2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #38697

Work in Progress: Assessing Engineering Students' Behavioral Engagement and Learning; Survey Development and Validation

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Mohammad Al Mestiraihi got his Ph.D. degree from the Engineering Education Department at Utah State University (USU) in July 2022, under Professor Kurt Becker's supervision. Before getting his Ph.D. from USU, Mohammad was a student at Oklahoma State University, where he received a Master of Science (M.Sc.) degree from the Electrical and Computer Engineering Department. Mohammad also received another master's degree in computer engineering from the Jordan University of Science and Technology (JUST) in Jordan. Besides, Mohammad also has a bachelor's degree in computer engineering from Al-Yarmouk University in Jordan. Complemented with his educational degrees, Mohammad has more than four years of teaching experience at Najran University, Saudi Arabia. Mohammad was also working as a Graduate Teaching Assistant (GTA) for 2.5 years at Oklahoma State University. Right now, Mohammad is working in the Electrical and Computer Engineering Department at the University of Texas Rio Grande Valley (UTRGV) as a Lecturer 2. He started this position in the fall of 2022, right after he got his Ph.D.

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Assessing Engineering Students' Behavioral Engagement and Learning: Survey Development and Validation (Work-In-Progress)

INTRODUCTION

Background

Water crises in the Middle East and North Africa (MENA) region are a colossal problem that has long existed. In the MENA region, war will likely erupt due to a water shortage [1], [2]. While the current crises in the region are because of oil, it is predicted that future wars will be inevitable if the water crisis is not solved [2], [3]. This is because three-quarter of the land mass is arid, and most water sources originate outside the region [3]. Among other things, water crises in the region have resulted from the mismanagement of available water, lack of optimization of water irrigation systems, increasing water demand, decreasing groundwater table, ecosystem loss, and water pollution [4].

Education should serve society by meeting its needs and solving environmental problems and challenges [5]. If the water crisis in Egypt is to be solved, then its higher education system must be positioned in such a way that it can prepare students who can solve its current challenges. It has been suggested that educational institutions align their aim with national priorities. For Egypt, the focus is solving the water crises [6]. One method the Egyptian government adopted to resolve the problem is improving the quality of higher education institutions in the region. Several ongoing studies and educational reforms are geared toward preparing graduates who can solve the water crises in the MENA region [7], [8]. More specifically, some of the ongoing educational efforts in Egypt include the examination of the industrial preparedness of students who graduate from Egypt University in solving the water crises [9], identifying and developing undergraduate water program courses that would meet the need of the Egyptian workforce [10], and the Toushka project to reform water management and distribution in Egypt [11].

Purpose of the Study

This study aims to develop and validate a quantitative scale as a needs assessment instrument. The needs assessment instrument will evaluate to what extent the existing curriculum used in the Egyptian universities' water program facilitates student learning, elicits student engagement, and develops the capacity for lifelong learning. Unfortunately, to the researchers' knowledge, existing surveys have not been administered in Egypt recently. Also, existing ones are not effectively tailored to capture the phenomenon the curriculum review team is interested in. Hence, the need for a validated survey.

Program needs assessments are conducted to investigate the unmet curriculum needs. Determining the student curricular needs based on the data and evidence sources available will dictate the effectiveness and fidelity of the implementation of the curriculum that is developed [5]. Other reasons we carry out need assessment include: setting priorities and determining criteria for solutions so that the planners can make sound decisions; it sets standards to determine how best to allocate money, people, facilities, and other resources to achieve the project objectives.

Knowing the current state of students' engagement and learning, which the validated survey will provide, is vital information the curriculum review committee will work with in reviewing the current curriculum and instructions used in the five Egyptian Partner Universities (EPU). Also, the survey outcome will help determine what pedagogical and learning workshops would be organized to equip faculty with skills to better design engaging classroom experiences and optimize student learning. Engaged students with better learning attitudes will become career-ready graduates prepared to solve the water crises in Egypt. This educational effort is sponsored by the United States Agency for International Development (USAID). The goal of the project, as extracted from the executive summary of the technical proposal, reads:

"*Our goal is to catalyze long-term improvement in Egyptian water resources management by improving its innovative applied research and education enterprise by creating the Center of Excellence (COE). The COE serves the needs of the Egyptian people, economy, and industry. In addition, COE supports the government to face water challenges, develop policy, and prepare the next generation of graduates and entrepreneurs to be change agents.*"

METHODS

Instrument Development

[12] five steps for the development and validation of the scale were followed. The five steps include: "define the construct, design scale, pilot test, administration, and item analysis, validate and norm" (p.8) (See Figure 1). Currently, we are on the fourth step.

The US team of experts working on the needs assessment survey have varying expertise. Two team members are water and environment professors with about 40 years of teaching and researching water-related topics, a curriculum review expert, a postdoctoral research associate in engineering education, and a psychometrician. The US team defined the construct of interest and reviewed literature and existing surveys relevant to the construct of interest. Item pools and measurement formats were created from these exercises. Every item was rated on a 4-point Likert scale with anchor points of strongly disagree, somewhat disagree, somewhat agree, and strongly agree. The faculty survey in teaching, learning, and assessment developed by the National Center for Postsecondary Improvement (NCPI) greatly influenced the final pool of items. Experts reviewed sixteen items pooled together for content validity. Examples of sample questions from the survey include *"Students understand the complexity of a topic better after exchanging ideas with peers," "Students are capable of learning the basic concepts," and "Students like to think about questions for which no single authoritative solutions exist.*'

Pilot Study

About fifty-one (forty-two males and nine females) faculty completed the data collection during the pilot study. The male-to-female ratio is a representation of the water program in Egypt. Lower female representation in STEM disciplines is a globally known fact. Participants were recruited from the 5 EPUs through convenience sampling for the pilot study. The researcher sent the developed scale to potential participants via email. All participants were required to speak

English fluently and be faculty affiliated with one of the 5 EPUs. The survey was administered online through the Qualtrics platform. Data was collected from the faculty to understand their perception of the students who come to the classroom. The way faculty perceive their students influences the pedagogical approach that will be adopted in the classroom. Also, since they interact with and assess students, faculty can give reliable information about class engagement and student learning. For the main study, data will be collected from both faculty and students.

Based on the feedback generated from the pilot study, some of the survey items were reworded, and others were regrouped. The survey was also rescaled following standard practice. One example was rescaling from a negative to a positive scale. This has been suggested to make the survey less leading [13]. The Cronbach alpha reliability score of the survey in the Egyptian context was computed as 0.72. A reliability score of 0.7 is acceptable [14], [15]. Hence the survey is reliable. The face validity was verified by the respondent, while, the content validity was re-verified by subject experts after the pilot study was completed. It should be noted that feedback from the pilot study has been implemented in developing the new survey administered.

For the pilot study, the Kaiser-Meyer-Olkin Measure (KMO) of Sampling Adequacy and Bartlett's test for sampling adequacy were conducted (See Table 1). The scree plots suggest that the scale can be a three-factor or four-factor model. The first three eigenvalues from the real data are larger than the parallel, average eigenvalues generated from 200 random data sets, indicating that three factors are the most optimal selection, according to parallel analysis. (see Figure 2). Additionally, the three-factor EFA solution was examined to find the most important indicators (items) for each factor using maximum likelihood (ML) estimation and Promax oblique rotation. Five of the 16 items in the initial pool had factor loadings that were less than 0.40 and may therefore be considered for exclusion from future analyses (See Table 2). The correlation between the factors was not problematically huge. However, these results have some limitations as the pilot study participants' sampling was insufficient. For sufficient sampling, a 10:1 ratio of cases to the number of variables is recommended [16].

Instrument Validation and Reliability

Survey validation is needed to ensure that scales measure an intended psychological construct. Also, survey validation is required when an instrument is administered in a different location where it has not been. Scale reliability ensures that items within a construct consistently elicit comparable responses. The data analysis plan details instrument reliability and validation test.

Data Collection and Analysis Plan

Data and evidence gathering for the needs assessment main study are ongoing. It involves faculty and students. A sample size of 200, or the ratio of the number of cases to the number of variables of 10:1, has been described as a sufficient sample size for Exploratory factor analysis (EFA) and Confirmatory Factor Analysis (CFA) [16]. Recruitment emails have been sent through the center of excellence to the 5 EPUs. The current recruitment update shows that about 1000 participants have been recruited. The survey has been administered through the mountain west institution Qualtrics website.

For the reliability test, Cronbach alpha (> 0.7) and correlation pattern (mostly > 0.3) indicates that items are related and reliable. The data will be analyzed after splitting it into two parts. With the first sample, item statistics and relationships between items will be examined to evaluate the psychometric properties of the measures. Next, exploratory factor analysis (EFA) is performed to determine the optimal number and nature of common factors to explain these relationship patterns. In addition to more conventional methods (e.g., Kaiser's criterion, scree test), parallel analysis calculates the number of factors to extract. Although Kaiser's eigenvalue larger than 1 (K1) criterion and Cattell's scree test are commonly recommended to determine if factors should be retained, these approaches have limitations. The K1 criterion is intended to serve as an upper bound for the number of factors included; therefore, researchers tend to reserve more factors. The rationale is that meaningful common factors derived from actual data should have higher eigenvalues than parallel factors derived from random data. Thus, only those factors that have observed eigenvalues bigger than the parallel average random eigenvalues are retained. Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), and the chi-square model fit test were also utilized to assess the model fit of the factor solution. Finally, the oblique rotation will be performed to interpret the final factor structure.

Confirmatory Factor Analysis (CFA) will be conducted for the second sample based on the model determined with the first sample for cross-validation. First, the item reliability will be evaluated using factor loadings. An item will only be deemed reliable if its standardized loading (in absolute value) is higher than 0.50 [17]. Second, the Model fit will be assessed using relative/normed model chi-square to determine both absolute and comparative fit such as $\chi 2/df$, root mean square error of approximation (RMSEA), standardized root mean square residual (SRMR), comparative fit index (CFI), and Tucker-Lewis index (TLI). According to [18], acceptable $\chi 2/df$ ratios typically range from 2 to 5, with lower values indicating a better fit. In addition, RMSEA/SRMR values should be equal to or less than .08 [19], and a CFI/TLI value should be equal to or greater than .90 [20] to be accepted. Third, the instrument's discriminant validity was examined. Factor correlations of less than.85 were considered to support the discriminant validity for a set of factors [17]. Finally, the bivariate correlation analysis will be carried out to establish construct validity.

Conclusion

The outcome of this study completion is a validated survey. The instrument will be an assessment tool to evaluate students' engagement and learning process. This outcome will provide vital information the curriculum review committee will work with in reviewing the current curriculum and instructions. Also, the survey outcome will help determine what pedagogical and learning workshops should be organized for the faculty. This effort provides a vital foundation for developing a top-notch water program in the 5 EPUs. Instruction and curriculum that improves students' engagement and optimize learning will better prepare career-ready graduates who will solve Egypt's water scarcity and pollution. The authors anticipate that the outcome of this study will be generalizable to other countries in the MENA region. Also, the researcher hopes that implementing this work in reforming the water program curriculum in the 5 EPUs, will serve as a template for other Universities in the MENA region to emulate.

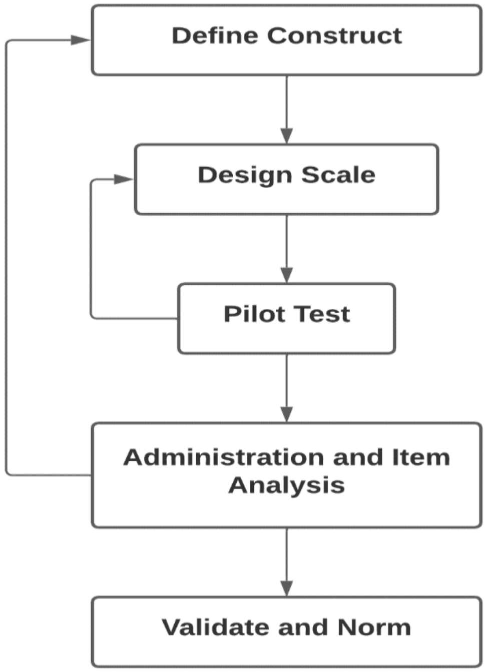

Figure 1: Major steps to developing a summated rating scale [12].

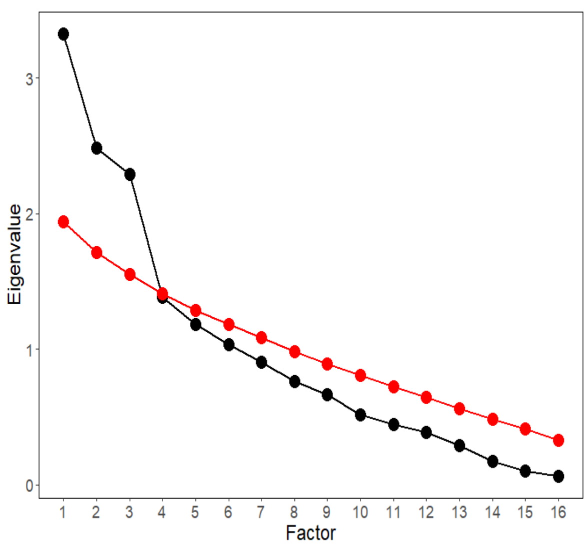

Figure 2: Scree plot from the pilot study (black) and from the simulated data for parallel analysis (red).

KMO and Bartlett's Test of Sphericity	Value
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.413
Bartlett's Test of Sphericity	
Approx. Chi-Square	162.157
df	120
Sig.	0.006

Table 1: KMO and Bartlett's Test of Sphericity

Item	Factor 1	Factor 2	Factor 3
1	**0.467**	0.263	
2	-0.296	**0.694**	0.140
3		0.29	0.150
4	0.214	**0.653**	-0.254
5	0.273	0.16	-0.133
6	-0.259	0.165	**0.853**
7	-0.126	0.174	0.340
8		**0.615**	0.146
9		**0.480**	
10	**0.518**	-0.131	0.123
11	0.246		0.305
12		0.328	
13	**0.924**	-0.122	
14	0.137		**0.429**
15	**0.535**	**0.431**	
16	0.294	-0.156	**0.590**

Table 2: Factor Loadings from EFA

Factor	1	2	3
1	1.000		
2	0.203	1.000	
3	0.11	0.114	1.000

Table 3: Factor correlation from EFA

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