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Towards Development of an Engineering Design Value-expectancy Scale (EDVES)

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Towards Development of an Engineering Design Value-Expectancy Scale (EDVES)

Introduction and Background

As high school programs are increasingly incorporating engineering content into their curricula, a question is raised as to the impacts of those programs on student attitudes towards engineering, in particular engineering design. From a collegiate perspective, there is a related question as to how first-year engineering programs at the college level should adapt to a greater percentage of incoming students with prior conceptions about engineering design and how to efficaciously uncover what those conceptions may be. Further, there is a broader question within engineering design as to how various design experiences, especially introductory experiences, may influence student attitudes towards the subject and towards engineering more broadly.

Student attitudes is a broad and well-studied area and a wide array of instruments have been shown to be valid and reliable assessments of various aspects of student motivation, self-efficacy, and interests. In terms of career interests, the STEM Career Interest Survey (STEM-CIS) has been widely used in grade school settings to gauge student intentions to pursue STEM careers, with a subscale focused on engineering (Kier et al 2014). In self-efficacy and motivation, the Value-Expectancy STEM Assessment Scale (VESAS) (Appianing and Van Eck, 2018) is a STEM-focused adaptation of the broader Values, Interest, and Expectations Scale (VIES), which in turns builds upon Eccles' Value-Expectancy model of self-efficacy (Eccles, 1983; Wigfield & Eccles, 2000). Similar to the STEM-CIS, the VESAS is focused on motivation to pursue an engineering career rather than on the doing of engineering activities. The Value-Expectancy model has also been used to evaluate STEM self-efficacy in the K12 environment (e.g. Kosovich et al, 2014). When it comes to engineering activities in particular, there have been a few attempts to develop more focused instruments, such as Carberry's Design Self-Efficacy Instrument (Carberry, Lee, and Ohland, 2010) which focuses on self-efficacy related to the various stages of engineering design. Another engineering self-efficacy instrument was developed by Mamaril, focusing on various engineering skill areas such as experimentation and tinkering (Mamaril et al, 2016).

For the purposes of this work, evaluating novice and beginning designer attitudes about engineering design, the available instruments were not found to assess the desired attributes. Design-focused instruments such as Carberry's were too narrowly focused on the stages of the design process, many of which required a certain a priori knowledge to effectively evaluate. Broader instruments such as the VESAS were too focused on working and studying engineering, rather than doing or identifying with engineering. A new instrument, the Engineering Design Value-Expectancy Scale (EDVES) was developed to meet this need.

To ground the EDVES instrument, the Expectancy-Value model of motivation was used as a foundation. Barron and Hulleman provide an excellent and recent overview of the framework, including history and recent developments, as well as make the case for the recently proposed third branch of the model – Cost (Barron and Hulleman, 2015). The framework was initially proposed almost 40 years ago as Eccles, later joined by Wigfield, explored the connections between expectancy and other constructs linked to student beliefs about their ability to perform various tasks (Eccles, 1983; Wigfield & Eccles, 2000; Eccles & Wigfield 2002). Expectancy-Value, and, later, Expectancy-Value-Cost has proven to be a useful umbrella with clear connections to many of the leading motivation theories such as Self-Efficacy Theory

(Bandura, 1986) and Self-Determination Theory (Deci and Ryan, 1985) as well as more recent theories such as Intrinsic-Extrinsic Motivation Theories (Sansone and Haraciewicz 2000). For the development of the EDVES instrument, cost was not included. The primary rationale for this was that it did not feel appropriate to the context in which the instrument was to be used. The primary motivation for assessing student attitudes was to evaluate the impact of several engineering activities being developed for high school and first-year engineering classrooms. As these activities were to be embedded into the pedagogy of the course, cost did not seem to be as relevant as it may be in other contexts.

In its current form the EDVES includes 38 items across several subscales covering expectancy of success in, perceived value of, and identification with engineering and doing engineering activities. This work presents the EDVES and discusses the development process of the instrument thus far.

Setting and Context

The current study was undertaken at Ohio Northern University, a small private college in the Midwest with a total enrollment of around 3,000 students. The T.J. Smull College of Engineering is home to six undergraduate only programs – Mechanical, Civil, Electrical, and Computer Engineering, Computer Science, and Engineering Education. The student population includes small numbers of students from underrepresented populations but is largely made up of those from small, rural, Midwestern towns. The focus population in this study is first-semester engineering and computer science students enrolled in an introductory design course which is taken by all majors.

The first-year engineering program was chosen as the pilot population due to ease of accessibility, size of the population, and the inclusion of students from across all disciplines. Additionally, the EDVES instrument is being developed to evaluate the impact of a series of introductory design activities which are covered within that course. A total of 196 students were enrolled in the course in the fall semester of 2020, when the survey was deployed, and response rates were very high due to the ability to embed the instrument in regular pre- and post-course surveys which are administered every semester. Data collection was administered using Qualtrics and all analysis was conducted using Minitab.

Instrument Development and Validation

The Engineering Design Value-Expectancy Survey (EDVES) is intended to assess student attitudes about engineering design activities as well as their identification as and interest in being a future engineer. Attitudinal items are based on Eccles' expectancy-value theory, with the intention to evaluate student expectations of success in engineering tasks and their valuation of those tasks. Students were asked to rate their agreement or disagreement with a series of statements using a 7-point Likert-type scale ranging from 1 (strongly disagree) to 7 (strongly agree). The instrument is scored by simple summation of student responses. Scores on the individual scales and subscales should be compared to the maximum possible score, which is seven times the number of items in the scale. All items, broken down by scale and subscale, are listed in the Appendix.

The 2014 *Standards for Educational and Psychological Measurement* (AERA, APA, & NCME, 2014) were used as a framework for gathering evidence of validity for the self-efficacy instrument, following the validation process presented by Cook (2016). A summary of validity evidence used is presented in Table 1 and discussed in detail below.

Table 1: Evidence of validity, definitions from Cook (2016, p3)

Type of Evidence	Definition	Evidence Used
Content	The relationship between the content of a test and the construct it is intended to measure	• Built on previously validated instruments • Review by an expert panel
Internal structure	Relationship among data items within the assessment and how these relate to the overarching construct	• Test item statistics • Internal consistency reliability
Relationship with other variables	Degree to which these relationships are consistent with the construct underlying proposed score interpretations	• Comparison of subpopulations with vs without prior engineering experiences • Comparison of pre- and post-course survey results
Response process	The fit between the construct and the detailed nature of performance actually engaged in	• Pre-deployment survey with subjects similar to study population
Consequences	The impact, beneficial or harmful and intended or unintended, of assessment	• Not examined in this study, presumed to be negligible given the nature of the assessment

Pre-Deployment

To establish evidence of content validity and to ensure that items were well-crafted and in line with established best practices, three valid and reliable instruments were adapted to form the EDVES instrument. The Value-Expectancy STEM Assessment Scale (Appianing and Van Eck, 2018) was used as a foundation for the EDVES, but given the emphasis on working in a STEM field, rather than performing engineering activities, the focus of the items required adjustment for application in the context of this study. The STEM Career Interest Survey (Kier et al 2014) provided a secondary source of items, predominately adapting from the Engineering subscale. Third, the Engineering Design Self-Efficacy (Carberry, Lee, and Ohland, 2010) provided a more task-specific focus, with some items being adapted from that instrument, predominately building from the subscale related to confidence in performing engineering design tasks.

Once the items were assembled and revised by the project team, the instrument was presented to a panel of experts consisting of two external engineering faculty members who are well established as educational researchers as well as a psychometrician. The items were then revised based on the feedback received by the panel and resubmitted to the panel for additional review and refinement. A total of 38 items were compiled, grouped into three scales: Expectancy (11 items), Value (18 items), and Identity (9 items). The expectancy and value scales are intended to measure attitudes about engineering activities while the identity scale measures identification as and interest in being a future engineer.

To begin to establish response process validity evidence, the instrument was then sent to a group of undergraduate students who had just completed the first-year engineering course sequence in which the instrument was intended to be deployed. The students were also sent a survey soliciting their commentary on wording and clarity of the items. No major concerns were raised by this group and minor editorial comments were addressed.

Pilot Deployment

The EDVES instrument was distributed to first-year engineering students enrolled in a college-wide foundations of design course ($N = 166$). The instrument was administered during the first week of classes, to minimize the influence of any of course activities on student attitudes. The same instrument was also deployed to the same population at the end of the semester ($N = 158$). Of the combined sample, $N = 143$ students completed both the pre- and post-surveys.

The pre-survey data was analyzed for evidence of internal structure validity. Basic statistics were run on the full data set to identify any items with extreme skewness (greater than 3.0) or kurtosis (greater than 10.0). No items were found to have excessive skew, but three were found with excessive kurtosis and were removed. Items within the three scales were analyzed further to identify any items with low interitem correlations (less than or equal to .30) or low item-to-scale-total correlation (less than or equal to .30). One item was thus removed from the expectancy scale, one from the value scale, and one from the identity scale. Cronbach's alpha was calculated for each of the three scales to provide a preliminary evaluation of internal consistency between the included items. The Expectancy and Value scales were found to exhibit a reasonable degree of internal consistency ($\alpha = 0.8021$ and $\alpha = 0.8710$, respectively) while the identity scale was lower but still marginally within generally accepted limits ($\alpha = 0.6647$). All proposed subscales within each exhibit acceptable internal reliability, with the exception of one identity subscale which is only marginally acceptable (external influences subscale, $\alpha = 0.6825$). The statistical data for the three scales and their respective subscales is shown in Table 2. Determinations of acceptable levels of alpha are based on the rule of thumb that the lower threshold for potentially viable constructs is somewhere in the range of 0.6-0.8 (Bland, 1997), while acknowledging that a more robust factor analysis is required to fully demonstrate the unidimensionality of the proposed factors (Taber, 2018).

Table 2: Summary statistics for the three scales of the EDVES

Scale/*Subscale*	Items	M	SD	Cronbach's α
Expectancy	11	52.530	6.561	0.8021
Success in Science	4	21.018	3.520	0.7681
Success in Engineering	6	31.512	4.432	0.7897
Value	14	87.675	6.255	0.8710
Intrinsic Value	3	18.337	2.008	0.7635
Attainment Value	6	37.795	2.702	0.7102
Extrinsic Value	5	31.542	2.466	0.7318
Identity	8	45.627	5.974	0.6647
Present Identity	1	5.446	1.148	--
Future Identity	4	25.639	2.086	0.7451
External Influences	3	14.542	4.633	0.6825

Examination of Other Relationships

To build validity evidence based on the relationships with other variables, survey responses were compared between subpopulations based on prior engineering experience, between the pre- and post-course survey data, and between subpopulations based on final grade in the course.

Relationship to Prior Engineering Experience

As part of the presurvey distribution, students were also asked to report their level of prior engineering experience as “none”, “some experience”, or “lots of experience”. Descriptive statistics for the three EDVES scales and for the overall instrument, separated by level of prior experience, are shown in Table 3.

Table 3: Pre-Course Scores by Level of Prior Engineering Experience

	None		Some		A Lot	
	N=33		N=99		N=34	
	Mean	StDev	Mean	StDev	Mean	StDev
Expectancy	46.1	5.33	46.8	6.11	49.3	5.95
Value	90.4	6.27	92.8	6.60	96.1	5.94
Identity	48.9	5.89	50.2	6.46	51.2	6.74
Total EDVES	185.3	12.6	189.8	15.2	196.6	14.43

Additionally, a series of two-sample t-tests (95% confidence) were generated comparing those with no experience to those with some or a lot of experience as well as comparing those with some experience to those with a lot of experience. Comparisons were made on each of the three scales individually as well as on the total instrument score. For students with no experience ($N = 33$) versus those with at least some experience ($N = 133$), statistically significant differences were observed for the value scale ($p = 0.011, \delta = 3.27$) as well as for the instrument as a whole ($p = 0.017, \delta = 6.3$) but not for the expectancy scale ($p = 0.199, \delta = 1.39$) or the identity scale ($p = 0.171, \delta = 1.82$). For students with some experience ($N = 99$) versus those with a lot of experience ($N = 34$), statistically significant differences were observed for the expectancy scale ($p = 0.039, \delta = 2.49$), the value scale ($p = 0.008, \delta = 3.34$), and for the instrument as a whole ($p = 0.023, \delta = 6.8$) but not for the identity scale ($p = 0.480, \delta = 0.95$). Based on these observations, it appears that the full instrument can differentiate based on level of prior exposure to engineering. The expectancy and value scales are similarly able to differentiate while the identity scale is not. It would make narrative sense for the self-efficacy and identity of respondents to be dependent, at least to an extent, on exposure to an experience with the underlying content. Having completed engineering activities in the past, it would be expected that you feel more capable of completing future activities and, if they were positive experiences, value those experiences more strongly. It should be noted that, since all participants are declared engineering students, there may be an element of selection bias present in responses to the identity scale items. This scale may prove to be more discerning in a broader population, such as in a K12 setting.

Relationship between Pre- and Post-Course Data

Examining only the $N = 143$ students who completed both the pre- and post-course survey, scores were compared for the full instrument as well as for each of the three scales. On average, students scored higher on the instrument as a whole ($p = 0.000, \delta = 9.43, \%\delta = 4.9\%$), the expectancy scale ($p = 0.000, \delta = 8.245, \%\delta = 17.4\%$), and the identity scale ($p = 0.017, \delta = 1.531, \%\delta = 3\%$) while scoring slightly lower on the value scale ($p = 0.664, \delta = -0.350, \%\delta = -0.4\%$). Statistical significance was determined using a paired t-test (95% confidence). The three scales exhibiting an increase were determined to be both statistically and technically significant, while the slight decrease in the value scale was determined to be neither statistically nor technically significant. One interpretation of this result may be that the instrument is able to accurately capture differences between beginner (pre-course) and novice (post-course) engineers. While comparable instruments for the value and identity scales have not been tested with this specific course, a previous study did use Carberry's Engineering Design Self-Efficacy Scale and found a similar increase on expectancy-related items as observed here (Hylton, 2017). The ability to discern beginner vs novice profiles as well as the alignment with results from previously established instruments both serve as additional evidence of validity.

A difference in difference analysis was also used to explore the change from pre- to post-course scores for students of various levels of prior engineering experience. Observing general trends in this data, level of prior experience appears to be inversely proportional to increase in instrument scores for the full instrument and all three individual scales. This makes narrative sense, as those students with no prior exposure to engineering would likely gain the most from an introductory engineering course. What is less clear is why there is an apparent decrease on the value scale for students with prior experience and, to a much lesser extent, on the identity scale only for those with the greatest degree of experience. It may be that students with prior experience are recalibrating their perceptions of what engineering is, seeing a more complete engineering experience in the first-year design course as opposed to their prior experience with what often amounts to tinkering or making at the K12 level.

Table 4: Pre/Post Differences by Level of Prior Engineering Experience

	None		Some		A Lot	
	N=29		N=85		N=29	
	Mean Δ	StDev Δ	Mean Δ	StDev Δ	Mean Δ	StDev Δ
Expectancy	9.79	6.66	8.06	7.12	7.24	8.91
Value	3.52	8.30	-0.91	9.51	-2.59	10.3
Identity	2.76	7.11	1.73	7.27	-0.28	8.93
Total EDVES	16.1	18.4	8.88	20.3	4.38	24.0

Two sample t-tests (95% confidence) were run to examine the significance of the differences between the various groups. For students with no experience ($N = 29$) versus those with at least some experience ($N = 114$) statistical significance was found for the full instrument ($p = 0.04$) and the value scale ($p = 0.009$) but not for the expectancy scale ($p = 0.179$) or identity scale ($p = 0.312$). Comparing the students with significant experience ($N = 29$) with those with limited or no experience, neither the full instrument nor any of the three scales were found to exhibit statistically significant differences. This result is surprising, given the clear trends in the data, and warrants additional study.

Conclusions and Discussion

A pilot of the Engineering Design Value-Expectancy Survey (EDVES) has been presented and some preliminary evidence of validity established. Although the instrument appears to have potential as a valid and reliable tool for studying engineering motivation and interest, much remains before such a claim may be made definitively. The identity scale in particular requires further exploration and connection to existing instruments on formation of identity. This scale largely fell out unintentionally during the pilot analysis and demands deeper grounding in existing literature, if not removal from the instrument. While still valuable in assessment of student mindset around engineering, the identity elements may not fit within the foundational theory of motivation underpinning the EDVES instrument.

In terms of additional validation evidence, the primary areas of need are internal structure evidence and evidence pertaining to relationships with other variables and instruments. In terms of internal structure evidence, the greatest need is for a full factor analysis to verify the unidimensionality and loading of the proposed subconstructs. In terms of relationships to other variables, comparison to pedagogical outcomes may prove fruitful, such as correlation with course grades and performance on specific interventions.

Finally, a major limitation of the current dataset is the restriction to first-semester engineering students. Ideally, the instrument should be tested on a broader population, including potentially upperclassman engineering students and/or high school students. If retained in the instrument, the identity scale in particular would benefit from examination of validity in a high school context where the entire population has not already self-selected into an engineering identity, thereby biasing the observed trends on that scale.

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References

American Educational Research Association, American Psychological Association, & National Council on Measurement in Education. (2014). *Standards for educational and psychological testing.* Washington, DC: American Educational Research Association.

Appianing, J. & Van Eck, R.N. (2018) Development and validation of the Value-Expectancy STEM Assessment Scale for students in higher education. *International Journal of STEM Education, 5: 24*. https://doi.org/10.1186/s40594-018-0121-8

Bandura, A., 1986. Social Foundations of Thought and Action: A Social Cognitive Theory. Prentice-Hall, Englewood Cliffs, NJ.

Barron, K.E., Hulleman, C.S., 2015. Expectancy-Value-Cost Model of Motivation. In: James D. Wright (editor-in-chief), International Encyclopedia of the Social & Behavioral Sciences, 2nd edition, Vol 8. Oxford: Elsevier. pp. 503–509. ISBN: 9780080970868

Bland, JM, & Altman, DG. (1997). Statistics notes: Cronbach’s alpha. Bmj, 314(7080), 572.

Carberry, A.R., Lee, H.-S., & Ohland, M. W. (January 2010) Measuring Engineering Design Self-Efficacy. *Journal of Engineering Education*, pp71-79.

Cook, D & Hatala, R. (2016). Validation of educational assessments: a primer for simulation and beyond. *Advances in Simulation, 1:31*, pp1-12. DOI 10.1186/s41077-016-0033-y

Deci, E.L., Ryan, R.M., 1985. Intrinsic Motivation and Self-determination in Human Behavior. Plenum, New York, NY.

Eccles (Parsons), J., Adler, T.F., Futterman, R., Goff, S.B., Kaczala, C.M., Meece, J.L., Midgley, C. (1983). Expectancies, values, and academic behaviors. In: Spence, J.T. (Ed.), Achievement and Achievement Motivation. W. H. Freeman, San Francisco, CA, pp. 75–146.

Eccles, J.S., Wigfield, A., 2002. Motivational beliefs, values, and goals. Annual Review of Psychology 53, 109–132.

Hylton, J.B., France, T., & DiBerardino, L.A. Impact of Various Pedagogies on Design Confidence, Motivation, and Anxiety of First-Year Engineering Students. *Presented at the ASEE Annual Conference and Exposition,* 2017.

Kier, M.W., Blachard, M.R., Osborne, J.W., & Albert, J.L. (2014) The Development of the STEM Career Interest Survey (STEM-CIS). *Research in Science Education, 44,* pp461-481. DOI 10.1007/s11165-013-9389-3

Kosovich, J., Hulleman, C.S., Barron, K.E., & Getty, S. (2014) A Practical Measure of Student Motivation: Establishing Validity Evidence for the Exectancy-Value-Cost Scale in Middle School. *Journal of Early Adolescence.* DOI: 10.1177/0272431614556890

Mamaril, N.A., Usher, E.L., Li, C.R., Economy, D.R., & Kennedy, M.S. (2016) Measuring Undergraduate Students' Engineering Self-Efficacy: A Validation Study.

Sansone, C., Haraciewicz, J.M., 2000. Intrinsic and Extrinsic Motivation: The Search for Optimal Motivation and Performance. Academic Press, San Diego, CA.

Taber, K.S. (2018) The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education*. Res Sci Educ* 48, 1273–1296 https://doi.org/10.1007/s11165-016-9602-2

Wigfield, A., Eccles, J.S., 2000. Expectancy-value theory of achievement motivation. Contemporary Educational Psychology 25, 68–81.

Appendix

Engineering Design Value-Expectancy Scale (EDVES)

All items rated on a seven-point agreement scale *Strongly Disagree* ---- *Strongly Agree*

<u>Expectancy Scale</u>

Expectancy for Success in Science

1. Compared to other students in my class, I usually do better in science courses.
2. (R) Compared to other students in my class, I usually do much worse in science courses.
3. Generally, I think I do well in science courses.
4. (R) Generally, I find science courses to be difficult.

Expectancy for Success in Engineering

5. Compared to other students in my class, I usually do better on engineering activities.
6. (R) Compared to other students in my class, I usually do much worse on engineering activities.
7. Generally, I think I do well on engineering activities.

8. (R) Generally, I find engineering activities to be difficult.

When doing engineering activities in class….

9. I am confident in my ability to identify problems which could be solved through design.
10. I am confident in my ability to identify conditions for a design to be successful.

<u>Value Scale</u>

Engineering Intrinsic Value

1. (R) I do not like working on engineering activities.
2. I have fun working on engineering activities.
3. I enjoy talking about engineering outside of class.

Engineering Attainment Value

4. I feel that the amount of effort it takes to do well on engineering activities is worth it.
5. It is important to me to be good at solving engineering-related problems.
6. It is important to me to get good grades on engineering-related assignments.
7. (R) I would rather learn about something else instead of engineering.
8. (R) Learning about engineering is a waste of my time.
9. I would be successful working in an engineering-related career.

Engineering Extrinsic Utility Value

10. Learning about engineering will be useful to me in my work after I finish school.
11. Learning about engineering will be useful to me in my daily life after I finish school.
12. If I learn about engineering, it will help me succeed in many different types of careers.

When I finish school and go to work, it will be useful for me to be able to…

13. Identify problems which could be solved through design.
14. Identify individuals who are affected by a situation/problem.

<u>Identity Scale</u>

Internal Identity

1. Being good at engineering is an important part of who I am.

Future Identity

2. I can see myself as an engineer.
3. I plan to use engineering skills in my future career.
4. (R) I do not think engineering will be the right career for me.
5. I would enjoy working in an engineering-related career.

External Influences

6. I have a role model who is an engineer.
7. I know of someone in my family who is an engineer.
8. Someone close to me (e.g. relative, mentor) is encouraging me to pursue an engineering career.