International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

Validation of the S-STEM Survey Questionnaire using Factor Analysis

Joy B. Araza

Samar State University

Abstract: ***The main purpose of this study was to establish the construct validity and reliability of the High School Students Attitude towards Science, Technology, Engineering and Mathematics (S-STEM) survey questionnaire. The S-STEM has been developed and validated by Friday Institute for Educational Innovation. The S-STEM Survey contains three constructs measuring attitudes toward STEM content and one measuring attitudes toward 21st century skills. Data utilized in the study were 360 grade school (grades 7 to 12) students from the Eastern Visayas Regional Science High School (EVRSHS). The construct validity of the questionnaire was tested using the Exploratory Factor Analysis (EFA), Principal components analysis (PCA), and Parallel Analysis; while the reliability was tested using Cronbach alpha. Results revealed that the S-STEM questionnaire consisted of nine factors based on EFA and PCA and five factors based on the parallel analysis. The questionnaire has good reliability. It can be concluded that the S–STEM is valid and reliable.***

Keywords: Factor Analysis, STEM education,S – STEM, Validation

1. Introduction

Historically factor analysis was used primarily by psychology and education; however its use within the health science sector has become much more common during the past decades (Williams , 2010)

Charles Spearman’s originated the factor analysis in the early 1900’s in his interest in human ability and his development of the Two-Factor Theory;This interest lead to flourishing of the development of the mathematical theories and principles of the factor analysis(Harman, 1976, Kieffer, 1999), cited by Williams, 2010.

Factor analysis is considered method of choice for interpreting self – reporting questionnaires. It is a multivariate statistical procedure that has many uses. It reduces a large number of variables into smaller variables, referred as factors.

Examine the structure or relationship between variables, detection and assessment of uni- dimentionality of theoretical construct, evaluates the construct validity of scale, test, or instrument.

Development of parsimonious (simple) analysis and interpretation, addresses multicollinearity (two or more variables that are correlated). Used to develop theoretical constructs and it is used to prove/disprove proposed theories (Williams, Onsman, Brown, 2010)

The goal of a factor analysis

The primary goal of factor analysis is to decrease the dimensionality of the original questionnaire or test and to give analysis to the new questionnaire or test, which spanned by a reduce new number of dimensions which are supposed to underlie the old ones (Rietveld and Van Hout, 1993: 254).

Factor analysis explain the variance in terms of underlying latent factors (Habing, 2003). Whereas a pre-defined hypothesis of inter- variable relationships is tested in confirmatory factor analysis (Kline, 1994; Stevens, 1996; Tabachnick & Fidell, 2001).

STEM education

The main objective of STEM education is to make students have problem-solving skills, understand the system of technology, think analytically, self-confident and have advanced communication skills (Bybee, 2010; Morrison, 2006).

Brown, Brown, Reardon, & Merrill, (2011) conducted a study on principals, teachers, and students on STEM education at the university level, this study disclose that STEM education is not well understood by the respondents, the teachers teaching STEM field do not cooperate with each other, the teachers implement a teaching method with different purposes. The objective of STEM education contributes to enhancing the skills of students, like problem solving, critical thinking, and analytical thinking which was been develop by an genuine environment.

Scientific and Educational Institutions suggested that STEM careers should start in early age of the students to develop their positive interest in STEM (Kier, Blanchard, Osborne, & Albert, 2014).

In the Philippines under the Republic Act 10533, Enhanced Basic Education Act of 2013 mandates the Department of Education to create another level of the basic education composed of two years. These two additional years in the secondary level shall comprise the senior high school program as set by the aforementioned law (Republic Act 10533 (2013). Congress of the Philippines). The primary goal of the program is to prepare secondary students to master the prerequisite skills needed in professional courses for those who will prefer academic tracks and to equip with employment and industrial skills needed for those who will prefer technical- vocational and other tracks [Department of Education (2013). DepEd Order No. 43, Series of 2013.

The Science, Technology, Engineering and Mathematics (STEM) track of the Philippine K to 12- Enhanced Basic

Education Curriculum is designed to produce graduates of secondary level who will take science, research, mathematics and engineering- related courses in tertiary level and thereby add to thescientific and scholarly workforce of the country.(Philippine Basic Education, 2013).

a) STEM survey questionnaire

The S-STEM Survey contains three constructs measure changes in students' confidence, efficacy in STEM subjects, 21st century learning skills, interest in STEM careers all on a five-point Likert scale (Strongly Disagree to Strongly Agree). Purpose of the instrument S-STEM is to determine the student attitude towards STEM in Australia because of the declining enrolees in the universities in STEM career courses become the bases for the educational manager in modification of their curriculum.

The Student Attitudes toward STEM (S-STEM) is a 37 items survey under four factors: "Student Attitude towards Math," "Student Attitude towards Science," Student Attitude towards Engineering/ Technology and "Student Attitude towards 21st Century Skills." (http://miso.ncsu.edu/articles/s-stem-survey or http://miso.ncsu.edu/articles/t-stem-survey.)

Objective of this validation

The objective of this study is to reduce the number of items of the survey questionnaire using factor analysis

2. Methods

2.1 Participants and Procedures

The study conducted between September 2017 and October 2017. The study cohort represents 81.81% (n = 360) of the total students (N= 440) at the Eastern Visayas Regional Science High School (EVRHS), Catbalogan City, encompassing both males (n = 129) and females (n = 231). The participants was randomly selected from Grade 7 to Senior High School by the researcher.

2.2 Instrument

The Student Attitudes toward STEM (S-STEM) Middle and High School Students (6-12th grades) Survey," developed by Friday Institute for Educational Innovation (2012).The S-STEM Survey contains three constructs measuring attitudes toward STEM content and one measuring attitudes toward 21st century skills, all on a five-point Likert scale (Strongly Disagree to Strongly Agree). The STEM content constructs measure attitudes toward science, mathematics, and engineering/technology. Engineering and technology are combined, treating technology as an inherent aspect of engineering. These STEM attitudes constructs were developed based on a survey for female, middle-school students in an engineering program (Erkut& Marx, 2005). The 21st century skills construct was adapted from a Student Learning. Middle/High School (6-12th) S-STEM Surveys are intended to measure changes in students' confidence and efficacy in STEM subjects, 21st century learning skills, and interest in STEM careers. The surveys are available to help program STEM coordinators make decisions about possible improvements to their program.

Conditions Survey (Friday Institute, 2010a). For these surveys, the researchers defined a measure of attitudes as a combination of self-efficacy and expectancy-value measures. Self-efficacy is a student's belief in his or her ability to complete tasks or influence events that will impact his or her life (Bandura, 1986). Expectancy-value is the belief that attaining a certain goal will be valuable for a student's future. The STEM attitudes constructs, therefore, measure both self- efficacy and expectancy-value. The 21st century skills portion only measures self-efficacy since 21st century skills are general tasks that are taught in connection to particular subject-areas, and therefore task values would be confounded. An example of an item measuring self-efficacy from the attitudes toward mathematics construct is, "I am the type of student to do well in mathematics," whereas an expectancy-value item reads, "I would consider choosing a career that uses mathematics."

The Student Attitudes toward STEM (S-STEM) is a 37 items survey under four factors: "Student Attitude towards Math," "Student Attitude towards Science," Student Attitude towards Engineering/ Technology and "Student Attitude towards 21st Century Skills." The first factor consists of eight items and the Cronbach-alpha reliability coefficient is α = .90. The second factor consists of nine items and the Cronbach-alpha reliability coefficient is α = .89. The third factor consists of nine items and the Cronbach-alpha reliability coefficient is α =.90. The fourth factor consist of eleven itemsand the Cronbach-alpha reliability coefficient is α =.92. The total variance explained by the whole scale is 45.31% and the Cronbach-alpha reliability coefficient is α =.92 (Erkut& Marx, 2005).(Alana, Unfried et. Al, 2014) For access to the full surveys, http://miso.ncsu.edu/articles/s-stem-survey or http://miso.ncsu.edu/articles/t-stem-survey.

2.3 Item Review

To ensure that the items of the questionnaire were appropriate and relevant to student respondents, the original instrument was shown to the subject professor of the test and scale in which this study was the major requirement, the principal of the Eastern Visayas Regional Science High School (EVRSHS) and one of her master teacher in Eastern Visayas Regional High School for their comments and suggestions regarding some words, phrases or sentences that could be modified or rephrased. This experts approved for the use of the original survey questionnaire.

2.4 Procedure

The researcher started gathering the needed data by requesting permission from the Division Superintendent of the City Division of Catbalogan, City then noted by the principal of Eastern Visayas Regional Science High School (EVRSHS), Catbalogan, City to allow here the conduct of the study among grade 7 to senior high school students. Upon their approval, the researcher got the list of enrolees per grade level from the school registrar, inclusive of the school year 2017 – 2018.

Then the researcher communicated to the respected teacher advisory to ask permission to conduct the study among the students of their respected classes or advisories. After their approval was obtained, the researcher distributed the questionnaire during their classes to ensure the presence of the respondents during the data collection period. The respondents were given considerable time to answer the instruments of the study. After which, the researcher personally retrieved the answered instruments to ensure 100 percent retrieval.

After the 100 percent retrieval the data was tallied for statistical treatment and analysis. The instrument was coded as follows: 1 - strongly Disagree; 2 – Disagree; 3 – Undecided; 4 –Agree; and 5 - Strongly Agree. Items that were expressed in negative format were coded the opposite. These items are as follows: Item number 1, 3, and 5.

2.5 Statistical Analysis

Responses from the students to the scale were coded and entered into IBM SPSS Statistics 21. Demographic missing data were coded as missing and excluded from relevant analysis. The researcher replaced items of missing data with the mean. However, those students who did not provide a response to four or more items were not included in subsequent analysis. Based on this, 24 (6%) students were excluded from the study. Descriptive analyses were performed on all items. Factor analysis on the questionnaire for construct validity was performed using tests contained in SPSS (IBM SPSS Statistics 21.).

The first multivariate statistical procedure used in this study is principal component analysis (PCA) with Varimax rotation. PCA is the ‘general name for a technique which uses sophisticated underlying mathematical principles to transform a number of possible correlated variables into a smaller number of variables called principal components’ (Richardson, 2009, p. 2). The main purposes of PCA is to investigate the internal structure of a scale, identify patterns and reduce the dimensions of the dataset with minimal loss of information (Labib&Vemuri, 2004).

The following criteria were used to determine how many factors/components should be retained: (1) The eigenvalues criterion (‘eigenvalues > 1’ rule) or the Kaiser Criterion, (2) point of inflection displayed by the scree plot, (3) proportion of variance accounted for’ criterion (A component was retained if it minimally explained an approximate additional 5% of the variance (Schonrock et al, 2009), and (4) interpretability criteria (A given component is retained if it contains at least three variables with significant loadings, a loading of at least 0.40 being suggested as the cut-off point; variables loading on the same component share the same conceptual meaning; variables loading on different components appear to measure different constructs; the rotated factor pattern demonstrates ‘simple structure. A rotated factor pattern demonstrates simple structure when first, most of the variables should have high loadings on one component, and near-zero loadings on the other components and each component should have high loadings for some variables, and near-zero loadings for the others. To retain an item, a factor loading of at least 0.40 was considered. Items that loaded on more than one dimension or factor were deleted in the final form of the scale (Burton et al, 2011)

Reliability analysis using Cronbach alpha was used to determine the internal consistency of the S-STEM instrument. An item has an acceptable level of internal consistency if its Cronbach alpha is at least 0.70(Nunally, 1978; Streimer& Norman, 2008). An item is considered to contribute highly to the construct being measured if its corrected item-total correlation has a value of more than 0.3(Yusoff et al, 2010)

Prior to performing PCA, the suitability of data for factor analysis was assessed. First, sampling adequacy has to be determined by the Kaiser-Meyer-Olkin(KMO) correlation. A KMO correlation of 0.60-0.70 is considered adequate. The second is to check whether the correlation matrix is not an identity matrix. This is done through Bartlett’s Sphericity test which provides a chi-square output that must be significant (Burton &Mazerolle, 2011).

3. Result

3.1 The Kaiser Criterion

The Kaiser-Meyer-Olkin (KMO) analysis was supposed to examine the criteria of Principal Component analysis (PCA) for identifying the factor structure. Since KMO index was 0.855, the data set is right for the purpose for factor analysis as it is greater than 0.50. Bartlett’s test of sphericity was highly significant (χ^2) =5980.711; $p \leq 0.01$) as shown in table 1. This information allowed us to perform factor analysis in this S – STEM survey scale to identify the factor model using the Principal Component Analysis (PCA) approach using syntax in SPSS.

Table 1: KMO and Bartlett's Test of theHigh School Student Attitudes towards Science, Technology, Engineering, and Math (S-STEM)

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.855
Bartlett's Test of Sphericity	Approx. Chi-Square	5980.711
	df	666
	Sig.	.001

3.2 Eigenvalues Criterion

Results of the principal components analysis revealed the presence of nine(9) components with eigenvalues exceeding one (1) as shown in Table 2. This explains a total of 64.63% of the variance with each dimensions contributing 21.723%, 11.849%, 8.545%, 6.2017%, 4.268%, 3.247.%, 3.029%, 2.994%, and 2.776% respectively. This result was different to the study of Unfried, et al (2015) “The Development and Validation of a Measure of Student Attitudes Toward Science, Technology, Engineering, and Math (S-STEM)” this study suggested the use of a four-factor structure to measure student attitudes toward science, math, engineering/technology, and 21st century skills.

Table 2: Eigenvalues greater than 1 from PCA

	PC1	PC2	PC3	PC4	PC5
Eigenvalue	8.037	4.384	3.162	2.294	1.579
Proportion	0.2172	0.1184	0.0854	0.0620	.0426
Cumulative	0.2172	0.3357	0.4211	0.48317	0.5258
	PC6	PC7	PC8	PC9	
Eigenvalue	1.201	1.121	1.108	1.027	
Proportion	.0324	0.0302	0.0299	0.0277	
Cumulative	.5583	0.5886	0.6185	0.6463	

3.3 Scree Plot

The scree plot graphic showed that there was a nine-factor solution or dimensions, the line change in its graph after the nine point as showed Figure 1 (Ford et al., 1986; Hayton et al., 2004). This result was also the same with the Principal Component Analysis (Table 2).

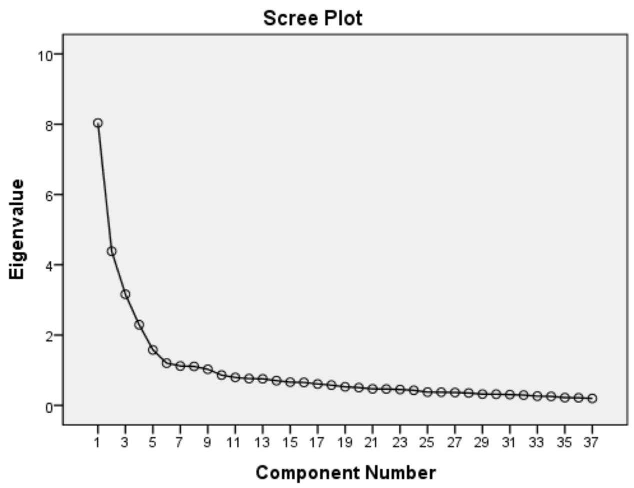

Figure 1: The PCA Scree Plot of the High School Student Attitude toward STEM(S-STEM)

Table 3: Parallel Analysis: Monte Carlo Parallel Analysis of the S - STEM
Raw Data Eigenvalues, & Mean & Percentile Random Data Eigenvalues

S.No	Root	Raw Data	Means	Percentile	Decision
1	000000	8.037387	1.663585	1.747499	Accept
2	000000	4.383952	1.581702	1.642394	Accept
3	000000	3.161637	1.521593	1.574278	Accept
4	000000	2.294363	1.469982	1.516706	Accept
5	000000	1.578991	1.422379	1.464970	Accept
6	000000	1.201452	1.379786	1.418852	Reject
7	000000	1.120818	1.339923	1.374449	Reject
8	000000	1.107632	1.302356	1.336475	Reject
9	000000	1.027162	1.267564	1.299478	Reject
10	000000	.862343	1.233428	1.264644	Reject
11	000000	.794739	1.200488	1.231055	Reject
12	000000	.762675	1.168164	1.197878	Reject
13	000000	.754275	1.137408	1.165201	Reject
14	000000	.703550	1.107556	1.135077	Reject
15	000000	.660400	1.077945	1.102134	Reject
16	000000	.652798	1.048928	.074953	Reject
17	000000	.608668	1.022205	1.048534	Reject
18	000000	.576458	.995225	1.021364	Reject
19	000000	.527423	.968201	.992077	Reject
20	000000	.506041	. 942567	.966866	Reject
21	000000	.470984	.915714	.939665	Reject
22	000000	.465085	.890856	.915212	Reject
23	000000	.451458	.864990	.888933	Reject
24	000000	.430190	.841317	.864863	Reject
25	000000	.377021	.816015	.839658	Reject
26	000000	.375287	.791247	.816371	Reject
27	000000	.366997	.767197	.792934	Reject
28	000000	.351594	.742905	.768641	Reject
29	000000	.321164	.717588	.742856	Reject
30	000000	.317287	.693506	.718383	Reject
31	000000	.305704	.668760	.694544	Reject
32	000000	.292129	.643397	.668027	Reject
33	000000	.263837	.617832	.642872	Reject
34	000000	.256414	.590692	.616813	Reject
35	000000	.219604	.562483	.589180	Reject
36	000000	.215369	.531989	.561751	Reject
37	000000	.197113	.492526	.528003	Reject

To check if the loaded factor by PCA was fitted for the factor analysis the actual data and the simulative data underwent parallel analysis through a syntax written in SPSS (Table 3) other method to validate the research instrument for determining the factor loading.The purpose of the use of parallel analysis was to provide further evidence or a basis to decide the number of factors more easily. Table 3 showed that the eigenvalue of the first factor in the actual data or raw data is 8.037, while it is 1.747 in the simulative data set. The eigenvalue of the second factor in the actual data is 4.383, whereas it is 1.642 in the simulative data. The eigenvalue of the third factor in the actual data is 3.161, while it is 1.574 in the simulative data. The eigenvalue of the fourth factor in the actual data is 2.294, while it is 1.516 in the simulative data set. The eigenvalue of the fifth factor in the actual data is 1.578, whereas it is 1.464 in the simulative data. When the researcher shift from the fifth factor to the sixth factor, the case was different and thus the number of the scale factors was determinedly restricted to five (5) because the eigenvalue of the simulative data of the sixth factor is higher than that of the actual data. This case should be considered as the point at which parallel analysis introduces a decision about the number of factors. Based on the parallel analysis by Monte Carlo the research instrument has five factor dimensions.

The parallel analysis disclose a five factor model the data underwent a principal component analysis for fixed factor analysis which were able to load higher than 0.400 by extraction method. As seen in table 4, based on the parallel factor analysis, the items 9 to 17 were items loaded in Factor 1 (High School Student Attitude towards Science), seven items in factor 2these were theitems 22, 21, 24, 23, 20, 18, and 26 (High School Student Attitude Toward Technology and Engineering), eight items in factor 3 these items were items 1 to 8 (High School Student Attitude towards Mathematics), eight items for factor 4, the items 1 to 8 (High School Student Attitude Towards Math), for factor 4 there were eight items, these are the items 30, 32, 31, 19, 25, 28, 30, and 32, lastly for factor 5, the factor analysis loaded five items, these are the items 35, 37, 36, 34, 33, 29, and item 27. No item had factor loading lower than 0.400. Item number 27 (I am confident I can lead others to accomplish a goal) was loaded to two factor, factor 2 and factor 5, this item was classify to factor 5 because in this factor the criterion value of (.435) in factor 5 was bigger than .413 in factor 2. Another item loaded to two factors was item 19(If I learn Engineering, then I can improve things that people use every day) the criterion value of .533 in factor 3 and .442 in factor

2, this item classify to factor 3. Since the criterion for retaining an item was a factor loading ≥0.400 and the criterion for deleting an item is loading on more than one dimension or factor. In this case, there was no item that was deleted based on the factor analysis.

Table 4: Sorted Rotated Factor Loadings and Communalities of the five dimension solution for Attitude towards STEM for High School Students

Variable	*Factor 1*	*Factor 2*	*Factor 3*	*Factor 4*	*Factor 5*	*Communalities*
10	0.770	0.000	0.000	0.000	0.000	0.644
11	.767	0.000	0.000	0.000	0.000	0.598
14	.734	0.000	0.000	0.000	0.000	0.619
13	.731	0.000	0.000	0.000	0.000	0.628
15	.712	0.000	0.000	0.000	0.000	0.642
9	.673	0.000	0.000	0.000	0.000	0.507
17	.626	0.000	0.000	0.000	0.000	0.567
12	.579	0.000	0.000	0.000	0.000	0.402
16	-.578	0.000	0.000	0.000	0.000	0.434
22	0.000	.738	0.000	0.000	0.000	0.592
21	0.000	.715	0.000	0.000	0.000	0.573
24	0.000	.694	0.000	0.000	0.000	0.506
23..	0.000	.689	0.000	0.000	0.000	0.496
20.	0.000	.639	0.000	0.000	0.000	0.465
18.	0.000	.552	0.000	0.000	0.000	0.360
26.	0.000	.535	0.000	0.000	0.000	0.507
1.	0.000	0.000	-.743	0.000	0.000	0.586
8.	0.000	0.000	.738	0.000	0.000	0.631
4.	0.000	0.000	.728	0.000	0.000	0.599
3.	0.000	0.000	-.727	0.000	0.000	0.539
5	0.000	0.000	-.699	0.000	0.000	0.505
2.	0.000	0.000	.600	0.000	0.000	0.509
7.	0.000	0.000	.545	0.000	0.000	0.436
6.	0.000	0.000	.496	0.000	0.000	0.461
30.	0.000	0.000	0.000	0.713	0.000	0.588
32.	0.000	0.000	0.000	.699	0.000	0.555
31..	0.000	0.000	0.000	.666	0.000	0.551
19.	0.000	0.442	0.000	.533	0.000	0.536
25	0.000	0.000	0.000	.496	0.000	0.437
28.	0.000	0.000	0.000	.483	0.412	0.490
35.	0.000	0.000	0.000	0.000	0.694	0.555
37.	0.000	0.000	0.000	0.000	0.665	0.562
36.	0.000	0.000	0.000	0.000	0.626	0.413
34..	0.000	0.000	0.000	0.000	0.511	0.414
33.	0.000	0.000	0.000	0.454	0.502	0.563
29.	0.000	0.000	0.000	0.000	0.439	0.518
27.	0.000	0.413	0.000	0.000	0.435	0.513

Table 5: New item groupings of the 37 retained items of the revised S –STEM

Items	Factor
10. I would consider a career in science	Factor 1 High School Attitude towards Science
11. I expect to use science when I get out of school	
14. Science will be important to me and my life work.	
13. I knew I can do well in science.	
15 I can handle most subjects well, but I cannot do a good job with science.	
9. I am sure of myself when I do science	
17. I am sure I could do advanced work in science.	
12. Knowing science will help me earn a living	
16. I am sure I could do advanced work in science.	
22. Designing products or structures will be important for my future work.	Factor 2 High school Students Attitude towards Technology and Engineering
21. I am interested in what makes machines work.	
24. I would like to use creativity and innovation in my future work.	
23. I am curious about how electronic work.	
20. I am good at building and fixing things.	
18. I like to imagine creating new products.	
26. I believe I can be a successful in a career in engineering.	
1. Math has been my worst subject	Factor 3: High School Students attitude towards Mathematics
8. I am good at math	
4. I am the type of student to do well in math.	
3. Math is hard for me	
5. I can handle most subjects well, but I cannot do a good job in math	
2. I would consider choosing a career that uses math	
7. I can get good grade in math	
6. I am sure I could do advance work in math	
30. I am confident I can respect the differences of my peers.	Factor 4: High School Students Attitude towards Working with Peers
32. I am confident I can include others' perspective when making decisions.	
31. I am confident I can help my peers.	
19. If I learn engineering, then I can improve things that people use every day	
25 Knowing how to use math and science together will allow me to invent useful things.	
28. I am confident I can encourage others to do their best.	
30. I am confident I can respect the differences of my peers.	
32. I am confident I can include others' perspective when making decisions.	
35. I am confident I can manage my time wisely when working on my own.	Factor 5: High School Students Attitude towards Attaining Goals
37. I am confident I can work well with students from different backgrounds.	
36. When I have many assignments, I can choose which ones need to be done first.	
34. I am confident I can set my own learning goals.	
33. I am confident i can make changes when things do not go as planned.	
29. I am confident I can produce high quality work.	
27. I am confedent I can lead others to accomplish a goal	

3.4 Reliability Analysis

The most broadly used system or method to check for reliability of a data is the Cronbach's alpha (α). This is to used determine the internal consistency of items in a questionnaire (Hinton, P.R., Brownlow, C., McMurray, I. and Cozens, B.,2011)-(Bland, J. and Altman, D.,1997). Acceptable values of Cronbach's α, is ranging from 0.70 to 0.95 (Hinton, P.R., Brownlow, C., McMurray, I. and Cozens, B.,2011). In this study, the Cronbach's alpha was 0.839 which indicated a scale of high reliability and the Cronbach's α based on standard items was .849which is also indicated high reliability as shown in Table 5. In statistics, a questionnaire is assume reliable when each item or a set of some items represent the same result as the entire questionnaire. The simplest method to test the internal consistency of a questionnaire is dividing the scores a participant received on a questionnaire in two sets with an equal amount of scores and calculating the correlation between these two sets (Field, 2009).A high correlation signals a high internal consistency.

Table 6: The Reliability Test of S -STEM

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of Items
.839	.849	37

4. Limitations of the Study

The findings of this study were based on data gathered from a single institution, arguably a sample of convenience. The findings may be somewhat limited in generalizability owing to their derivation from only a single STEM school. The entirety of the sample is nonetheless representative of students from diverse multicultural and social backgrounds which may mitigate the aforementioned limitation. In addition, the PCA generated a hypothesised factor structure for the data set, which is confirmed on the same data set by the CFA. Because the same data set is used to both generate and then confirm the factor structure it may be less informative. Therefore CFA should be conducted with a different data set using the hypothesised factor structure. The researcher wished to perform a secondary CFA in another school but it was not practically feasible. The research hope that other schools in the Philippines catering STEM strand curriculum use CFA in order to test the model by using their own data set. Finally, one cannot overemphasise the limitations of self-reported data as this may limit the validity of findings. Respondents for various reasons may under or overestimate the high school student attitude toward STEM. A methodological problem frequently associated with the use of self-report measures, which may have been evident in the present study, is the inability to determine the extent to which responses accurately reflects the respondents' experiences and expectations of their attitude due to social desirability and inaccurate recall.

Table 7: Reliability Test: Item-total Statistics S - STEM

Item-Total Statistics				
ITEMS	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
1) Math has been my worst subject	127.8500	158.512	-.185	.852
2) I would consider choosing a career that uses math	127.0278	148.801	.198	.839
3) Math is hard for me	127.2583	158.805	-.210	.851
4) I am the type of student to do well in math.	127.2278	147.714	.274	.837
5) I can handle most subjects well, but I cannot do a good job in math	127.4444	159.780	-.247	.852
6) I am sure I could do advance work in math	127.1139	144.413	.409	.833
7) I can get good grade in math	126.7417	146.125	.377	.834
8) I am good at math	127.1083	146.431	.368	.834
9) I am sure of myself when I do science	126.8667	148.088	.309	.836
10) I would consider a career in science	126.6167	147.881	.225	.839
11) I expect to use science when I get out of school	126.5722	148.078	.266	.837
12) Knowing science will help me earn a living	126.1417	148.607	.280	.836
13) I knew I can do well in science.	126.3028	147.799	.293	.836
14) Science will be important to me and my life work.	126.6028	146.574	.416	.833
15) I can handle most subjects well, but I cannot do a good job with science.	126.3278	147.112	.338	.835
16) I am sure I could do advanced work in science.	127.7361	160.707	-.317	.851
17) I am sure I could do advanced work in science.	126.7889	145.415	.421	.833
18) I like to imagine creating new products.	126.4861	144.986	.401	.833
19) If I learn engineering, then I can improve things that people use every day	126.4222	143.782	.525	.830
20) I am good at building and fixing things.	127.0417	144.625	.472	.831
21) I am interested in what makes machines work.	126.6278	142.663	.455	.831
22) Designing products or structures will be important for my future work.	126.7611	143.369	.415	.832
23) I am curious about how electronic work.	126.3806	144.186	.413	.833
24) I would like to use creativity and innovation in my future work.	126.3222	144.999	.470	.832
25) Knowing how to use math and science together will allow me to invent useful things.	126.1389	144.766	.466	.832
26) I believe I can be a successful in a career in engineering.	127.0722	141.544	.476	.830
27) I am confident I can lead others to accomplish a goal	126.6806	142.107	.592	.828
28) I am confident I can encourage others to do their best.	126.5056	143.398	.502	.830
29) I am confident I can produce high quality work.	126.7639	142.950	.582	.829
30) I am confident I can respect the differences of my peers.	126.2889	145.114	.459	.832
31) I am confident I can help my peers.	126.4250	144.095	.506	.831
32) I am confident I can include others' perspective when making decisions.	126.3000	144.901	.449	.832
33) I am confident i can make changes when things do not go as planned.	126.5306	143.698	.557	.830
34) I am confident I can set my own learning goals.	126.4389	146.163	.486	.832
35) I am confident I can manage my time wisely when working on my own.	126.4917	148.875	.276	.836
36) When I have many assignments, I can choose which ones need to be done first.	126.2278	149.998	.225	.838
37) I am confident I can work well with students from different backgrounds.	126.5667	144.670	.476	.831

5. Discussion

The purpose of this study is to determine the validity and reliability of the S –STEM survey questionnaire. The survey questionnaire was develop and validated Australia, using the exploratory factor analysis (EFA)(Unfried et. al,2015) to author knowledge however, this is the first study assessing the validity and reliability of the construct here in the Philippines in which the respondents are students from a high school in which the curriculum is a STEM .Based on the data,KMO index was 0.855, the data set is suitable for factor analysis. Bartlett's test of sphericity was highly significant ($\square^2$) =5980.711; $p \leq 0.01$) it is appropriate to perform factor analysis to identify the factor model using the PCA approach using syntax in SPSS. The scree plot graphic and the PCA showed that there were nine -factors model, and the number of factors correspond to the number of factors determined via the eigenvalue methods.The actual data and the simulative data underwent Monte Carlo parallel analysis by using SPSS. The researcher generated a five-factor model using extraction using fixed number of factor that was derived from the parallel analysis. The factor identifications based on the parallel analysis were High School attitude towards Science for factor 1 it consists of 8 items, factor 2 is High school Attitude towards Technology and Engineering with 7 items, while factor 3 is the High School Attitude towardsMathematics there were 8 items. For factor 4 is the High School Attitude towards dealing with Peers there with 8 items. Lastly for factor 5 it was for High school Attitude towards Attaining Goals, these factor loaded 7 items. Based on the analysis there was no item had factor loading lower than 0.400 (Henson and Roberts, 2006). The data was based on high school students enrolled in Eastern Visayas Regional science High School(EVRSHS) a Science High School that the curriculum is committed to provide quality STEM education that is equitably accessible to the intellectually, gifted STEM inclined youth who understand and have internalized the value of scientific knowledge towards the advancement of the country.

In general based on the data, the Cronbach's alpha was 0.839 which indicated a scale of high reliability (Bland, J. and Altman, D. (1997). The Cronbach's α based on Standard Items was .849which is also indicated high reliability. A reliable question is expected to have a positive relationship with the overall total, ideally having a corrected item-total correlation (Hinton, P.R., Brownlow, C., McMurray, I. and Cozens, B., 2011), (Bland, J. and Altman, D., 1997). These values were larger than the cut-off point of 0.70 for reliability (Hair, Anderson, Tathom, & Black, 2010) and were comparable to the values reported by Tapia and Marsh (2004).It is assumed that a questionnaire was reliable and an individual item renders the same result as the entire questionnaire it signal high internal consistency.

6. Conclusion

Based on the result of this study the evaluated questionnaire seems reliable and construct valid. The items measure the same underlying construct. The extraction of five factors in the factor analysis just seems to be a consequence of the wording of the questionnaire items, they only differ on the sequences of the number of determining the dimensions. After all, the five factors correlate highly with each other. The result of the reliability measure was high: α = 0.84. All items contribute to the reliability and construct validity of the questionnaire: the items correlate more than 0.4 with the factors that underlie them, the Cronbach's alpha does not increase when one of the questionnaire items is deleted, and the average correlation coefficient sometimes just a bit. From the various validity and reliability tests, it appears that High School Student Attitude towards STEM(S –STEM) could be a valid and reliable instrument to measure the high school attitude toward STEM. Collectively, these measures indicated that the S- STEM could be a useful tool for further studies on the middle/high school attitude towards STEM.

References

[1] Baldi, S., Jin, Y., Skemer, M., Green, P.J., &Herget, D. (2007). Highlights from PISA 2006: Performance of U.S. 15-year-old students in science and mathematics literacy in an international context (NCES 2008–016). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

[2] Bandura, A. (1986). Social foundations of thoughts and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice Hall

[3] Bartholomew, D., Knotts, M., &Moustaki, I. (2011). Latent variable models and factor analysis: A unified approach. (3rd ed.). West Sussex, UK: John Wiley & Sons.

[4] Betz, N. E. &Voyten, K. K. (2012). Efficacy and outcome expectations influence career exploration and decidedness. The Career Development Quarterly, 46(2), 179-189.

[5] Bland, J. and Altman, D. (1997) Statistics Notes: Cronbach's Alpha. BMJ, 314, 572. http://dx.doi.org/10.1136/bmj.314.7080.572

[6] Braza, Melanie T. and Sweden S. Supapo (2014). Effective Solutions in the Implementation of the K to12 Mathematics Curriculum. West Visayas State University. Iloilo City. Retrieved September 15, 2016 from www.googlescholar.com

[7] Brown, R., Brown, J., Reardon K., & Merrill, C. (2011). Understanding STEM: Current perceptions. Technology and Engineering Teacher, 70(6), 5-9.

[8] Buja, A., &Eyuboglu, N. (1992). Remarks on parallel analysis. Multivariate Behavioral Research, 27(4), 509–540

[9] Bybee, R. W. (2010). What is STEM education. Science, 329, 996. doi: 10.1126/science.1194998.

[10] Carnevale, A. P., Smith, N., & Melton, M. (2011). STEM: Science, technology, engineering, mathematics. Washington, DC: Georgetown University Center on Education and the Workforce.

[11] Cattell, R.B. (1978). The scientific use of factor analysis in behavioral and life sciences. New York, NY: Plenum Press. Cattell, R.B. (1973). Factor analysis. Westport, CT: Greenwood Press.

[12] Chen, G., Gully, S. M., Whiteman, J. A, &Kilcullen, R. N. (2000). Examination of relationships among trait-like individual differences, state-like individual differences,

and learning performance. The Journal of Applied Psychology, 85, 835-847.
[13] Cho, J., & Kim, J. (2010). Collaborative project curriculum applying project-based learning. Journal of the Korea Academia-Industrial Cooperation Society, 11(1), 214–219.
[14] Cho, H., & Kim, D. (2013). The relationship between cooperation learning in mathematics and their attitudes towards mathematics. Korean Comparative Education Society, 23(4), 131–154.
[15] Choi, N., & Lee, J. (2008). The comparative analysis on the rate of return to post-secondary education between engineering and medical school graduates. The Journal of Educational Administration, 26(1), 369–389.
[16] Child, D. (2006). The essentials of factor analysis. (3rd ed.). New York, NY: Continuum International Publishing Group.
[17] Cortina, J.M. (1993). What is coefficient alpha? An examination of theory and applications. Journal of Applied Psychology, 78, 98-104.
[18] DeCoster, J. (1998). Overview of factor analysis. Retrieved March 22, 2012 from http://www.stat-help .com/notes.html
[19] Dejarnette, N.K. (2012). America's children: Providing early exposure to STEM (Science, Technology, Engineering and Math) initiatives. Education, 133(1), 77-84.
[20] Department of Education (2013). DepEd Order No. 43, Series of 2013. Implementing Rules and Guidelines of R.A. 10533. Retrieved September 2016 from www.deped.gov.ph
[21] Eccles, J. S., &Wigfield, A. (2002). Motivational beliefs, values, and goals. Annual Review of Psychology, 53, 109-132.
[22] Erkut, S. & Marx, F. (2005). 4 schools for WIE (Evaluation Report). Wellesley, MA: Wellesley College, Center for Research on Women. Retrieved January 2, 2012 from http://www.coe.neu.edu/Groups/stemteams/evaluation.pdf
[23] Estonanto, Acceptability and Difficulty of the STEM Track Implementation in Senior High School 2016 from hudsonvalleysingers.org Acceptability; Also Retrieved October 12, 2016
[24] Fan, W. (2011). Social influences, school motivation and gender differences: An application of the expectancy-value theory. Educational Psychology, 31, 157-175. doi:10.1080/01443410.2010.53652
[25] Field,A. (2000). Discovering Statistics using SPSS for Windows. London – Thousand Oaks – New Delhi: Sage publications.
[26] Fishbein, M. &Aizen, I. (1975). Belief, attitude, intention, and behavior: An introduction to theory and research. Reading, MA: Addison-Wesley.
[27] Floyd, F. J., &Widaman, K. F. (1995).Factor analysis in the development and refinement of clinical assessment instruments. Psychological Assessment, 7(3), 286–299.
[28] Friday Institute (2010a). Governor Perdue's North Carolina Student Learning Conditions Survey (SLCS): Survey Implementation Study. Raleigh, NC: Author.
[29] Gardner, P. L. (1975). Attitude measurement: a critique of some recent research. Educational Research, 17(2), 101-109
[30] Gonzales, P., Williams, T., Jocelyn, L., Roey, S., Kastberg, D., &Brenwald, S. (2008). Highlights From TIMSS 2007: Mathematics and science achievement of U.S. fourth- and eighth-grade students in an international context (NCES 2009–001 Revised). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.
[31] Harman, H.H. (1976). Modern factor analysis (3rd ed. revised). Chicago, IL: University of Chicago Press
[32] Hair, J.F., Anderson, R.E., Tatham, R.L. & Black, W.C. (2010). Multivariate data analysis (7th ed.). New Jersey: Prentice-Hall
[33] Hinton, P.R., Brownlow, C., McMurray, I. and Cozens, B. (2011) SPSS Explained. Using SPSS to Analyse Questionnaires: Reliability. Routledge Taylor & Francis Group, London, 355-365.
[34] Humphreys, L. G., &Montanelli, R. G. Jr. (1975).An investigation of the parallel analysis criteria on for determining the number of common factors. Multivariate Behavioral Research, 10, 193–205
[35] Kier, M. W., Blanchard, M. R., Osborne, J. W., & Albert, J. L. (2014). The development of the STEM career interest survey (STEM-CIS). Research in Science Education, 44(3), 461-481.
[36] Lent, R. W., & Brown, S. D. (1996). Social cognitive approach to career development: An overview. Career Development Quarterly, 44, 310-321.
[37] Lent, R. W., Brown, S. D., & Hackett, G. (2000). Contextual supports and barriers to career choice: A social cognitive analysis. Journal of Counseling Psychology, 47, 36-49. doi:10.1037//0022-0167.47.1.36
[38] Lent, R. W., & Brown, S. D. (2006). Integrating person and situation perspectives on work satisfaction: A social-cognitive view. Journal of Vocational Behavior, 69, 236-247. doi:10.1016/j.jvb.2006.02.006
[39] Lent, R. W., Lopez, A. M., Lopez, F. G., &Sheu, H. (2008). Social cognitive career theory and the prediction of interests and choice goals in the computing disciplines. Journal of Vocational Behavior, 73, 52-62. doi:10.1016/j.jvb.2008.01.002 Lent, R. W., Sheu, H., Gloster, C. S., & Wilkins, G. (2010). Longitudinal test of the social cognitive model of choice in engineering students at historically Black universities. Journal of Vocational Behavior, 76, 387-394. doi:10.1016/j.jvb.2009.09.002
[40] Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. Science Education, 95, 877-907. doi:10.1002/sce.20441
[41] McDonald, R.P. (1985). Factor analysis and related methods. Hillside, NJ: Lawrence Erlbaum Associates, Inc.
[42] Minner, D., Ericson, E., Wu, S., & Martinez, A. (2012). Compendium of STEM student instruments PART II: Measuring students' content knowledge, reasoning skills, and psychological attributes. Washington, DC: Abt Associates.

[43] Multon, K. D., Brown, S. D., & Lent, R. W. (1991). Relation of self-efficacy beliefs to academic outcomes: A meta-analytic investigation. Journal of Counseling Psychology, 38(1), 30-38.
[44] National Academy of Engineering. (2008). Grand challenges for engineering. Washington, DC: The National Academies Press.
[45] National Academy of Engineering. (2008). Grand challenges for engineering. Washington, DC: National Academies Press. National Academy of Engineering and the National Research Council. (2014). STEM integration in K-12 education: Status, prospects, and an agenda for research. Washington, DC: National Academies Press.
[46] National Center for Education Statistics (NCES - 2) (2015). Supplemental Tables to Education and Certification Qualifications of Departmentalized Public High School-Level Teachers of Selected Subjects: Evidence From the 2011–12 Schools and Staffing Survey http://nces.ed.gov/pubs2014/2014059.pdf (Accessed July 20, 2016)
[47] National Center for Education Statistics. (2011). The Nation's Report Card: Mathematics 2011 (NCES 2012–458). Washington, DC: Institute of Education Sciences, U.S. Department of Education.
[48] Oskamp, S. & Schultz, P. W. (2005). Attitudes and opinions (3rd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.
[49] O'Connor, B. P. (2000). SPSS and SAS programs for determining the number of components using parallel analysis and Velicer's MAP test. Behavior Research Methods, Instruments, and Computers, 32(3), 396–402.
[50] Pajares, F. (1996). Self-efficacy beliefs in academic settings. Review of Educational Research, 66(4), 543-578.
[51] Partnership for 21st Century Skills. (2004). Homepage. Retrieved March, 2006, from http://www.21stcenturyskills.org/index.php
[52] Pathways to Prosperity Project (2011). Pathways to Prosperity: Meeting the Challenge of Preparing Young Americans for the 21st Century. Harvard Graduate School of Education: Cambridge, MA.
[53] Philippine Basic Education (2013). DepEd K to 12: Teaching Math and Science. Retrieved September 2016 from Philbasiceduaction.blogspot.com/2013/08/deped – k to 12 – teaching – math –and – science.html.
[54] Republic Act 10533 (2013). Congress of the Pilippines. Retrieved September 2016 from www.gov.ph/2013/05/15/republic-act-no-10533.html; Also Retrieved October 12, 2016 from searchanddiscovery.com; Also Retrieved October 12, 2016
[55] Rietveld, T. & Van Hout, R. (1993). Statistical Techniques for the Study of Language and language Behavior. Berlin – New York: Moutan de Gruyter.
[56] Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. Science Education, 96, 411-427. doi:10.1002/sce.21007
[57] Schunk, D. H. (1991). Self-efficacy and academic motivation. Educational Psychologist, 26(3/4), 207.
[58] Scott, A., & Mallinckrodt, B. (2005). Parental emotional support, science self-efficacy, and choice of science major in undergraduate women. Career Development Quarterly, 53, 263-273.
[59] Shim, J. (2012). The avoidance of science and engineering majors for the last 15 years. The disaster emerges [이공계기피 15년, 재앙이시작됐다]. Retrieved from http://blog.joins.com/media/folderlistslide.asp?uid=sjw33&folder=2&list_id=12906020
[60] Simpkins, S. D., Davis-Kean, P. E., &Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. Developmental Psychology, 42, 70-83. doi:10.1037/0012-1649.42.1.70
[61] Suhr,Diana D. Ph.D.Exploratory or Confirmatory Factor Analysis?.University of Northern Colorado
[62] Tang, M., Pan, W. &Newmeyer, M. D. (2008). Factors influencing high school students' career aspirations. Professional School Counseling, 11(5), 285-295.
[63] Tapia, M., & Marsh, G. E., II. (2002). Confirmatory factor analysis of the Attitudes Toward Mathematics Inventory. Paper presented at the Annual Meeting of the Mid-South Educational Research Association, Chattanooga, TN. (ERIC Document Reproduction Service No. ED 471 301
[64] Tucker, L.R., &MacCallum, R.C. (1997). Exploratory factor analysis. Retrieved March 27, 2012 from http://www.unc.edu/~rcm/book/ch7.pdf
[65] Unfried A, Faber M. Stanhope D. (2015). The Development and Validation of a Measure of Student Attitudes Toward Science, Technology, Engineering, and Math (S-STEM)Journal of Psychoeducational Assessment© 2015 SAGE Publications.
[66] United States Department of Commerce. (2012). The Competitiveness and Innovative Capacity of the United States. Washington, DC: United States Department of Commerce. 3.
[67] U.S. Department of Commerce. (2012). The competitiveness and innovative capacity of the United States. Washington, DC: Author
[68] Wang, X. (2013). Why students choose STEM majors: Motivation, high school learning, and postsecondary context of support. American Educational Research Journal, 50, 1081-1121. doi:10.3102/0002831213488622
[69] Wigfield, A., &Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. Contemporary Educational Psychology, 25(1), 68-68.
[70] Wissehr, C., Barrow, L. H., &Concannon, J. (2011). Looking back at the sputnik era and its impact on science education. School Science and Mathematics, 111(7), 368-375.
[71] Zwick, W. R., &Velicer, W. F. (1986). Comparison of five rules for determining the number of components to retain. Psychological Bulletin, 99(3), 432–442.
[72] Joy B. Araza, Assistant Professor 1, Samar State University Catbalogan City, Samar, finished her Bachelor of Secondary Education(BSE) at Samar State Polytechnic College(SSPC), 2000, Master of Arts in Teaching (MAT, math) in Samar State University (SSU), 2008 and currently enrolled in Ph. D. in Social Science Research (Ph. D. SSR) in Leyte Normal University(LNU) Tacloban City.