Engineering Students' Motivational Beliefs

Development of a Scale Utilizing an Expectancy, Value, and Cost Framework

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***Abstract*— In the current study, researchers developed a 12-item instrument (Engineering Student Motivational Beliefs Scale; ESMBS) to assess engineering students' perceived expectancies, values, and costs of being an engineering major and pursuing an engineering career. The purpose of the paper is to present the ESMBS development process, including *preliminary* psychometric information. Researchers used Benson's model of construct validation, encompassing three phases, to guide the development and preliminary validation of ESMBS. The substantive phase included a thorough review of the literature to theoretically and empirically define the expectancy, value, and cost constructs within the context of undergraduate engineering. The structural phase consisted of psychometric investigations of the scale to examine internal consistencies. Finally, during the external phase, the relationship between the ESMBS constructs and student engagement was examined. The results from this preliminary instrument development study were mixed, showing the need for further examination of the measure.**

Keywords*—motivation, expectancy, value, cost, student engagement, expectancy-value theory, construct validation.

I. INTRODUCTION

Research suggests that a person's motivational beliefs impact her or his choice to engage in a domain or task [1]. Students' motivational beliefs have been of particular interest to educational research in many different areas, including STEM fields. Motivational beliefs have been used, for example, to predict student achievement and intention to leave a given field [2][3]. Expectancy-Value Theory (EVT) provides a framework for understanding motivation. According to EVT, individuals' expectancies and perceptions of the value of a certain domain influence their level of involvement in that particular domain [4][5]. Translated into the context of engineering education, students' level of confidence in their learning capacities, and perspectives about the value of engineering most likely will influence the students' future academic and professional choices.

Recent development in the motivation literature enriches the interpretation of student motivation by focusing on a component largely ignored in previous studies: the perception of the costs or drawbacks of a domain or task. Among the different attempts to operationalize and measure the cost component, the Expectancy-Value-Cost (EVC) model emerges as a sound framework for accounting for this component [4]. According to the EVC model, students' perception of the costs involved in a specific task is a salient construct for explaining students' behavior and should be differentiated from the other components of the expectancy-value model [6]. A number of recent instruments in the STEM education literature have attempted to capture the cost component while providing valuable insight into the discussion of STEM students' achievement and academic behavior [3][7][8]. However, these instruments follow the traditional EVT framework, ignoring the latest conceptual and psychometric contributions on the matter. We believe that there is a need for developing an engineering motivation instrument based on the EVC model in order to better account for students' experience in engineering. Thus, in the current study, a 12-item instrument (The Engineering Student Motivational Beliefs Scale; ESMBS), based on the EVC model, was developed to assess engineering students' expectancies, and perceived values and costs of the engineering major and career (in what follows: expectancy, values, and costs, respectively).

II. FRAMEWORK OF THE CURRENT STUDY

The ESMBS scale was developed using Benson's model of construct validation [9]. This model incorporates three different construct validation phases: the substantive, the structural, and the external phase. In the initial *substantive phase*, a thorough review of the literature was conducted to theoretically and empirically define the expectancy, value, and cost constructs within the context of undergraduate engineering. After defining the constructs, items were created and reviewed by content experts. These items were also presented to engineering students during two think-alouds conducted to evaluate sources of response error. The items were then edited based on the feedback from both the content experts and students. The *structural phase* consisted of psychometric investigations of the scale —including inter-correlations among the ESMBS items, and between each item and its corresponding subscale— to examine the internal consistency of the measure. Finally, during the *external phase*, the relationship between the ESMBS constructs and student engagement was examined to determine whether the constructs were related as predicted.

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III. THE SUBSTANTIVE PHASE

The purpose of this initial phase was to gain deeper understanding of the theoretical and empirical definitions of the expectancy, value, and cost constructs and to develop a measure based on the findings. First, a literature review of seminal motivational beliefs theories and existing measures developed in STEM education was conducted. Based on the investigation, operational definitions of the constructs of expectancy, value, and cost within the context of engineering education were developed. We then generated items to measure engineering students' perceived expectancies, values, and costs. Feedback from a team of content experts and research methodologists, as well as information gained during two think-aloud procedures with engineering students were used to modify the instrument.

A. Literature Review

1) Theoretical Framework

The Expectancy-Value-Cost **(**EVC) model is based on the Expectancy-Value Theory of motivation developed by Atkinson and extended into education by Jacquelyn Eccles [4]. Within EVT, motivation has been described as being governed by a person's expectancy of acquiring a specific goal and the value that the individual feels that the goal has [10]. EVT has been used to research many different academic domains, including the work pioneered by Eccles on gender differences in mathematic achievement [11]. This and other studies suggest that the EVT framework is useful for understanding students' academic behavior, from the standpoint of their motivations.

The two main components of EVT are expectancies and values. The first portion of this theory refers to having an expectancy of being successful in a task. The second portion of EVT is defined as having a value for engaging in a specific task [4]. The value component of EVT is broken down into four subcomponents that include interest, attainment, utility, and cost [12]. Having *interest value* is defined as having significance for the experience from engaging in a task, or having interest in engaging in that task. *Attainment value* is the importance of doing well on a task as defined by one's personal values. *Utility value* is the perceived usefulness of engaging in a task. Finally, *cost*, is defined as the perceived amount of effort or drawbacks that will be incurred from engaging in an activity. Eccles and colleagues [5] further partitioned the cost construct into perceived effort, loss of valued alternatives, and psychological cost. *Perceived effort* was defined as how much effort is needed to be successful at a task. *Loss of valued alternatives* was defined as not being able to engage in other valued activities due to engaging in one activity. *Psychological cost* was defined as the anxiety associated with potential failure related to the task.

A recent effort in the motivation literature has been focused on investigating the so called *forgotten* component of the expectancy-value equation: cost [6]. Work in that area illustrates the need for a consensus on the operational definitions and measurement of cost [6]. In Eccles and colleagues' initial work, for example, cost was considered a *mediator* of value [5], whereas in their later work it was considered as a *type* of value [12]. More importantly, as mentioned by Flake and colleagues, although Eccles and colleagues provide a strong theoretical rationale for cost they have not developed a comprehensive measurement tool [6]. In that context, the EVC model emerges as an attempt to provide a clear framework for understanding the experience of cost in motivation. After a thorough literature review of the role of cost in the expectancy value models, Barron and Hulleman [4] found that there is no conceptual or empirical support for identifying cost as a subcomponent of value. Throughout the literature, cost has been found to depict motivational dynamics that supplement the components of expectancy and value. On these grounds, the EVC model proposes that cost should be separated and examined as an independent component, which interacts with both expectancy and value to determine when someone is motivated [4]. During their own qualitative and quantitative research program, the EVC team also found new dimensions of cost: the effort required by the task itself (i.e., effort-related cost) and the effort required by other tasks (i.e., effort-unrelated cost) [13]. Finally, through a mixed-methods study, researchers found that sometimes effort-related cost was associated with *both* motivating and demotivating tasks, but in each case it was valued differently. In other words, the effort put into *motivating* tasks was perceived positively whereas the effort put into *demotivating* tasks was perceived negatively [13]. As Barron and Hulleman [4] explain, this became a key finding for measuring cost, as depending on how the effort-cost item is worded it could be perceived as something valuable (e.g., "this class is challenging") or as a burden (e.g., "this class is *too* challenging") [4]. Thus, in order to truly capture the negative connotation of cost, the EVC researchers recommended to phrase the item in a way that represents that the effort needed has surpassed a critical threshold and is perceived as overwhelming" [4].

2) EVT and EVC Related Literature in STEM Fields

Given that our interest rests in developing an instrument based on the EVC model that directly targets the engineering student population, we mainly focused our research of motivational beliefs measures within undergraduate engineering and STEM fields. These instruments are presented briefly in this section. The Engineering Motivation Survey was created using the Expectancy Value framework and several motivation instruments from engineering education [8]. The survey consists of 35 questions: 5 interest value items, 7 attainment value items, 7 utility value items, 7 self-efficacy or expectation for success items, and 9 cost items. To test the validity and reliability of the survey, a study was conducted with more than 200 freshmen engineering students at a large public university. The results showed acceptable to good internal reliability, with all Cronbach's alphas for the items being higher than .70. Factor analysis suggests that this instrument measures five constructs from the expectancy value theory, including utility value, attainment value, interest value, cost, and self-efficacy or expectancy for success. The factor analysis revealed that the cost items loaded on two different factors, suggesting that these items may be measuring different types of cost. However, the researchers did not differentiate conceptually between types of costs and interpreted all the cost items as measuring the same construct. Some of the interest and attainment value items were shown to load on the same factors, meaning that these items may be measuring the same construct. The researchers decided to keep these two sets of items separate arguing that interest and attainment have similar definitions.

Perez and colleagues [3], following EVT, created an instrument to assess STEM students' competence beliefs, values, and costs. For this scale, the original construct of expectancies was changed to competence beliefs, in order to incorporate both expectations for success and ability beliefs. The instrument consists of 5 competence beliefs items, and 7 value items evaluating attainment, intrinsic, and utility values, all adapted from Eccles and Wigfield [12]. In addition, 20 cost items for college STEM majors, measuring effort cost, opportunity cost, and psychological cost, were adapted from Battle and Wigfield [14]. The results of this study showed that competence beliefs, values, and perceptions of cost were related to achievement in chemistry and intent to leave STEM [3].

Jones and colleagues [2] also created an instrument based on EVT, which assesses expectancies and values in engineering students. Jones and colleagues' instrument contains 2 expectancies for success in engineering items, 2 engineering intrinsic interest value items, 3 engineering attainment value items, and 2 engineering extrinsic interest value items. All items in this measure were taken directly from Eccles and Wigfield [12], and modified to assess perceptions of expectancies and values for engineering instead of mathematics. After administering this instrument, it was found that not only do students' expectancies and values for the engineering major decrease within the first year, but that value for the major is positively associated with future career plans in engineering [2].

Panchal and colleagues [15] applied the EVT framework to an undergraduate Engineering Design course in order to create a universal model for teaching design classes. At the end of the semester, students were given a thirty-question survey created by Panchal and colleagues [15] designed to measure both expectancy beliefs and values pertaining to the design project assigned in the class. The survey consisted of 9 expectancy belief questions and 9 value questions, based on the attainment, intrinsic, utility and cost constructs. The researchers found that motivation for completing the project was positively correlated with both expectancy beliefs for the use of mathematics skills and values for the project [15]. Expectancies and values were also positively correlated with learning outcomes and performance on the project. Results related to the cost items are not clearly stayed but findings suggest that cost might have been *positively* correlated with proficiency in mathematics and motivation.

Flake and colleagues [6] created a non-discipline specific cost scale to study the dimensions of the cost component of the EVC model. Their investigation supported the previous dimensions of cost described by Eccles and colleagues [5] and identified a new dimension, outside effort [6]. Outside effort cost is defined as the time or effort allotted to tasks other than the one of interest. The scale developed by Flake and colleagues consists of 5 task effort cost items, 4 outside effort cost items, 4 loss of valued alternative items, and 6 emotional cost items. None of the items on this measure pertained to a particular domain, and all of them were designed for use in a variety of classroom settings. Correlational analyses showed a negative relationship between cost and both expectancies and values, as well as grades and long-term interest [6].

After a thorough investigation of STEM measures of student motivational beliefs we have found that there is no instrument that focuses solely on engineering students and takes into account the latest contributions on the cost construct. Moreover, in some cases the theoretical implications of the unexpected findings have not been discussed. This suggests the need for developing an instrument to study the motivations of engineering students using the most up to date research on the literature.

3) Operational Definitions of the Constructs

Based on our research on the theoretical and empirical definitions of the expectancy, value, and cost constructs, we offer preliminary working definitions of these constructs within the context of engineering (Table I).

B. Development of the ESMBS Scale

TABLE I.

Operational Definitions of the ESMBS constructs	
ESMBS Construct	***Working Definitions***
Expectancy	The confidence that engineering students have in their current and future abilities to do well in the engineering major.
Value	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	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.

In the current section, we describe the development of the ESMBS scale based on the findings of the literature review. Specifically, we explain the item generation process, the content experts' analysis of the items, and the use of two think-alouds to evaluate and clarify the items and measure.

Based on the working definitions developed in the initial stage of this investigation, 10 items were developed referencing existing items observed in other EVT-related measures. In the developing process, the research team also took into account recommendations provided by a group of EVC content experts on how to measure the expectancy, value, and cost constructs. For example, following one of these recommendations [16], instead of wording the items as statements, we worded the items as questions (e.g., "How confident are you with your current abilities to do well in the engineering major?") and developed a different scale for each item (e.g., from 1 "Not confident at all" to 7 "Very confident"), so that the scale directly responds to the specific question. Thus, three expectancy items, three value items (attainment, utility, and interest), and four cost items (loss of valued alternatives, effort related to engineering, effort not related to engineering, and psychological cost) were created in this process.

Engineering content experts and research methodologists evaluated the list of 10 items, which were then modified following the experts' feedback. For example, based on previous research showing the difference between an engineering student identity and an engineer identity [17][18][19], the engineering content expert suggested creating two attainment value items, each addressing a different kind of identity: a student and a professional identity. The engineering content expert also suggested creating an additional utility value item focused on the social aspect of engineering. According to the expert's experience in the field, women tend to be more focused on the social impact of engineering whereas men tend to focus more on the financial aspect [19].

After creating and modifying the items, team researchers conducted two think aloud sessions with engineering students (one female and one male) for evaluating sources of response error in the survey. Specifically, following Willis' [21] guide for cognitive interviewing, the sessions were focused on whether the items were interpreted as expected. After conducting the think aloud, some items were modified for language clarity, avoiding language ambiguity or imprecision. The final ESMBS scale (see Table II illustrating sample items and their sources) is comprised of 3 expectancy items, 5 value items, and 4 cost items. Each question is answered using a 7-point Likert scale. For each subscale, responses are averaged, with the lowest score for each subscale being a 1 and the highest score being a 7. Following Flake and colleagues' [6] work on cost, question number 11 (i.e., effort not related to engineering) is reverse coded.

TABLE II.

ESMBS Sample Items and their Sources		
Item Type	***ESMBS Item***	***Sources***
Expectancy	How confident are you with your current abilities to do well in the engineering major?	"How much confidence did you have in your ability to excel in your engineering major over next semester?" [2]
Value (utility)	How useful do you find engineering in bettering the world around you?	Content expert recommendation
Cost (effort related to engineering)	How much effort do you think is typically required to do well in the engineering major?	"This class requires too much of my effort" [13]

IV. Structural Phase

The purpose of the structural phase is to evaluate the psychometric properties of the instrument. We conducted a small sample size study to obtain preliminary data on the internal consistency of the ESMBS items. Future directions for further analysis of the internal structure of the instrument are discussed at the end of the section.

A. Psychometric Properties of the ESMBS Scale

Cronbach's alpha, item-to-item correlations, and item-subscale correlations were calculated in order to conduct a preliminary investigation into the structure of the measure. Spearman's non-parametric correlations were used, as recommended in the case of small sample size studies [22]. Given the small sample size of 19 students, no exploratory or confirmatory factor analyses were conducted.

1) Participants and Procedures

Twenty-one engineering students from a mid-Atlantic comprehensive university participated in this study. The survey was administered towards the end of the fall freshman semester. Incomplete surveys, surveys completed in less than 5 minutes or reflecting clear response bias (e.g., selecting only the highest point in the Likert scales throughout the entire survey) were not used. A final number of nineteen participants (3 females and 16 males) were included. Participants received an email that contained informed consent information and a link to the online survey.

2) Results and Discussion

Before examining the relationships among items and between items and subscales, data were examined for normality. Finney and DiStefano [23] suggest that skewness greater than |2| and kurtosis greater than |7| be considered indicative of univariate non-normality. An examination of ESMBS items (Table III) reveals that all skewness and kurtosis values for all the items fall within the acceptable range. However, a review of item-level scatter and Q-Q plots raised concern regarding the normality and linearity of the items, as did the restricted range of responses associated with many of the items observed in Table III. This, along with the small sample size, suggested the need for non-parametric analyses.

Cronbach's alpha was calculated for each subscale as a measure of internal consistency. For ESMBS, internal consistencies for the three subscales were 0.89, 0.87, and 0.71 (expectancy, value, and cost, respectively). According to Kline [24], values greater than .70 are considered acceptable.

TABLE III.

Item-Level Descriptive Statistics					
Items	***Range (actual)***	***M***	***SD***	***Skewness***	***Kurtosis***
Exp 1	4 - 7	5.05	1.13	0.92	-0.42
Exp 2	3 - 7	5.11	1.29	0.48	-0.94
Exp 3	4 - 7	5.11	1.10	0.61	-0.87
Value 1	4 - 7	6.21	1.18	-1.13	-0.37
Value 2	3 - 7	5.74	1.37	-0.92	-0.28
Value 3	4 - 7	5.95	0.91	-0.87	0.54
Value 4	4 - 7	6.32	1.06	-1.35	0.54
Value 5	4 - 7	6.42	0.90	-1.52	1.59
Cost 1	3 - 7	5.53	1.43	-0.44	-1.13
Cost 2	4 - 7	6.42	0.90	-1.52	1.60
Cost 3*	4 - 7	5.37	1.01	0.58	-0.66
Cost 4	4 - 7	5.42	1.02	0.06	-0.98
* Cost item 3 is the only item negatively worded.					

TABLE IV.

Spearman's correlations between expectancy, value, and cost items and their subscale total			
Items	**Spearman's r_s (effect size r_s^2)**		
	Expectancy Total	***Value Total***	***Cost Total***
Expectancy1	.871* (**0.759**)	—	—
Expectancy2	.898* (**0.806**)	—	—
Expectancy3	.873* (**0.762**)	—	—
Value1	—	.668*(**0.446**)	—
Value2	—	.896* (**0.803**)	—
Value3	—	.881* (**0.776**)	—
Value4	—	.718* (**0.516**)	—
Value5	—	.725* (**0.526**)	—
Cost1	—	—	.709* (**0.503**)
Cost2	—	—	.770* (**0.593**)
Cost3	—	—	-.138 (0.019)
Cost4	—	—	.810* (**0.656**)
** 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* [25]. *Medium to large effect sizes have been bolded.*			

While the expectancy and value subscales appear to show satisfactory internal consistency, the cost subscale only minimally meets Kline's acceptable range. Table IV shows the relationship between each item and its corresponding subscale. As expected, each of the items, with the exception of cost item 3, moderately to highly correlates with its respective subscale.

A review of the inter-item correlation matrix (Table V) gives us additional insight into how the items function in relationship to one another. Items should correlate highly with other items measuring the same construct and correlate only moderately with items measuring different constructs. In the case of the ESMBS, we would expect the expectancy, value, and cost items to relate more closely with items within their respective subscales than with items from other subscales.

In examining the inter-item correlations (Table V), we do see that the expectancy items moderately correlate with one another. This suggests that all three expectancy items may pertain to the same factor. We have a similar scenario when observing the correlations among the five value items. However, with the cost items, cost item 3 (i.e., effort not related to engineering) does not appear to relate to the other items on the cost subscale in a way that would lead us to believe it is measuring the same construct as the other cost items. Thus, in examining only how items relate to other items on the *same* subscale, the subscales (again, with the exception of cost item 3) appear to have satisfactory internal consistency. Nevertheless, when examining how items relate to items from *other* subscales, we see some issues. For example, although value and expectancy items present practically significant correlations, only *some* on these correlations are statistically significant. Also, some of these correlations are stronger than the correlations these items have within their own construct. Value item 2, for example, is more strongly correlated with the expectancy items than with the majority of the value items. This is problematic because as one would expect expectancy and value items to be positively correlated [4][12], value items should not correlate *more strongly* with expectancy items than with other items measuring the value construct. There are a couple of reasons why this may be happening. One is that the developers may have written these particular items in a way that makes their interpretation by subjects problematic. Another reason could be that the items may actually be measuring the same construct. Either way, this would indicate the need for further study (e.g. larger sample size to verify findings) and item revision.

Of particular interest, surprisingly, cost items 1 (loss of valued alternatives) and 2 (effort related to engineering) are positively correlated with all the expectancy and value items. This finding does not align with motivational beliefs theory, as costs are defined to be in tension with expectancies and values, and to hinder motivation [4]. However, research conducted by the EVC research team could help to interpret these findings. Qualitative research found that related-effort is not always perceived negatively [13], which resonates with findings in other studies [26][27]. Thus, in order to truly capture the *negative* aspect of cost the items should measure not simply effort but *overwhelming* effort [4]. In that sense, one possible explanation for the positive relationship observed between the ESMBS cost 1 and 2 items and the expectancy and value items could be the wording of the cost items. It could be that cost items 1 and 2 do not really represent *overwhelming* cost, at least not to the engineering students. This last point is important as the way students perceive cost could be related with the specific student culture. The engineering culture, for example, is known for its grit —or "perseverance and passion for long-term goals" [28]— and appreciation for sacrifice and effort [29]. Under such a culture,

TABLE V.

Spearman'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	.764**	1.000	–	–	–	–	–	–	–	–	–	–
3. Expectancy 3	.587**	.690**	1.000	–	–	–	–	–	–	–	–	–
4. Value 1	.421	.424	.407	1.000	–	–	–	–	–	–	–	–
5. Value 2	.593**	.754**	.805**	.462*	1.000	–	–	–	–	–	–	–
6. Value 3	.554*	.573*	.703**	.552*	.799**	1.000	–	–	–	–	–	–
7. Value 4	.339	.331	.432	.419	.559*	.521*	1.000	–	–	–	–	–
8. Value 5	.430	.305	.349	.493*	.512*	.561*	.694**	1.000	–	–	–	–
9. Cost 1	.308	.297	.491*	.679**	.346	.332	.260	.175	1.000	–	–	–
10. Cost 2	.430	.427	.325	.826**	.469*	.552*	.449	.523*	.626**	1.000	–	–
11. Cost 3	-.535*	-.636**	-.690**	-.552*	-.650**	-.611**	-.234	-.251	-.578**	-.411	1.000	–
12. Cost 4	-.021	-.166	-.029	.568*	-.045	.216	.170	.220	.348	.500*	.034	1.000

*Note: *p < .05, **p < .01*

certain aspects of cost could certainly be valued positively. To our knowledge there is no research on variations on perceptions of cost across academic fields. It would be interesting to see if certain academic fields (e.g., engineering) tend to perceive cost more positively than others, and what the implications are for measuring cost in those specific settings.

Another interesting finding is that cost item 3 is negatively correlated not only with all the expectancy items and some of the value items, but, surprisingly, also with the other cost items. One possible reason for this result could be the wording of the item. This is the longest item on the scale and combined with the negative wording this item could have caused participants some confusion. It is also important to consider that this item was created based on a new construct (i.e., "outside effort") developed by Flake and colleagues [6], and might require further evaluation.

B. Conclusions of the Structural Phase

The evaluation of the psychometric properties of the ESMBS scale has provided valuable information regarding how the initial ESMBS items are functioning. The expectancy items present a good internal consistency, and are strongly correlated among each other and with the expectancy subscale. The same holds for the value items. However, the strong relationship among some of the value items and some of the expectancy items suggest that these items may be assessing similar constructs. The cost items present a more complex picture and require further evaluation, particularly item 3. The positive relationship observed among some of the cost items and the expectancy and value items certainly requires additional study. Future steps for evaluating the internal structure of the ESMBS scale include collecting data from a new and larger sample and conducting a confirmatory factor analysis.

V. External Phase

In a construct validation process, the purpose of the external phase is to provide evidence of the relationship between the focal constructs and other constructs with which they are theoretically related [9]. The EVC motivational model suggests that students' expectancies and perceptions of the values and costs of studying engineering are related to their engagement in engineering [4]. In a study conducted with undergraduate engineering students at a large university, Jones and colleagues [2] found that as students' expectancies for success in engineering courses and perceptions of the intrinsic, attainment, and utility values decreased, engagement in the major also decreased. Thus, not surprisingly, when students had lower confidence in their abilities in engineering and did not value as much engineering, they tended to be less engaged in the major than when they expressed a stronger confidence in engineering and perceived its value more positively.

Unfortunately, to our knowledge, little research has focused on investigating the relationship between student engagement and students' motivational beliefs in the context of engineering. Some research findings outside the field suggest that such a relationship does exist, though. In the school context, for example, the relationship between students' motivational beliefs and engagement in the classroom is widely recognized [30][31][32]. Moreover, within the field of reading motivation, seminal motivation theorists have claimed that motivation is "what activates behavior" and therefore is essential to engagement [33]. These and other findings support the hypothesis that engineering students' level of confidence in the matter and perceptions of the values and costs of engineering are related to their level of student engagement.

A. Correlations between ESMBS and Student Engagement

A small sample size exploratory study was conducted for evaluating whether the ESMBS constructs are related to student engagement as expected.

1) Participants and Procedures

The data for this study were collected under the same circumstances of the previous one, and therefore the participants and procedures are the same.

2) The Student Engagement Survey

Engineering students' level of engagement was measured utilizing the Student Engagement (SE) Survey [34]. This survey was developed utilizing the National Survey of Student Engagement [35]. Fourteen questions from the NSSE were selected for assessing student engagement, specifically collaborative learning, cognitive development, and personal skills development. Psychometric information reported by researchers provides good support for the reliability and validity of the SE. The alpha reliability for the SE was 0.84, and, when compared to the NSSE's Engagement Score, the SE provides similar values [34]. In the current study, the instructions for the three subscales (collaborative learning, cognitive development, and personal skills development) were modified for targeting the entire engineering major and not only one class.

3) Data Analysis

We examined the relationship between student engagement and expectancy, values, and costs. Given the small sample size and the non-normal distribution of the data, Spearman's non-parametric correlations were used to assess the relationship between student engagement and the ESMBS constructs [22].

4) Results and Discussion

a) Relationship between Expectancy and Student Engagement

The correlation between students' expectancy scores and student engagement was not statistically or practically significant (Table VI). This finding is particularly surprising as higher scores in the SE represent high level of cooperative learning, cognitive level, and personal skills and development. We would expect that students with high confidence in engineering also have high levels of participation inside and outside the classroom, are engaged in high cognitive processes (e.g., they prefer to analyze instead of simply memorize), and belief that engineering provides them the tools to develop professionally and personally. More research is required to see if this finding truly represents the engineering student population.

TABLE VI.

Correlations of student engagement with expectancy, values, and costs

	Correlation (Spearman's r_s)	***Effect size (r_s^2)***
Expectancy	.197	0.039
Value: Attainment	.376	0.141
Value: Interest	.220	0.048
Value: Utility	.455*	0.207
Value: Total	.391	0.153
Cost: Loss valued	.242	0.059
Cost: Effort related	.287	0.082
Cost: Effort not related	-.206	0.042
Cost: Psychological cost	-.078	0.006
Cost: Total	.071	0.005

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

b) Relationship between Value and Student Engagement

Statistically significant correlations were only found between student engagement and the utility value, which had a small positive correlation (r_s=.455, p=.050, r_s^2=.207). Thus, the more engaged students report to be, the more they report to value the utility of engineering as a source of financial stability and/or for bettering the world around us. This is expected from anyone who reports an interest in a domain: to value the utility of the domain. Contrary to what we anticipated, on the other hand, attainment, interest, and the total value constructs were not statistically significantly correlated with student engagement. However, there are some trends in the data that do align with the literature. For example, as expected, all the value constructs have a positive relation with student engagement. Again, these findings are not strong enough to make conclusions about the validity of the scale but represent trends that are worthy of attention and further evaluation.

c) Relationship between Cost and Student Engagement

Cost items 3 (effort not related to engineering) and 4 (psychological cost) were not statistically or practically related to student engagement. Interestingly, student engagement did have a small *positive*, though non-significant, correlation with the other two cost constructs: loss of valued alternatives (item 1) and effort related to engineering (item 2). This trend does not align with the main literature on cost. From the motivational beliefs literature, valuing a domain as costly will most likely go hand in hand with disengagement from that domain [4]. The misalignment between the theory and the direction that the obtained results are trending could be an indicator of the inability of our cost items 1 and 2 to accurately measure the cost constructs *within the engineering context*. As mentioned earlier, within engineering, sacrifice and effort are not perceived as negative as theory would expect. Some students might consider, for example, that it is worthwhile to make some sacrifices for becoming successful engineering students and professionals. They could be recognizing the large amount of effort and the loss of other valued alternatives that engineering comprises, but, at the same time, are willing to invest that to stay in the major or career. This would suggest the need to adjust our cost items (specifically 1 and 2) to truly represent *negative* cost, a level of sacrifice and effort that undermines students' motivation in engineering.

B. Conclusions from the External Phase

With some exceptions, the relationships observed between student engagement and the expectancy, value, and cost constructs were not as predicted. Cost items 1 and 2 reported an unexpected positive —but not statistically significant— correlation with student engagement. This could be an indicator of a need to evaluate the wording of the items to better represent cost within engineering. Expectancy, attainment and interest value, effort not related to engineering, psychological cost, and the cost total, were also not statistically correlated with student engagement. This certainly requires attention as it could indicate that there is, in reality, no relationship between these variables, or that those ESMBS items are not accurately capturing the EVC constructs. However, the absence of significant patterns could also be due to a restriction of range issue. The student engagement scores do not represent a full range of engagement, as they only go from fully engaged to moderately engaged. The same is observed in the case of the expectancy, value, and cost scores. Finally, another possible contributing factor for the non-significant correlations could be the student engagement measure utilized in this study. The Student Engagement Survey operationalized student engagement as a combination of cooperative learning, cognitive level, and personal skills. This could be considered a somewhat narrow understanding of student engagement, as this construct has been defined by seminal thinkers in the area as both the amount of time and effort a student puts forth in activities that are related to desired outcomes of college and how the university propagates these activities in students [36][37].

VI. General Discussion and Future Directions

In the current study, we followed a construct validation process for developing the Engineering Student Motivational Beliefs Scale. In the initial phase, an extensive literature review of the theoretical and empirical definitions of the expectancy, value, and cost constructs was the basis for developing working definitions of these constructs within the context of engineering.

Based on these definitions and after an extensive evaluation of all the items, a 12-item instrument was created for measuring engineering students' expectancy and perspectives about the values and costs of engineering. Cronbach's alpha, item-to-item correlations, and item-to-subscale correlations were used to conduct a preliminary examination of item functioning and scale structure. Finally, the relationship between each of the ESMBS constructs (expectancy, value, and cost) and student engagement was evaluated using the Spearman's correlation analysis.

These findings provide some preliminary support for the internal consistency of some expectancy and value items, while raising questions about other items. For example, some expectancy and value items seem to be measuring the *same* construct or do not show a strong association with their corresponding constructs. Cost items 1 and 2 were positively correlated with the expectancy and value constructs; whereas cost items 3 and 4 were negatively correlated with the expectancy construct and —mainly in the case of item 3— with the value construct. From the standpoint of the literature on motivational beliefs and cost, these are puzzling results and the initial step should be to evaluate the quality of the items and see whether they are truly measuring cost. It is important to note that cost items 1 and 2 also presented a small —although not statistically significant— correlation with student engagement. The specific participants' culture could help to explain these findings. In the think aloud sessions, for example, students indicated that while there are sacrifices and costs associated with engineering, some are positive and beneficial, teaching them valuable skills. Thus, within engineering, certain dimensions of cost (i.e., "loss of valued alternatives" and "effort related to engineering") could be perceived as a necessary investment for being successful in the field. This resonates with what has been observed in other studies [26][27][13]. One way to address this issue could be adjusting the highest scale point on the cost item to represent an *overwhelming* level of cost (e.g., "*too* much effort" instead of "large amount of effort").

The current study is a preliminary evaluation of the ESMBS scale. Initial results indicate a need for further scale development. Data are currently been collected from a new and larger sample of engineering students. So far, initial findings concerning freshmen students (N=28) show similar trends to the current study. Additional analyses, such as a confirmatory factor analysis, will allow us to examine the ESMBS structure in more detail.

A. Limitations

There were several limitations to the current study. The small sample size constrains our analyses. Findings should be interpreted cautiously. This study provides only general guidelines for future steps in the development and evaluation of the ESMBS scale. Special attention should be given to the possibility that students who participated in our study are not representative of the general engineering population. It is likely that students who chose to participate are in general more engaged than those who did not participate in the study, which is represented by the restriction of range described earlier. Also, as mentioned before, the Student Engagement Survey utilized in the study understands engagement as cooperative learning, cognitive level, and personal skills and development, which could be considered a somewhat narrow definition of student engagement. In that sense, it would be interesting to see if the relationships between expectancy, value, costs, and student engagement observed in this study are confirmed when utilizing a different measure of student engagement.

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