Learning Engagement through Technology for Space Science

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Learning Engagement Through Technology for Space Science

This paper aimed to determine whether the technology would enhance learning in space science. By reviewing the combination of questions and rating items completed by participants in a space science activity, this article seeks to provide a higher-level view of what underlying constructs are being measured and identify ways of showing evidence of learning engagement.

The instrumentation for assessing the learning engagement through technology for space science was custom-designed based on prioritized key ideas and dispositions supplied by NASA's Science Activation (SciAct) Division and project directors at NASA's Goddard Space Flight Center.

Factor Analysis

For this analysis, the Kaiser-Meyer-Olkin (KMO) Test ascertains the suitability of the data for factor analysis. To further analyze the results, we will use the values that Kaiser (1947) placed on the results, which are 0.00 to 0.49 unacceptable, 0.50 to 0.59 miserable, 0.60 to 0.69 mediocre, 0.70 to 0.79 middling, 0.80 to 0.89 meritorious, and 0.90 to 1.00 marvelous. In addition, factor analysis was run to ascertain if the 19 items on the data represented more than one construct. As shown in Table 1, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was found to be .767, which is considered an adequate sample, and Bartlett's Test of Sphericity was significant ($p < .05$).

Table 1

KMO and Bartlett's Test

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.767
Bartlett's Test of Sphericity	Approx. Chi-Square	573.513
	df	171

Sig.	<.001

Upon running the initial factor analysis, it was determined that three factors in the data accounted for 73% of the common variance. The scree plot (see Figure 1) depicts the significance of the three factors. The rotated component matrix (Table 2) demonstrates the survey questions related to each factor for everything less than .1. For example, eight survey questions (had a strong relation to factor one, seven were strongly related to factor two, and four had a strong relation to factor three. In addition, five were found to be cross-loaded between the three factors (Table 2).

Figure 1

Scree Plot

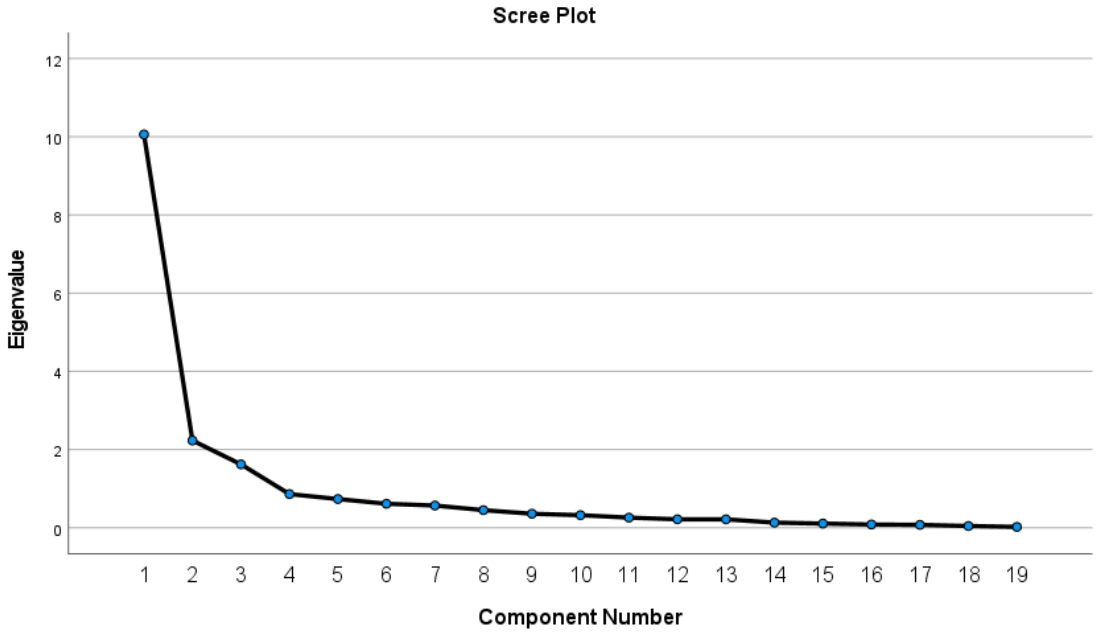


Table 2

Rotated Component Matrix

Rotated Component Matrix[a]

	Component		
	1	2	3
TechCntrlPst	.884		.109
TechHlpLrnPst	.824		.338
SpaceEarthPst	.791	.212	
SpaceWthrLifePst	.786	.181	.117
TechEngagPst	.706	.150	.352
SS2Pst	-.696	-.487	
SS5Pst	.638	.456	.442
Marspst	.556	.514	.257
SSCareerpst		.937	.109
SSCarLikePst		.851	.233
SS1Pst	-.396	-.717	-.229
SS3Pst	-.566	-.666	
MarsLrnPst	.516	.648	.268
SS4Pst	.293	.621	.363
SpaceTravlPst	.405	.464	.439
Sunpst		.141	.918
SunLrnPst	.161	.178	.863
SSLrnPst	.493	.388	.641
SSIntpst	.231	.479	.567

Note. Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization [a]. A Rotation converged in 5 iterations.

In order to further clean up and analyze the data, the data was re-run and imposed for everything less than .5 (see Table 3). This allowed for a clear separation of the instrument items, and in each study, a considerable cross-load of many items was found. However, the results indicated that there were fewer cross-loaders among all three components. One notable difference in the factor output, SpaceTravelPst, did not make it on any factor. Three factors were

cross-loaded across components one and two (see Table 3). After running the factor analysis (principal component, varimax rotation), with the default of Eigenvalue of 1 as a selection criterion, three factors were extracted, which accounted for 73.24% of the total comment variance (see Table 4). The results also indicated that the three factors are well balanced. Factor one's total variance is 30.128%, factor two's variance is 25.402%, and factor three's variance is 17.711%.

Table 3

Rotated Component Matrix

Rotated Component Matrix[a]

	Component		
	1	2	3
TechCntrlPst	.884		
TechHlpLrnPst	.824		
SpaceEarthPst	.791		
SpaceWthrLifePst	.786		
TechEngagPst	.706		
SS2Pst	-.696		
SS5Pst	.638		
Marspst	.556	.514	
SSCareerpst		.937	
SSCarLikePst		.851	
SS1Pst		-.717	
SS3Pst	-.566	-.666	
MarsLrnPst	.516	.648	
SS4Pst		.621	
SpaceTravlPst			
Sunpst			.918
SunLrnPst			.863
SSLrnPst			.641
SSIntpst			.567

Note. Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 5 iterations.

Table 4

Total Variance Is Explained By Three Factors

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.060	52.947	52.947	10.060	52.947	52.947	5.724	30.128	30.128
2	2.233	11.752	64.699	2.233	11.752	64.699	4.826	25.402	55.529
3	1.623	8.542	73.240	1.623	8.542	73.240	3.365	17.711	73.240

To account for the negative items (SS2Pst, SS1Pst, SS3Pst) shown in Table 3, reverse coding was conducted, and the results are depicted in Table 5. Finally, each element is described in terms of its common themes in Table 6.

Table 5

Rotated Component Matrix, Reversal Coding of (SS2Pst, SS1Pst, SS3Pst)

Rotated Component Matrix[a]

	Component		
	1	2	3
TechCntrlPst	.884		
TechHlpLrnPst	.824		
SpaceEarthPst	.791		
SpaceWthrLifePst	.786		
TechEngagPst	.706		
SS2PstReverse	.696		
SS5Pst	.638		
Marspst	.556	.514	
SSCareerpst		.937	
SSCarLikePst		.851	
SS1PstReverse		.717	
SS3PstReverse	.566	.666	
MarsLrnPst	.516	.648	
SS4Pst		.621	
SpaceTravlPst			
Sunpst			.918
SunLrnPst			.863

SSLrnPst			.641
SSIntpst			.567

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 5 iterations.

Table 6

The Distribution Of Survey Items And Their Descriptions Among Three Factors

Factor	Question	Factor Description	Code
Factor 1	*TechCntrlPst* – Using technology to learn gives me more control over my learning. (Likert Scale 1-5) *TechHlpLrnPst* - Innovative technologies help me learn (Likert Scale 1-5) *SpaceEarthPst* – I believe exploring space can teach us things about the earth. (Likert Scale 1-5) *SpaceWthrLifePst* – I believe weather that occurs in space can impact my life. (Likert Scale 1-5) *TechEngagePst* -Innovative technologies make learning more engaging. (Likert Scale 1-5) *SS2PstReverse* - To me, Space Science is (Likert Scale 1-7, Appealing - Unappealing) *SS5Pst* – To me, Space Science is (Likert Scale 1-7, Boring - Interesting) *MarsPst* – I would like to learn more about Mars. (Likert Scale 1-5)	Participants' disposition towards learning with technology and the impact technology would have on learning.	F1Tech
Factor 2	*SSCareerpst* – I am interested in a career in space science. (Likert Scale 1-5) *SSCarLikePst* – I would like to have a career in space science. (Likert Scale 1-5) *SS1PstReverse* - To me, Space Science is (Likert Scale 1-7, Fascinating - Ordinary) *SS3PstReverse* - To me, Space Science is (Likert Scale 1-7, Exciting - Unexciting) *MarsLrnPst* – I want to learn more about Mars. (Likert Scale 1-5) *SS4Pst* - To me, Space Science is (Likert Scale 1-7, Means nothing – Means a lot)	Participants' interest in a career involving space science.	F2Career

Factor 3	*SunPst* – I would like to learn more about the Sun. (Likert Scale 1-5) *SunLrnPst* – I want to learn more about the sun. (Likert Scale 1-5) *SSLrnPst*- I want to learn more about space. (Likert Scale 1-5) *SSInterPst* – I am interested in space science. (Likert Scale 1-5)	Participants' enthusiasm towards learning about the sun and space science.	F3Sun

Higher-Order Factor Analysis

Based on the factor analysis, three rulers were generated using the means of the questions in each relevant subscale. Then, I used higher-order factor analysis on these subscales to look for probable relationships between them.

As shown in Table 7, the KMO measure of sampling adequacy is .496. This is considered right on the border of unacceptable and miserable if rounded up, and Bartlett's Test of Sphericity rendered a value of .001 and is considered significant ($p < .05$). Figure 2 shows the scree plot and demonstrates the significance of the first factor. Although KMO is on the borderline of .5 or below, we are using the sampling adequacy as .496. Considering that the KMO produced a result of less than .5, it can be inferred that the factor analysis is not likely to provide any added benefit due to the strong possibility of underlying influences.

Table 7

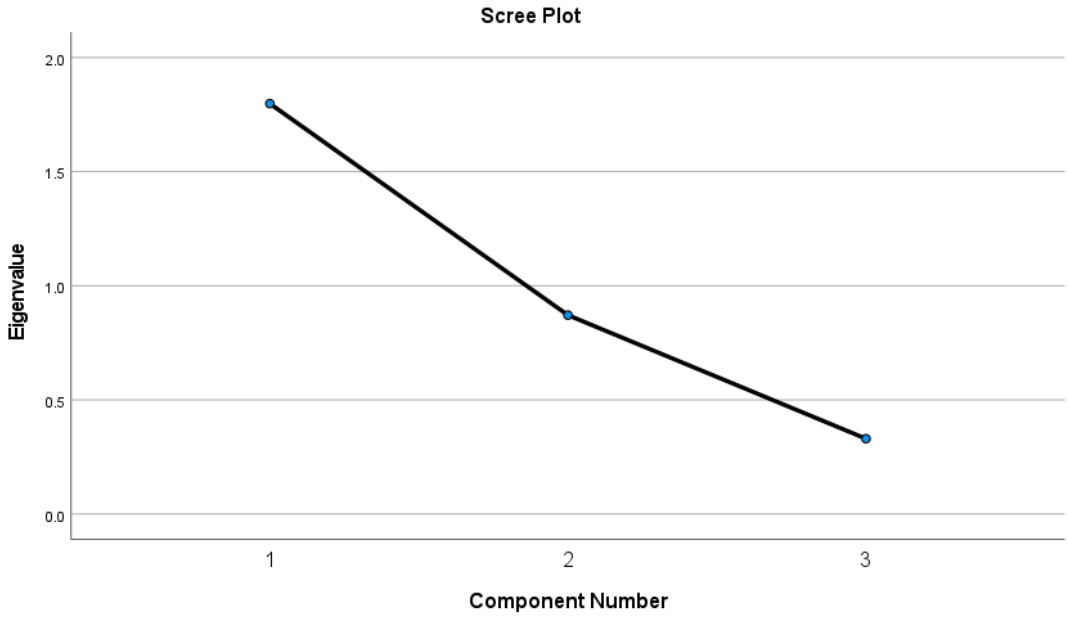
KMO And Bartlett's Test For Three Factors

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.496
Bartlett's Test of Sphericity	Approx. Chi-Square	21.192
	df	3
	Sig.	<.001

Figure 2

Scree Plot For Three Factors



Upon re-running the factor analysis, three components were forced. F3Sun showed as a cross loader among two components as seen in Table 8. It seemed as if two factors (F1Tech and F3Sun) loaded in component one possibly as those items focused on questions students answered based upon material they learned.

Table 8

Rotated Matrix of the Three Factors Forced into Three Components

Rotated Component Matrix[a]

	Component		
	1	2	3
F1Tech	.953		
F2Career		.981	
F3Sun	.334		.914

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 4 iterations.

Table 9

Total Variance Explained

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.798	59.943	59.943	1.798	59.943	59.943	1.022	34.074	34.074
2	.872	29.052	88.995	.872	29.052	88.995	1.016	33.874	67.948
3	.330	11.005	100.000	.330	11.005	100.000	.962	32.052	100.000

Extraction Method: Principal Component Analysis.

Factor analysis was re-run forcing two components as shown in Table 10. Although F3Sun shows as a cross loader, as predicted, F1Tech and F3Sun loaded together showing some correlation between the two factors. As mentioned previously, this is most likely due to the nature of the questions. F2Career contains items asking participants about future career plans and therefore explains why it is grouped in component two.

Table 10

Rotated Matrix of the Three Factors Forced into Two Components

Rotated Component Matrix[a]

	Component	
	1	2
F1Tech	.940	
F3Sun	.806	.415
F2Career		.976

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Table 11

Rotated Matrix of the Three Factors Forced into Two Components

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.798	59.943	59.943	1.798	59.943	59.943	1.545	51.489	51.489
2	.872	29.052	88.995	.872	29.052	88.995	1.125	37.506	88.995
3	.330	11.005	100.000						

Extraction Method: Principal Component Analysis.

Reliability was run on all questions within each factor (F1Tech, F2Career, F3Sun) to determine Cronbach's Alpha to determine the level of internal consistency (>.9 = Excellent; .9-.8 = Good; .8 -.7 = Acceptable; .7-.6 = Questionable; .6-.5 = Poor; <.5 = Unacceptable). Cronbach's Alpha does this by assessing the homogeneity of the set of items. "It is an indication of how well the different items complement each other in their measurement of different aspects of the same variable or quality" (Litwin, 2003, p. 22). Cronbach's Alpha can be affected by numerous elements such as the length of the test, a short test can decrease the Alpha level, and a lengthy test can increase the alpha level. Cronbach's Alpha's rule of thumb for interpreting alpha for dichotomous or Likert scale questions is based on a range of one and zero. Where values closer to zero are indicative of lower internal consistency and values closer to one are indicative of a higher level of consistency. According to McMillan and Schumacher (2001), groupings of items that have an alpha less than .70 should be used cautiously.

Reliability of F1Tech items revealed a Cronbach's Alpha of .916. Therefore, it can be determined that the F1Tech scale had an excellent level of internal consistency, as shown in Table 12. F2Career scale revealed a Cronbach's Alpha of .867. It can be determined that the F2Career scale had a good level of internal consistency, as shown in Table 13. F3Sun scale

revealed a Cronbach's Alpha of .871. It can be determined that the F3Sun scale had a good level of internal consistency, as shown in Table 14.

Table 12

Cronbach's Alpha F1Tech Scale

Reliability Statistics

Cronbach's Alpha	N of Items
.916	8

Table 13

Cronbach's Alpha F2Career Scale

Reliability Statistics

Cronbach's Alpha	N of Items
.867	6

Table 14

Cronbach's Alpha F3Sun Scale

Reliability Statistics

Cronbach's Alpha	N of Items
.871	4

Hierarchical Cluster Analysis

Hierarchical clustering is the process of creating a cluster tree (a dendrogram) to represent data, with each group linking to two or more successor groups. The groupings are layered and structured as a tree, which should result in a coherent categorization system. Hierarchical clustering is illustrated by a dendrogram, which is a visual representation of the links between comparable sets of data. A hierarchical analysis can help us corroborate the factor analysis findings and get better semantic information over the data being analyzed. Hierarchical clustering organizes data into rows and columns based on commonalities, making it simple to identify where the associations are. After clustering individual items, we may analyze the results—dendrogram, which shows the relationships between the survey items.

The first hierarchical clustering was conducted on the three scales (F1Tech, F2Career, F3Sun), as shown in Tables 15 and 16. We can see F1Tech and F3Sun are clustered together, indicating they are more similar together than F2Career, confirming our finding in the factor analysis. When we utilize scales instead of items for our cluster analysis, the results are identical to those of our factor analysis.

Table 15

Dendrogram using Average Linkage

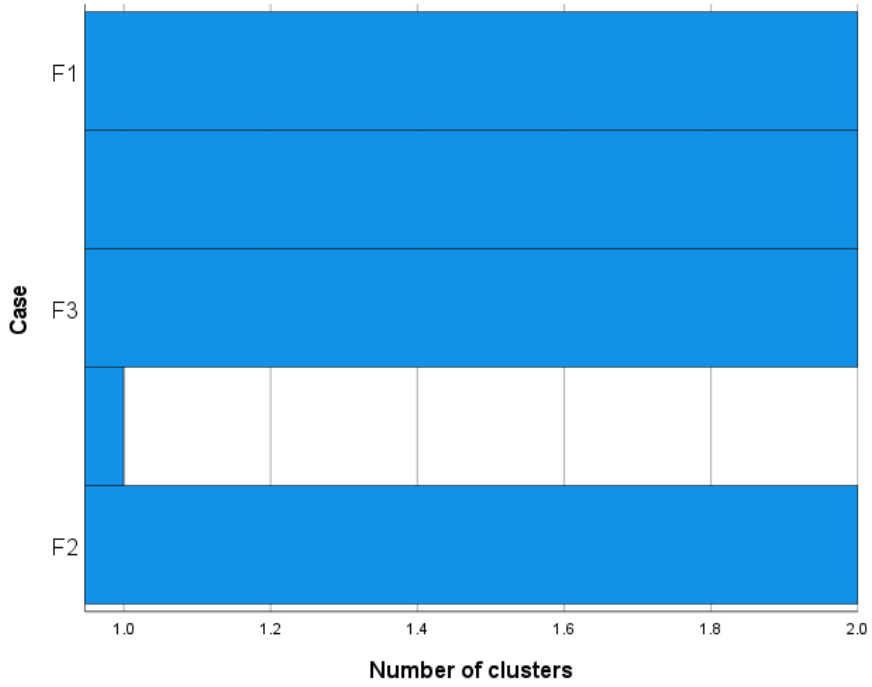
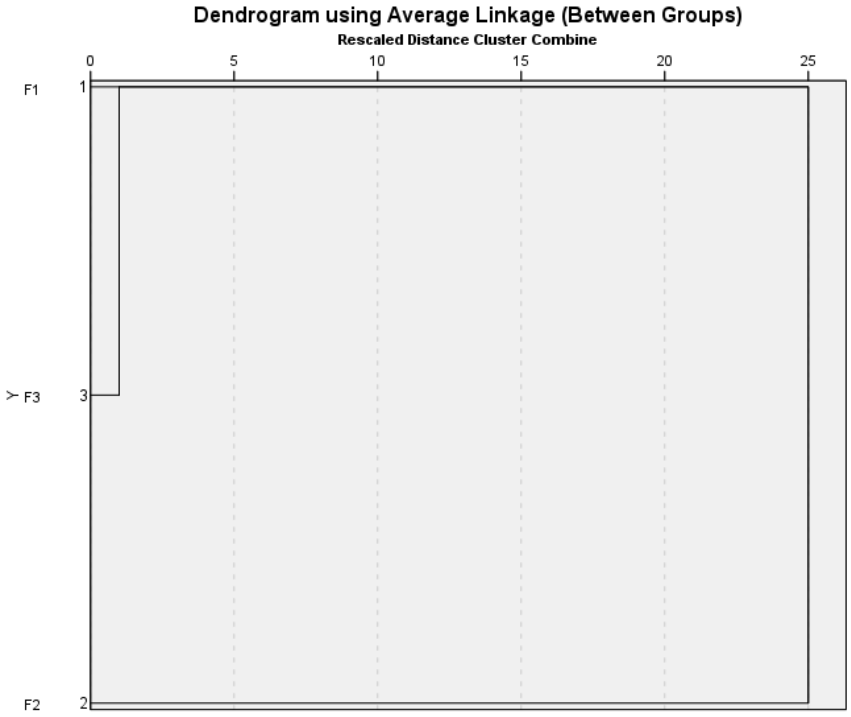


Table 16

Dendrogram using Average Linkage



As shown in Tables 17 and 18, there are five distinct clusters that have formed. The first two are more similar to each other, therefore, are clustered closer together. On the bottom half of the dendrogram, we see F1Tech and F3Sun clustered closer together, indicative of items similar to each other. Furthermore, hierarchical cluster analysis confirms our results from the factor analysis performed earlier.

Table 17

Dendrogram using Average Linkage

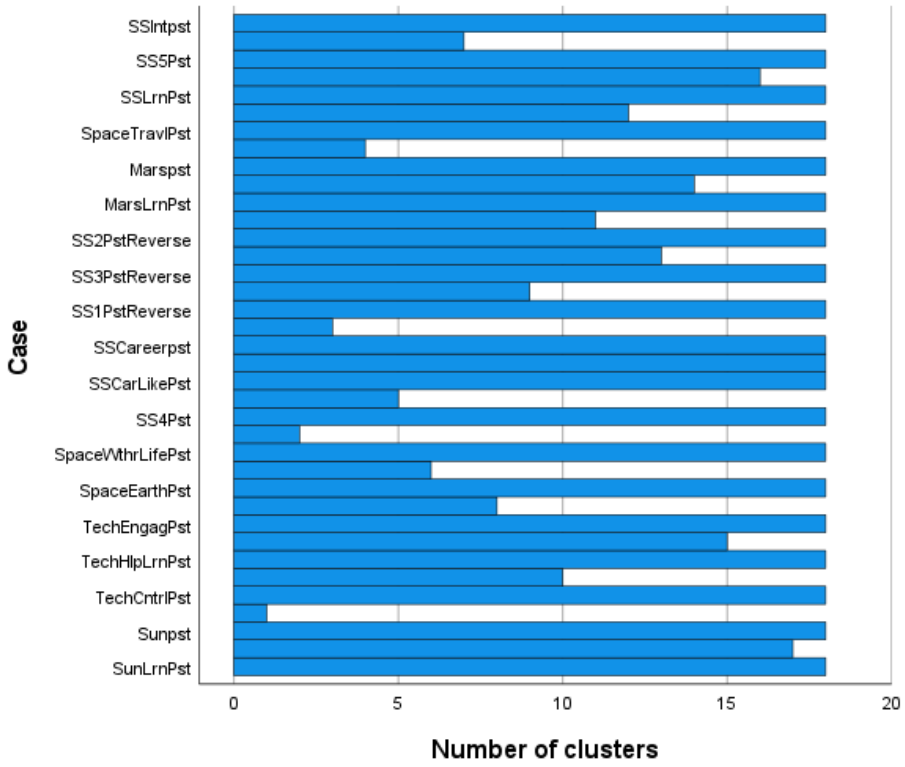
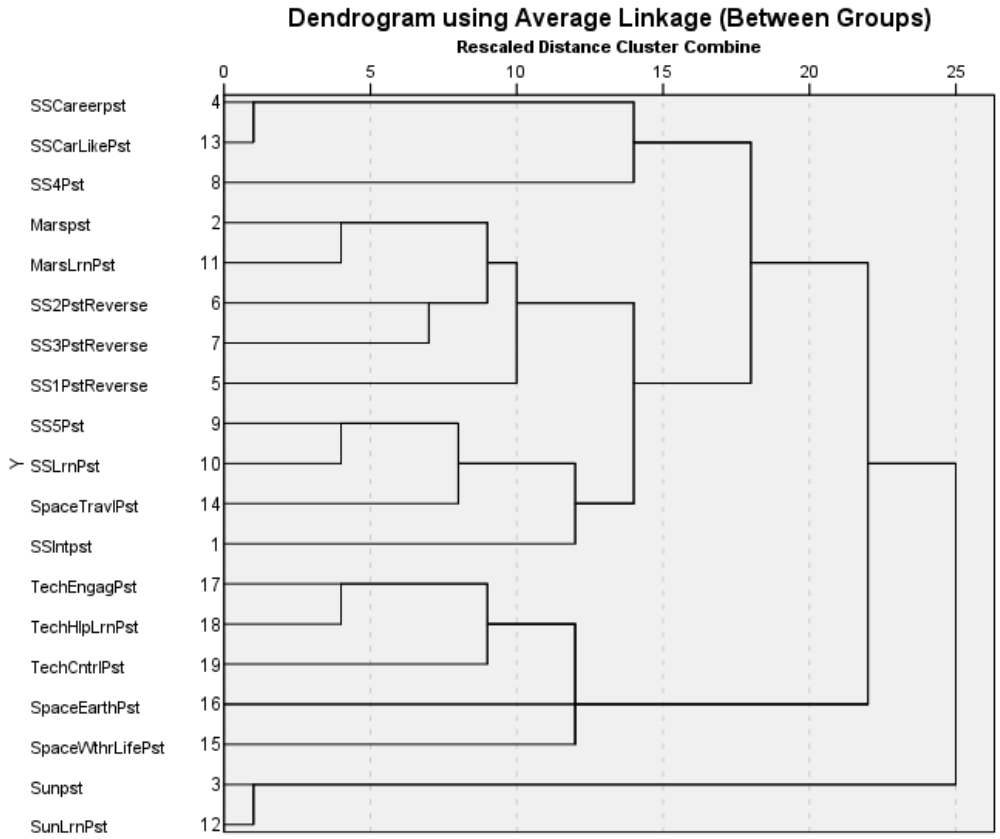


Table 18

Dendrogram using Average Linkage



By analyzing the hierarchical cluster of results in our higher-order factor analysis, we can conclude that the correlations between items and scales in higher-order factor analysis are accurate, and there is no difference between higher-order factor analysis and cluster analysis.

Multidimensional Scaling

The multidimensional scaling method seeks to determine a conglomeration of points in space, usually Euclidean, in which each point represents an item and where the distance between the points represents the original dissimilarity between the items. Using multidimensional scaling, it is possible to visualize the differences between groups of items based on their distance from one another Additionally, with the use of multidimensional scaling, dissimilarities can also be interpreted by means of graph distances; multidimensional scaling may also be used to reduce the dimension of high-dimensional data (Buja et al., 2007).

Multidimensional Scaling - ALSCAL Analysis

A multidimensional ASCAL analysis was conducted to compare the distance and correlations on all 19 items: SSIntpst, Marspst, Sunpst, SSCareerPst, SS1PstRe, SS2PstRe, SS3PstRe, SS4Pst, SS5Pst, SSLrnPst, MarsLrnPst, SunLrnPst, SSCarLikePst, SpaceTravlPst, SpaceWthrLifePst, SpaceEarthPst, TechEngagPst, TechHlpLPst, and TechCntrPst. The Euclidean distance model was selected with the configuration derived in 2 dimensions. Six iterations were run to produce an S-stress improvement of less than the value of .001000. A stress value of .09739 and an RSQ value of .96181 (96%) were yielded for the matrix, as shown in Table 19. An R-squared of 96% is considered good as the larger the R-squared value, the better it fits the observations made and is a good indicator of the response variables around the mean.

Table 19

ALSCAL 2 Dimensional Solution

Iteration history for the 2 dimensional solution (in squared distances)

Young's S-stress formula 1 is used.

Iteration	S-stress	Improvement
1	.14403	
2	.10574	.03829
3	.09894	.00680
4	.09632	.00262
5	.09503	.00129
6	.09438	.00065

Iterations stopped because
S-stress improvement is less than .001000

Stress and squared correlation (RSQ) in distances

RSQ values are the proportion of variance of the scaled data (disparities) in the partition (row, matrix, or entire data) which is accounted for by their corresponding distances. Stress values are Kruskal's stress formula 1.

For matrix

Stress = .09739 RSQ = .96181

Configuration derived in 2 dimensions

Stimulus Coordinates

Stimulus Number	Stimulus Name	Dimension 1	Dimension 2
1	SSIntpst	.7834	.0928
2	Marspst	1.0723	-.1611
3	Sunpst	1.0177	-.9770
4	SSCareer	2.4317	.8252
5	SS1PstRe	-1.9750	.6973
6	SS2PstRe	-1.9106	-.1737
7	SS3PstRe	-1.2711	.6938
8	SS4Pst	-.9689	1.1880
9	SS5Pst	-2.1459	-.3082
10	SSLrnPst	.4022	.0598
11	MarsLrnP	.8148	.1987
12	SunLrnPs	.9540	-.9873
13	SSCarLik	2.3658	.3411
14	SpaceTra	.5471	.1990
15	SpaceWth	-.2246	-.3494
16	SpaceEar	-.6068	-.2668
17	TechEnga	-.3391	-.2008
18	TechHlpL	-.4467	-.4478
19	TechCntr	-.5001	-.4237

The Euclidean Distance Model of the 19 items (Figure 3) shows a few distinct clusters created. The first cluster is in the lower-left dimension, just below the x-axis with SS5Pst and

SS2PstReverse. These are close in proximity, so we can infer that there is a relationship between these two items. We see the same type of proximity between the next cluster which is identified in the lower right dimension with SunLrnPst and Sunpst.

The next visible cluster is also in the lower-left dimension, nestled close to the inner corner of the x/y axis with SpaceEarthPst, TechCntrlPst, SpaceWthrLifePst, TechEngagPst, and TechHlpLPst. We can further evaluate that TechCntrlPst and TechEngagPst are closer in proximity to each other than the other three (SpaceEarthPst, SpaceWthrLifePst, and TechHlpLPst), indicating a stronger dissimilarity between those two items within that cluster.

The next cluster we can assume is SpaceTravlPst, MarsLrnPst, SSLrnPst, and SSIntpst. It might even be considered that SpaceTravlPst and SSLrnPst are considered a cluster as they are more close in proximity than MarsLrnPst and SSIntpst. Furthermore, it can be considered that MarsLrnPst and SSIntpst are a cluster as they are closer in proximity, indicating a stronger dissimilarity between those two items within that cluster. Marspst is close by but not close enough.

Lastly, the two remaining clusters evaluated are located in the upper left dimension encompassing SS1PstReverse, SS3PstReverse, and SS4Pst. These items are slightly clustered together based on how dissimilar they were. Furthermore, we can see the same slight cluster between SSCareerPst and SSCarLikePst based on the dissimilarity between the items.

Figure 3

Euclidean Distance Model of 19 Items

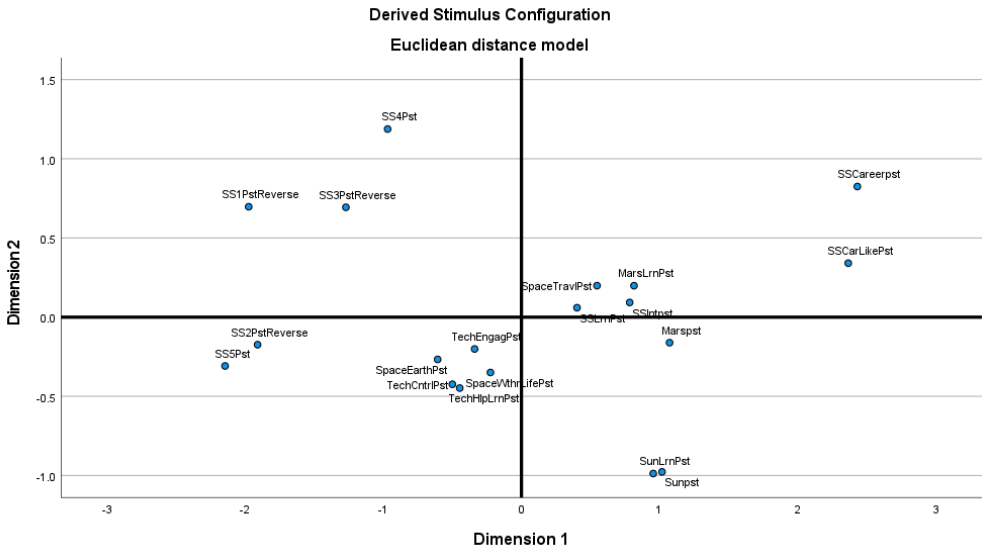
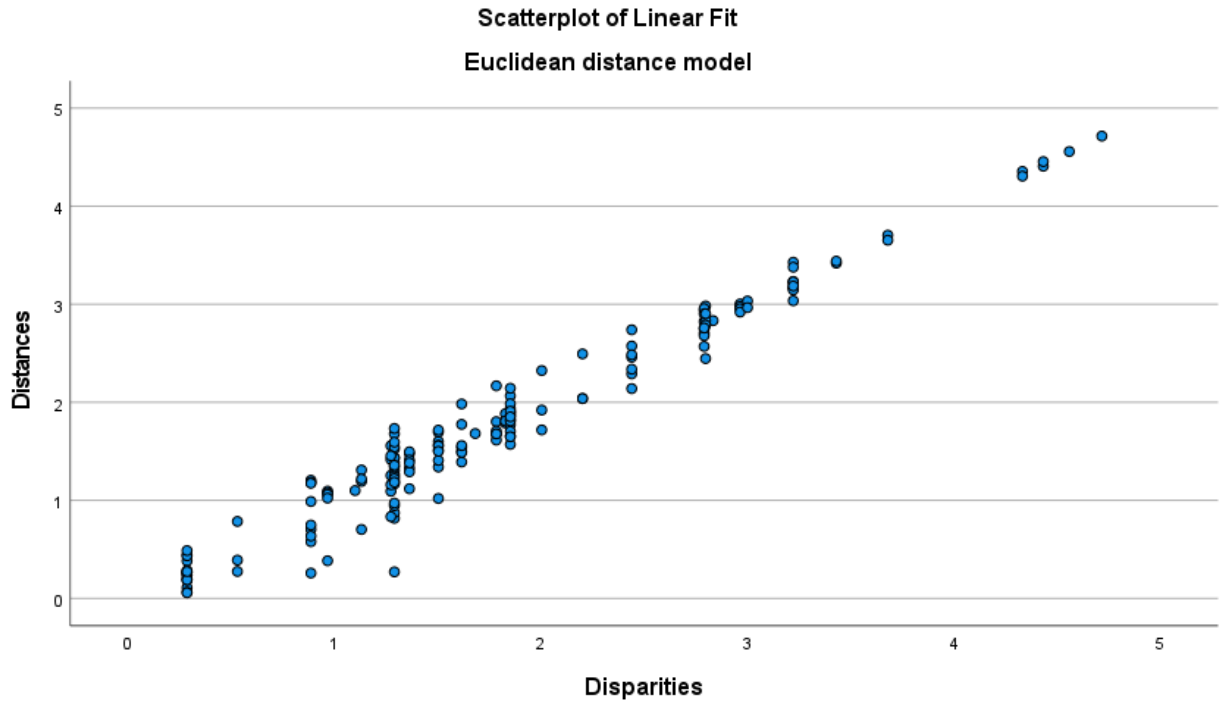
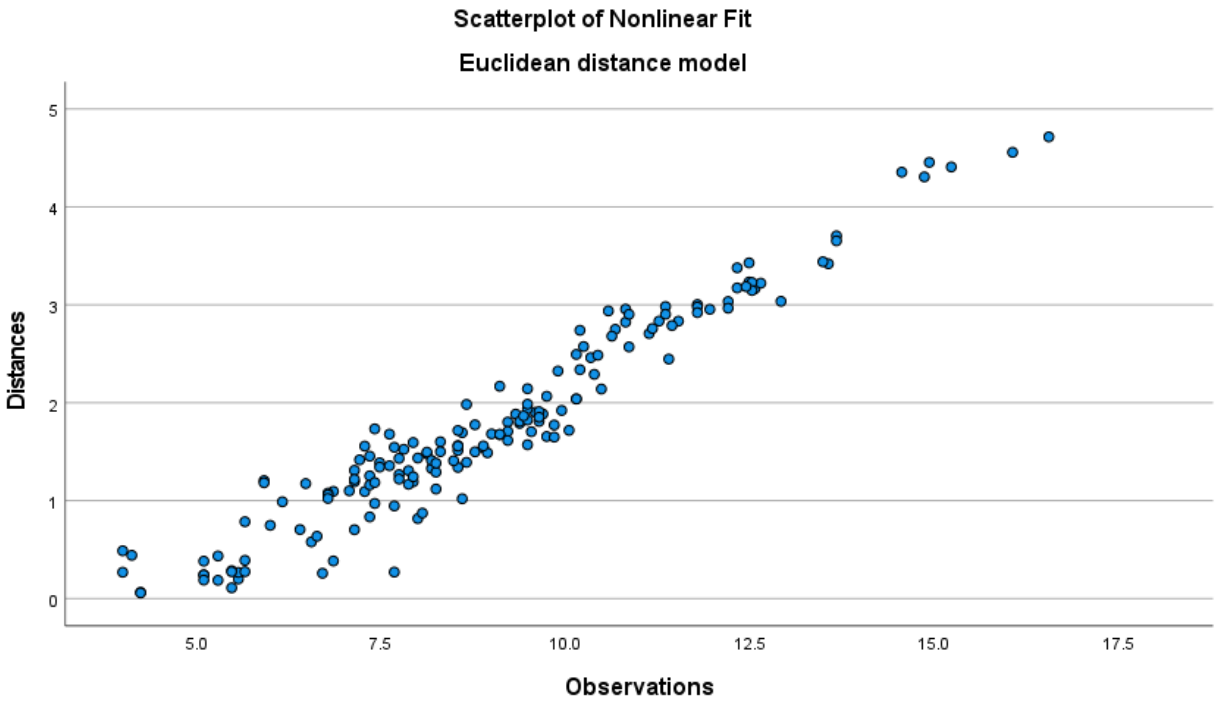
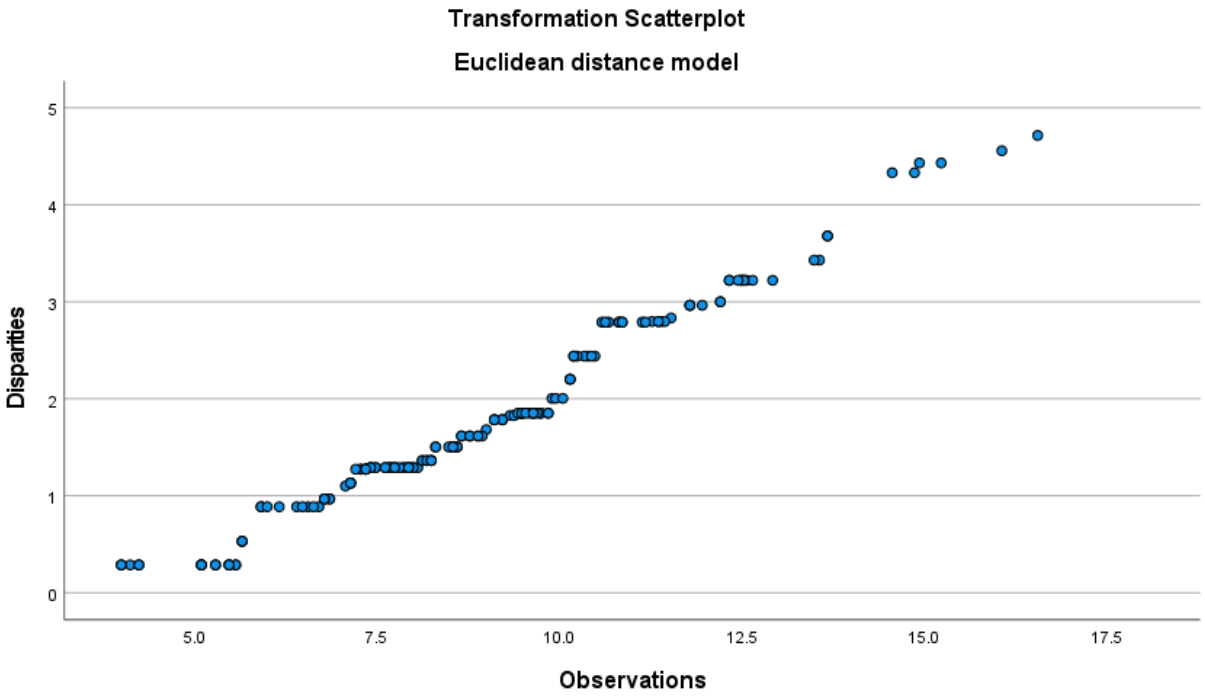


Figure 4

Scatterplots of 19 Items







Interestingly, there are similarities between the dendrogram generated earlier and the multidimensional scaling analysis. Multidimensional scaling aligns with the dendrogram results

to the cluster analysis, as the cluster analysis from the dendrogram revealed a stronger relationship between similar items. The items which were slightly clustered (e,g, SpaceEarthPst, TechCntrlPst, SpaceWthrLifePst, TechEngagPst, and TechHlpLPst) together based on how dissimilar they were, indicated a possibility of some similarity but not a strong one. Clusters indicative of the strongest dissimilarity are clearly represented with the cluster being very close in proximity (e.g., SunLrnPst, and Sunpst).

Conclusion

The study analyzed in this paper was analyzed using SPSS to show higher-order factor analysis, cluster analysis, and multidimensional scaling analysis. The multidimensional scaling confirms the results yielded in the factor analysis. It was determined that the various technologies, including drones and smartphones with goggles installed, implemented in this research study had a positive impact on student learning. Further research with a larger data set in this area would confirm the findings.

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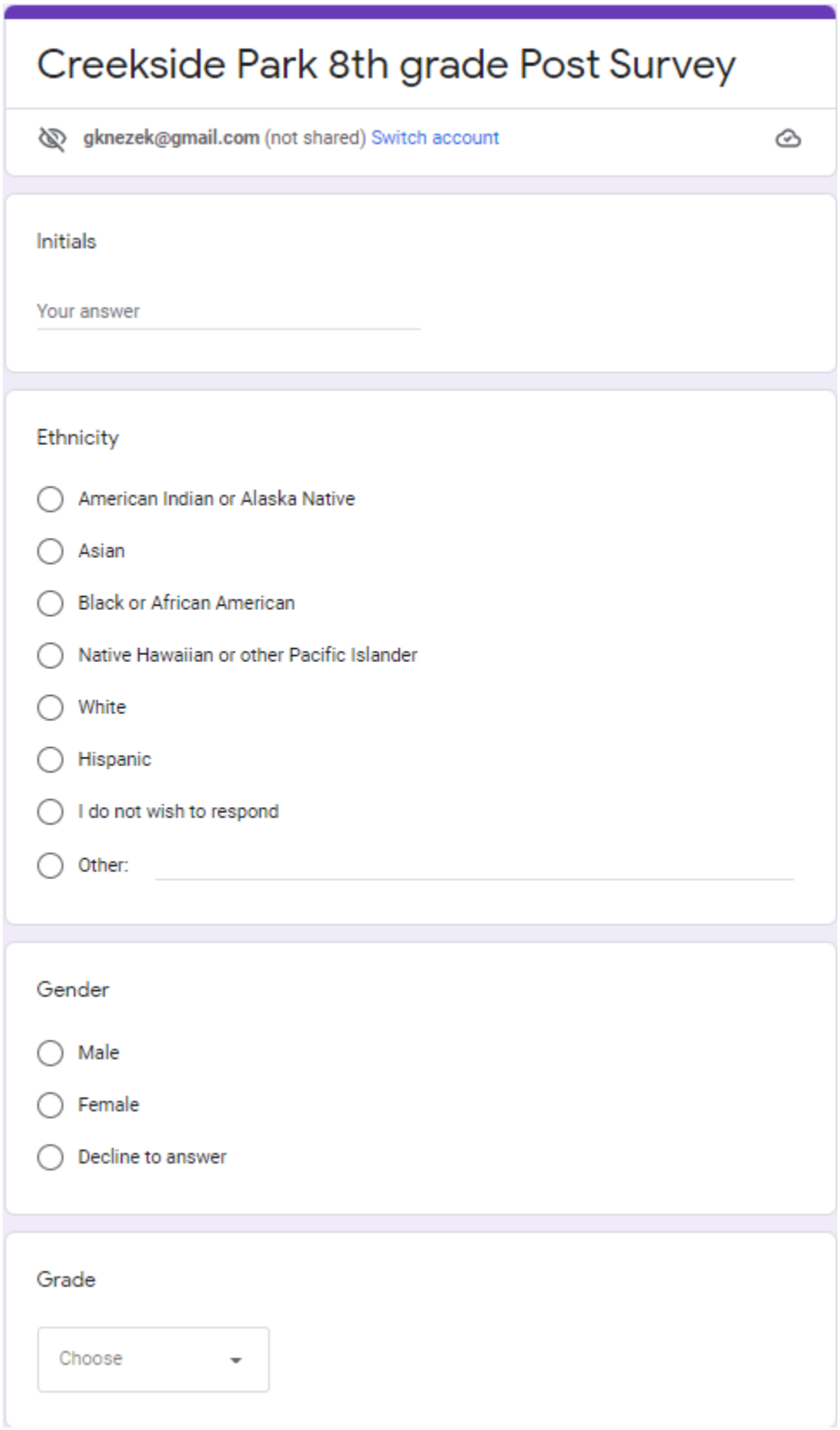
Appendix A



Creekside Park 8th grade Post Survey

gknezek@gmail.com (not shared) Switch account

Initials

Your answer

Ethnicity

- American Indian or Alaska Native
- Asian
- Black or African American
- Native Hawaiian or other Pacific Islander
- White
- Hispanic
- I do not wish to respond
- Other:

Gender

- Male
- Female
- Decline to answer

Grade

Choose

Grade

Choose

Thinking of what you thought BEFORE you participated in the space science activities, give your impressions that you can recall.
Rate each statement on a scale of 1-5, 1=Strongly disagree, 5=Strongly agree

I am interested in space science.

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

I would like to learn more about Mars.

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

I would like to learn more about the Sun.

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

I am interested in a career in space science.

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Thinking of things you have learned, (for each question) please choose the circle beside the answer you think is most correct.

1. Our sun is a medium-sized star located in a spiral arm of:

- ◯ the Sombrero Galaxy
- ◯ the Whirlpool Galaxy
- ◯ the Milky Way Galaxy
- ◯ the Grand Spiral Galaxy

2. As the moon orbits earth, it cycles through _____ distinct phases.

- ◯ six
- ◯ eight
- ◯ four
- ◯ two

3. An eclipse is defined as an astronomical event that occurs when one celestial object moves _____ another, partially or fully obscuring it from view.

- ◯ next to
- ◯ in front of
- ◯ in back of
- ◯ on top of

4. When can a solar eclipse occur?

- ◯ anytime
- ◯ during a new moon
- ◯ during a full moon
- ◯ in the last quarter of the moon phases

5. Which type of eclipse occurs when the Sun is completely obscured by the moon? The Sun is replaced by only a dark silhouette of the moon. The corona of the Sun is still visible, but only faintly.

- ◯ total eclipse
- ◯ annular eclipse
- ◯ partial eclipse
- ◯ hybrid eclipse

6. How is an aurora formed?

- ◯ From the change in temperature in the Northern Hemisphere during winter
- ◯ From the interaction of the solar wind with Earth's magnetosphere and atmosphere
- ◯ From a reflection off the snow in the northern regions of the planet
- ◯ From the interaction of the moon phases and the Sun

7. What is a KP index?

- ◯ the measure of the temperature between the Sun and the Earth
- ◯ a geomagnetic activity index
- ◯ the amount of oxygen and nitrogen levels detected
- ◯ the amount of dust particles created by the Sun

8. How long does it take a solar storm to reach the Earth?

- ◯ up to 3 days
- ◯ 1 week
- ◯ 1 month
- ◯ 1 year

9. Why do scientists study auroras?

- ◯ They can cause power outages.
- ◯ They can create craters in the Earth.
- ◯ They impact how much light is visible in winter.
- ◯ They are visible markers of space weather.

10. The purpose of the Parker Solar Probe is to help scientists...

- ◯ accurately predict space weather effects that can cause problems on Earth.
- ◯ determine the temperature of the Sun.
- ◯ find out the distance from the earth to the Sun.
- ◯ learn how the Sun interacts with Venus and Mars.

11. The sun's outer layer that reaches temperatures up to 2 million degrees Fahrenheit (1.1 million degrees Celsius) is known as:

- ◯ the ionosphere
- ◯ the corona
- ◯ the heliosphere
- ◯ the crust

12. The solar wind continuously flows outward from the Sun and consists mainly of protons and electrons in a state known as:

- ◯ light
- ◯ radio waves
- ◯ plasma
- ◯ pulsars

13. One kind of solar storm is called a coronal mass ejection in which the sun produces a huge bubble of electrified gas traveling toward the earth. When it comes toward the earth, it hits the magnetic field and small particles travel down the lines at the north and south poles creating:

- ◯ electromagnets
- ◯ changes in seasons
- ◯ auroras
- ◯ eclipses

14. Predicting space weather allows scientists to protect:

- ◯ spacecraft
- ◯ astronauts
- ◯ communication
- ◯ all of the above

15. Sunspots are large, dark regions of the sun called umbra. The sun spots are _____ the surrounding surface of the sun.

- ◯ the same temperature as
- ◯ cooler than
- ◯ hotter than
- ◯ either hotter or colder than

16. What is the purpose of the earth's magnetic field?

- ◯ to prevent meteorites from hitting the earth
- ◯ to create dark skies at night
- ◯ to produce clouds and rain
- ◯ to shield the earth from solar particles

Why are solar wind and space weather something we should think about on Earth?

Your answer

Thinking of AFTER participating in the space science activities, give your impressions.

Rate each statement on a scale of 1-5, 1=Strongly disagree, 5=Strongly agree

I am interested in space science.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly Agree

I would like to learn more about Mars.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly Agree

I would like to learn more about the Sun.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly Agree

I am interested in a career in space science.

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly Agree

Thinking of how you feel:
Choose one circle between each adjective pair to indicate how you feel about space science

To me, Space Science is

	1	2	3	4	5	6	7	
Facinating	○	○	○	○	○	○	○	Ordinary

To me, Space Science is

	1	2	3	4	5	6	7	
Appealing	○	○	○	○	○	○	○	Unappealing

To me, Space Science is

	1	2	3	4	5	6	7	
Exciting	○	○	○	○	○	○	○	Unexciting

To me, Space Science is

	1	2	3	4	5	6	7	
Means nothing	○	○	○	○	○	○	○	Means a lot

To me, Space Science is

	1	2	3	4	5	6	7	
Boring	○	○	○	○	○	○	○	Interesting

Thinking of your current interests:
Rate each statement on a scale of 1-5, 1=STRONGLY DISAGREE, 5=STRONGLY AGREE

I want to learn more about space.

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

I want to learn more about Mars.

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

I want to learn more about the sun.

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

I would like to have a career in space science.

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

I would like to know more about space travel.

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

I believe weather that occurs in space can impact my life.

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

I believe exploring space can teach us things about the earth.

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Innovative technologies make learning more engaging.

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Innovative technologies help me learn.

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Using technology to learn gives me more control over my learning.

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

I plan to have a career in:

- ◯ Science
- ◯ Technology
- ◯ Engineering
- ◯ Mathematics
- ◯ Other: _____

Thank you!

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