120th ASEE Annual Conference & Exposition
FRANKLY, WE DO GIVE A D*MN
June 23-26, 2013

Paper ID #6156

Evaluating the "Impacts" Section of the Engineering Self-Efficacy, Interest, and Perception Survey

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Introduction

The new century has seen the U.S. workforce struggle to keep pace with the nation's demand to produce more engineers.[1] The challenge of meeting the nation's demands for more engineers is exacerbated by the inability of formal learning environments to excite many underrepresented students about the science, technology, engineering, and mathematics (STEM) professions. The emphasis on math and science skills for engineers, and the nation's precipitous fall in these areas has coalesced to produce a bleak outlook for the U.S. Many feel that the engineering field has failed to attract underrepresented populations due to a misguided perception of the field, low interest and low self-efficacy for underrepresented populations.[2,3] In response, many co-curricular programs have introduced programs that offer exposure to the field of engineering and implement authentic engineering challenges that help develop students' self-efficacy through hands-on activities and practical application of math and science. An example of this is the Math, Engineering, Science, Achievement (MESA) program which uses a plethora of activities that offer exposure to engineering fields and careers.

Co-curricular programs such as the MESA program have shown some success in providing pathways to STEM careers. MESA has created a model that is currently being used in nine states employing a range of activities to introduce underrepresented students to STEM careers including: college and career advisement, hands-on activities, state competitions, field trips, and guest lecturers.[4] The Engineering Self-Efficacy, Interests, and Perceptions Survey (ESIPS) instrument was developed by our research team to investigate the influence these activities have on underrepresented students. After a preliminary study we determined that the instrument required more detail to understand the influences of the various activities and consequently an "impacts" section was developed using qualitative data that emerged as a result of focus group interviews conducted with MESA students.

Purpose

In this paper we focus on the newest development of the ESIPS instrument, the "impacts" section and the statistical techniques used to refine the subscale. The addition of the impacts section is an important addendum to the ESIPS as it provides insight into the specific experiences which students felt make MESA a successful program. We will discuss steps utilized to reduce the number of survey items in the subscale as well as add clarification to the survey instrument. We conclude with a brief discussion of our future work.

Background

Working with MESA State supervisors in California, we proposed to investigate the mechanisms of MESA and determine how these areas are impacting students. A mixed-method research study was developed and funded by the National Science Foundation to examine the impacts of MESA's activities on students' engineering, self-efficacy, interest, and perceptions. The MESA activities include field trips, guest lectures, design competitions, hands-on activities, and student

career and academic advisement. We developed the ESIPS instrument in 2010 as part of our work with the National Center for Engineering and Technology Education (NCETE). We were able to pilot the initial instrument with 166 students MESA students in California and Utah.[5]

The results of the NCETE pilot study and resulting factor analysis conducted on the collected data revealed limitations with our psychometric instrument. As observed by our advisory committee chair, the ESIPS instrument was not calibrated in a manner that would allow researchers to unpack the influence of the "activity variables". On the advice of the committee chair the researchers conducted focus group interviews with MESA students throughout California. Five groups consisting of seven to ten MESA students were interviewed for approximately one hour. They were asked two questions:

(1) Can you describe one of the best times you have had in MESA?
(2) What do you think you are gaining by participating in MESA?

Using a grounded theory approach, focus group interviews produced eight distinctive themes: (a) informal mentoring, (b) makes learning fun, (c) time management, (d) application of math and science, (e) feelings of accomplishment, (f) builds confidence, (g) comradery, and (h) exposure to new opportunities.[6]

Insights gained from the focus group interviews contributed to the development of the "impacts" section of the survey instrument which consists of 39 statements. Each statement began with the phrase "My experience in MESA allows me to". Example survey items included (a) My experience in MESA allows me to discuss future plans with my advisor and (b) My experience in MESA allows me to feel a sense of accomplishment.

Data Collection

In Spring 2012, the revised ESIPS survey that included the "impacts" section was distributed to students from the states of Washington, California and Utah. Students completed the test online using SurveyMonkey[7] and were asked to rate their degree of agreement, on a 10-point scale, with the 39 impacts statements. Of the 224 students completing the survey, fifty-eight percent of the students were female and forty-two percent were male. Forty-six percent identified themselves as Hispanic / Latina / Latino, twenty percent identified themselves as white, and fourteen percent identified themselves as black or African American. In addition to the 39 impact statements, the survey also included the self-efficacy and interest sub-scales.

Analysis of the survey results provided evidence that it was long and students ran out of enthusiasm to finish. For example, slightly more than 20 students did not provide any response to the last section (MESA Impacts). Over 30 students provided identical answers to each of the 39 items in the last section (e.g. all 10's or all 1's).

Analysis

In order to reduce the number of survey items in the impacts section, the research team utilized the technique of principal component analysis (PCA). PCA is a variable reduction procedure

available in many statistical analysis packages such as SPSS. Investigators employ PCA when they believe it is possible to reduce the number of variables into a small number of "principle components" that will account for most of the variance in the observed variables.[8,9] The analysis was conducted for 153 surveys with 51 cases excluded using the "listwise deletion based on all variables in the procedure" option in SPSS. Prior to extraction, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was calculated and found to be an acceptable 0.951.[10] Bartlett's test of sphericity was significant: $\chi^2(741) = 6495$, $p < 0.001$.

Using PCA with the orthogonal rotation algorithm varimax and Kaiser normalization, the SPSS results provided four components with eigenvalues greater than one. The rotation converged in 15 iterations. The components are shown in Tables One through Four below. Survey items were selected that loaded the highest in a single component – we required a load of 0.50 or greater onto a single component as the criteria for retaining a survey item as a member of a component family. Survey items that loaded into Component 1 with a loading of 0.50 or greater are shown in Table One. Also shown in Table One are magnitudes of the loads on the other factors. For example, the survey item "My experience with MESA allows me to apply the math I have learned (number 1.1)" has a high load factor of 0.744 on component one which is why it is included in Table One. It also has lower loads on Components 2, 3 and 4 (0.360, 0.343, 0.184, respectively) which are included in the table. We also eliminated survey items that had *similar* loadings on two or more factors. For example, the survey item "My experience with MESA allows me to be more confident in tutoring others in science" loaded almost equally onto Component 1 (0.543) and Component 3 (0.555). By *similar*, we mean loads that differed by less than 0.2 for two or more components. The survey items that we eliminated because they loaded too closely onto two or more components are shown with strike-through lines in the Table One. Similarly, survey items with loadings greater than 0.50 for components two, three and four are shown in Tables Two, Three, and Four, respectively. Items that loaded closer than 0.20 were eliminated in these tables as illustrated by the strike-through lines. The Cronbach's Alphas for the four components are: $\alpha 1 = 0.928$, $\alpha 2 = 0.932$, $\alpha 3 = 0.897$, $\alpha 4 = 0.894$.

Table One: Items with Loadings Greater than 0.5 on Component One

Number	Item	Component			
		1	2	3	4
	My experience in MESA allows me to:				
1.1	Apply math I have learned	.744	.360	.343	.184
1.2	Be more confident in tutoring others in math	.701	.096	.439	.329
1.3	Be more confident in tutoring others in science	.686	.101	.483	.336
1.4	Increase my math level/understanding	.672	.402	.228	.154
1.5	Be more confident in seeking math help	.668	.343	.265	.357
~~1.6~~	~~Develop creative solutions to problems~~	~~.604~~	~~.543~~	~~.135~~	~~.363~~

Table One Continued					
Number	Item	Component			
~~1.7~~	~~Identify role models~~	~~.597~~	~~.433~~	~~.377~~	~~.231~~
~~1.8~~	~~Compare solutions~~	~~.594~~	~~.487~~	~~.302~~	~~.324~~
~~1.9~~	~~Be more confident in seeking science help~~	~~.579~~	~~.279~~	~~.491~~	~~.384~~
1.10	Breakdown stereotypes	.554	.302	.336	.351
~~1.11~~	~~Be more confident in tutoring others in science~~	~~.543~~	~~.280~~	~~.555~~	~~.273~~
~~1.12~~	~~Spend time with like-minded peers~~	~~.511~~	~~.485~~	~~.191~~	~~.454~~
~~1.13~~	~~Be engaged~~	~~.504~~	~~.370~~	~~.391~~	~~.492~~

Table Two: Items with Loadings Greater than 0.5 on Component Two

Number	Item	Component			
		1	2	3	4
	My experience in MESA allows me to:				
2.1	Clarify my college goals	.251	.769	.387	.253
2.2	Clarify my career goals	.411	.748	.232	.158
2.3	Be recognized	.222	.723	.366	.305
2.4	Feel supported in choices for my future	.213	.720	.412	.269
2.5	Experience success	.195	.694	.308	.383
2.6	Feel a sense of accomplishment	.407	.681	.247	.364
~~2.7~~	~~Envision my future~~	~~.458~~	~~.630~~	~~.220~~	~~.351~~
~~2.8~~	~~Explore my creativity~~	~~.490~~	~~.617~~	~~.124~~	~~.429~~
~~2.9~~	~~Learn something new in a fun way~~	~~.213~~	~~.545~~	~~.458~~	~~.385~~

Table Three: Items with Loadings Greater than 0.5 on Component Three

Number	Item	Component			
		1	2	3	4
	My experience in MESA allows me to:				
3.1	Connect engineering content to the real world	.327	.287	.738	.238
3.2	Discuss personal problems with my advisor/teacher	.189	.151	.703	.296

Table Three Continued					
Number	Number	Component			
3.3	Feel supported in my choices in engineering	.303	.337	.682	.219
3.4	Discuss future plans with my advisor	.199	.383	.623	.423
~~3.5~~	~~Establish professional connections/networking~~	~~.392~~	~~.462~~	~~.617~~	~~.162~~
~~3.6~~	~~Increase my science level/understanding~~	~~.460~~	~~.401~~	~~.609~~	~~.059~~
~~3.7~~	~~Learn perseverance~~	~~.292~~	~~.297~~	~~.575~~	~~.476~~

Table Four: Items with Loadings Greater than 0.5 on Component Four

Number	Item	Component			
		1	2	3	4
	My experience in MESA allows me to:				
4.1	Overcome nervousness	.394	.345	.203	.720
4.2	Socialize	.082	.433	.343	.700
4.3	Develop leadership skills	.498	.273	.278	.687
4.4	Overcome embarrassment	.272	.372	.283	.646
~~4.5~~	~~Study with friends~~	~~.256~~	~~.131~~	~~.416~~	~~.616~~
~~4.6~~	~~Perform better individually~~	~~.499~~	~~.434~~	~~.150~~	~~.549~~
~~4.7~~	~~Have high quality experience~~	~~.462~~	~~.490~~	~~.185~~	~~.530~~
~~4.8~~	~~Have a sense of belonging~~	~~.410~~	~~.280~~	~~.446~~	~~.529~~
~~4.9~~	~~Overcome anxiety~~	~~.265~~	~~.331~~	~~.460~~	~~.500~~
~~4.10~~	~~Learn time management skills~~	~~.432~~	~~.368~~	~~.432~~	~~.457~~

Implications

Using PCA to reduce the number of survey items which accounted for most of the variance resulted in 20 MESA "impacts" items which are listed below:

My experience in MESA allows me to:

- Apply math I have learned
- Be more confident in tutoring others in math
- Be more confident in tutoring others in science
- Increase my math level/understanding
- Be more confident in seeking math help
- Breakdown stereotypes
- Clarify my college goals

Clarify my career goals
Be recognized
Feel supported in choices for my future
Experience in success
Feel a sense of accomplishment
Connect engineering content to the real world
Discuss personal problems with my advisor/teacher
Feel supported in my choices in engineering
Discuss future plans with my advisor
Overcome nervousness
Socialize
Develop leadership skills
Overcome embarrassment

When we compared the 20 items listed above with the results of the focus groups described earlier, we found some of the eight themes were still represented by these statements. In particular, the themes of informal mentoring, application of math and science, feelings of accomplishment, building confidence, and comradery remained. Themes of time management, making learning fun, and exposure to new opportunities did not emerge as a result of the PCA. This may be because the survey items were developed loosely around the eight themes rather than explicitly defining a set number of survey items per theme.

The improved ESIPS survey will be administered to 1500 students throughout four states in the spring of 2013. The results of this study will help describe the influence that MESA activities have on underrepresented students and can be extended to other co-curricular STEM programs. Our hope is that co-curricular and curricular programs will be able to use the study results to learn "best practices" within the MESA program that might assist with the national agenda of guiding underrepresented students into STEM programs.

Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant No. 1020019. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. The authors are also grateful for the support of Oscar Porter, Executive Director, and Juanita Muniz-Torrez, Program Operations, of California MESA.

References

1. Chubin, D.E., May, G.S., and Babco, E.L. (2005). Diversifying the engineering workforce. *Journal of Engineering Education (94)* 1, pg. 73-86.
2. Denson, C., & Hill, R. B. (2010). Impact of formal mentorship programs on African-American high school students. *Journal of Industrial Teacher Education, 47*(1), 100-128.
3. Austin, C. (2010). Perceived factors that influence career decision self-efficacy and engineering related goal intentions of African-American high school students. *Career and Technical Education Research, 35*(3), 119-135.

4. MESA USA. Retrieved from http://mesa.ucop.edu/about/mesausa.html. February 17, 2012.
5. Hailey, C., Austin, C., Denson, C., & Householder, D. (2011). *Investigating influences of the MESA program upon underrepresented students.* Paper presented at the meeting of the American Society for Engineering Education, Vancouver, BC.
6. Denson, C., Austin, C. Y., & Hailey, C. E. (2012). *Investigating unique aspects of the MESA program for underrepresented students.* Paper presented at the meeting of the American Society for Engineering Education, San Antonio, TX.
7. Finley, R. (2009). SurveyMonkey [Computer Software]. Available from http://SurveyMonkey.com
8. Principal Component Analsysis. Retrieved from http://support.sas.com/publishing/pubcat/chaps/55129.pdf . December 21, 2012.
9. Abdi, H. & Williams, L.J. (2010). Principal component analysis. *Wiley Interdisciplinary Reviews: Computational Statistics*, *4*(2), 433-459.
10. Cerny, C.A., & Kaiser, H.F. (1977). A study of a measure of sampling adequacy for factor-analytic correlation matrices. Multivariate Behavioral Research, 12(1), 43-47.