost: Effort related	.241*	0.058
Cost: Effort not related	-.189	0.036
Cost: Psychological cost	.068	0.005
Cost: Total	.137	0.019

**Statistically significant results at .05. ** Statistically Significant results at .01. Cohen's benchmarks: 0.1 is small, 0.3 is medium, and 0.5 is large.*

For the cost construct, only loss of valued alternatives and effort related to engineering showed significant relationships with student engagement. These relationships were positive and statistically significant, though again not practically significant. This finding is unexpected, as literature indicates that cost items should not be positively related with student engagement, and that cost should actually lead to *dis*engagement. Effort not related to engineering, psychological cost, and the total cost subscale were not significantly correlated to student engagement, though effort not related to engineering was the only cost item that shared a negative relationship with student engagement. Again, this finding does not coincide with previous literature and motivation theory. These findings could be due to multiple factors, including an inability of the cost items to accurately measure cost within the context of engineering. As previously stated, sacrifice and effort may not be perceived as negative attributes of the engineering domain, therefore students may actually interpret these items in a positive manner. Another issue could be the lack of internal consistency for the cost subscale. Due to these unexpected results, further examination of cost within the context of engineering must be conducted in order to accurately define and measure what cost means for engineering students and professionals.

3. *Conclusions from the external phase*

The results of the external phase are mixed, with only expectancy items behaving in the way that theory would predict. This could indicate a need for further work on the ESMBS, and to rework items. More think-a-louds must be done to see how the engineering students are interpreting the items before revisions are undertaken. In the case of the items that were not related to student engagement, more research must be done to determine if these constructs do relate in engineering and how they are related to each other in this domain. This research is needed because certain aspects of cost may behave differently in a culture, like engineering, that places value on the effort needed to succeed and the need for hard work [24][25]. The lack of relationships found in this study could be due to the wording of the items, or could truly be capturing the relationship between student engagement and motivational constructs within engineering. Perhaps the issue could lie with the student engagement survey used, as it may not capture all aspects of student engagement within the culture of engineering. Future research on the ESMBS should use a different measure of engagement to see if the problem truly lies with the SE items.

V. General discussions and conclusion

The current study utilized the Benson’s model of construct validation in the development of the Engineering Student’s Motivational Beliefs Scale. After previously administering the ESMBS to a smaller sample of engineering students, it was decided that a larger administration was needed to examine the structure of the ESMBS. The second administration of this instrument provided much information, and while the relationships between some items changed from the previous small n study, other relationships stayed consistent, indicating the need for further examination of these constructs. Specifically, the construct of cost warrants further investigation within the specific context of engineering education.

Despite cost item 3 being the only cost item to consistently relate to other constructs as expected, there are many issues with the item. For example, cost item 3 is the only reversed scored item, as it was negatively worded in the study. This could have led to the misinterpretation of the item, which may be seen in the large range of responses (Table 2) that cost 3 has in comparison with the other items. The mean response for cost item 3 was also much lower than the means for all other items on the ESMBS. When excluding cost item 3, the

Cronbach's alpha for the cost subscale drastically increases (from .45 to .67), showing a increase in internal consistency of the cost subscale. After removing cost 3 from the overall cost subscale score, cost's relationship with student engagement was shown to change. In the original analyses of the relationship between student engagement and cost, the relationship was found to be positive, but not significant (r=.137). Now, after removing cost item 3 from the subscale total, the relationship between cost and student engagement remains positive, but, becomes significant (.250) at the .05 alpha level.

In contrast with expectancy value theories of motivation, which dictate that cost should be negatively correlated with expectancies, values, and student motivation [14][15][16], the revised cost subscale in this study showed a positive and statistically significant relationship with these constructs. As previously discussed, these unexpected relationships could be due to a number of factors, though one particular hypothesis is of particular interest. It may be that the *cost construct behaves differently in the context of engineering*, and that engineers view cost as a positive attribute of their field, instead of a deterrent to motivation.

These findings pose interesting questions of whether or not cost behaves differently in the context of engineering, and if the unexpected results of this study were due to this context specific functioning of cost within an engineering culture. When taking out the divergent item, cost 3, it becomes clear that there may be something else going on in engineering, and that engineers may view cost as a positive attribute of their field. In order to study how cost behaves in engineering, a new study will be conducted, with cost as the focus, in which students are interviewed about their expectancies, values, and costs in regards to the engineering major. By further exploring cost in new settings, we hope to inform EVC theory, and further explain some of the inconsistent findings that we have seen while utilizing the ESMBS.

A. Limitations

Perhaps the biggest limitation of this study is the extremely low Cronbach's alpha found for the cost subscale. Due to the low internal consistency of the cost subscale, all results pertaining to the cost construct should be taken lightly and should not be used to do more than to speculate about how cost behaves in the context of engineering. A major limitation is that the students who chose to participate in this study may not be representative of all engineering students. These students may be more engaged and motivated within the major, as shown by their desire to volunteer for this study. Also, the university at which the study was conducted has a unique general engineering program, in which students do not declare a specific discipline within engineering, but instead are encouraged to explore the different disciplines. Finally, it could be that the student engagement survey does not capture all facets of student engagement, specifically within the domain of engineering. In the future, a different measure of student engagement could be used to see if these relationships hold true.

[1] A. Wigfield, and J. S. Eccles, "Expectancy–value theory of achievement motivation," in Contemporary educational psychology, vol. 25.1, 2000, pp. 68-81.

[2] J. S. Eccles, T. F. Adle, R. Futterman, S. B. Goff, C. M. Kaczala, J. L. Meece, and C. Midgley, "Expectancies, values, and academic behaviors" in Achievement and achievement motives: Psychological and sociological approaches, J. T. Spence Eds. San Francisco: W.H. Freeman and Company. 1983, pp. 75–138.

[3] K. Barron, and C. Hulleman, "Expectancy-Value-Cost model of motivation," in International Encyclopedia of Social and Behavioral Sciences, 2nd ed. Oxford. 2015.

[4] B. D. Jones, M. C. Paretti, S. F. Hein, and T. W. Knott, "An analysis of motivation constructs with first-year engineering students: Relationships among expectancies, values, achievement, and career plans" in Journal of engineering education, vol. 99.4, 2010, pp. 319-336.

[5] Q. Li, D. B. McCoach, H. Swaminathan, and J. Tang, "Development of an instrument to measure perspectives of engineering education among college students," in Journal of Engineering Education, vol. 97.1, 2008, pp. 47-56.

[6] T. Perez, J. C. Cromley, and A. Kaplan, "The role of identity development, values, and costs in college STEM

retention" in Journal of educational psychology, vol. 106.1, 2014, pp. 315.

[7] P.R. Brown and H.M Matusovich, "Unlocking student motivation: Development of an engineering motivation survey," in 120th Annual conference and Exposition of the American Society for Engineering Education, 2013.

[8] E. Godfrey, T. Aubrey, and R. King, " Who leaves and who stays? Retention and attrition in engineering education", in Engineering Education, vol.5.2, 2010, pp. 26-40.

[9] B.N. Geisinger, and D.R. Raman, "Why they leave: Understanding student attrition from engineering majors", in International Journal of Engineering Education, vol. 29.4, 2013, pp. 914.

[10] J. Benson, "Developing a strong program of construct validation: A test anxiety example," in Educational Measurement: Issues and Practice, vol. 17.1, 1998, pp. 10- 17.

[11] M.T. Panizo, C.W. Williamson, O. Pierrakos, R.D. Anderson, V. Bethke, and C.A. Welch, "Engineering students motivational beliefs: Development of a scale utilizing an expectancy, value, cost framework", in the Annual conference of Frontiers in Education, 2015.

[12] J. W. Atkinson, "Motivational determinants of risk-taking behavior," in Psychological review, vol. 64.1, 1957, pp. 359.

[13] J. S. Eccles, "Sex differences in mathematics participation", in Advances in motivation and achievement, vol. 2, 1984, pp. 93-137.

[14] J. S. Eccles, and A. Wigfield, "In the mind of the actor: The structure of adolescents' achievement task values and expectancy-related beliefs," 1995.

[15] J. Flake, K. Barron, C. Hulleman, D. McCoach, and M. Welsh, "Measuring cost: The forgotten component of the expectancy-value theory", in Contemporary Educational Psychology, vol. 41, 2015, pp. 232- 244.

[16] J. K. Flake, "Measuring Cost: The forgotten component of expectancy value theory," unpublished master's thesis, James Madison University, Virginia, 2012, p.82.

[17] J.S. Eccles, and R.D. Harold, " Gender differences in sport involvement: Applying the Eccles' expectancy-value model", in Journal of applied sport psychology, vol. 3.1, 1991, pp. 7-35.

[18] J. H. Panchal, O. Adesope, and R. Malak, "Designing undergraduate design experiences—A framework based on the expectancy-value theory," in International journal of engineering education, vol. 28.4, 2012, pp. 871.

[19] S. J. Finney, and C. DiStefano, "Non-normal and Categorical data in structural equation modeling. In G. R. Hancock & R. O. Mueller (Hrsg.). Structural equation modeling: a second course," Greenwich, Connecticut: Information Age Publishing, 2006, pp. 269–314.

[20] R. B. Kline, "Principles and practice of structural equation modeling" (3rd ed). New York, NY: The Guilford Press, 2011.

[21] J. Cohen, "Statistical power analysis for the behavioral sciences (2nd ed.)," Lawrence Erlbaum Associates, 1988.

[22] S. Mauno, U. Kinnunen, and M. Ruokolainen, Job demands and resources as antecedents of work engagement: A longitudinal study," in Journal of vocational behavior, vol. 70.1, 2007, pp. 149-171.

[23] A. Van den Broeck, N. De Cuyper, H. De Witte, and M. Vansteenkiste, “Not all job demands are equal: Differentiating job hindrances and job challenges in the Job demands–resources model,” in European journal of work and organizational psychology, vol. 19.6, 2010, pp. 735-759.
[24] A. L. Duckworth, C. Peterson, M. D. Matthews, and D. R. Kelly, “Grit: perseverance and passion for long-term goals,” in Journal of personality and social psychology, vol. 92.6, 2007, pp. 1087.
[25] J. Pappas, O. Pierrakos, E. Pappas, and K. Paterson, “True grit: Toward a culture of psychological preparedness in engineering education,” in Frontiers in Education Conference, 2013 IEEE, 2013, pp. 764-766.
[26] G. D. Kuh, “The NSSE 2000 report: National benchmarks for effective educational practice,” Bloomington, IN: Center for Postsecondary Research and Planning, 2000.
[27] S. Ahlfeldt, S. Mehta, and T. Sellnow, “Measurement and analysis of student engagement in university classes where varying levels of PBL methods of instruction are in use,” in Higher Education Research & Development, vol.
24.1, 2005, pp. 5-20.

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