A Comparison of Male Student Views of Science Topics as Reported on the Student Questionnaire for PISA 2006

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Introduction

Background, Literature Review, and Research Questions

The Programme for International Student Assessment (PISA) is a triennial survey of the knowledge of 15-year-olds in the areas of reading, mathematics, and science. It is sponsored by the Organization for the Economic Co-Operation and Development (OECD). The OECD is a group of 30 countries that work together to address issues associated with globalization. Although the main goals of PISA are to compare academic mastery and maintain uniform academic standards on an international level, it also administers a student survey that asks respondents to answer questions that assesses which science topics are focused on more in classrooms and where students obtain science information. With each PISA administration, questions are added. In addition to questions on the issues previously mentioned, students are also asked demographic information about their home lives, including how much access they have to the Internet, how many books are in their home, and the educational credentials of their parents in addition to other items. In 2006, approximately 400,000 students from 57 countries took the assessment. PISA 2006 was focused on scientific literacy in a way that the previous assessments in 2000 and 2003 had not been. The guiding principle of PISA 2006 was to reveal "the content that students need to acquire, the processes that need to be performed and the contexts in which knowledge and skills are applied" (OECD, 2006). Unfortunately, there is currently no scholarly research available pertaining to the student questionnaire. In many countries, institutions often have an impact on student performance and this tends to be ignored in most discussions of education policy, which often focus on an implicitly assumed positive link between resources and learning outcomes (Fuchs & Wößmann, 2007). In addition, culture, poverty, and religion can also affect student achievement.

For this mini research study I will be working with Azerbaijan. Azerbaijan was ranked 55 of 57 countries in science on PISA 2006. Azerbaijan did not participate in PISA 2000 or PISA 2003. As I have an interest in international and comparative education, I believed that choosing another country would be worthwhile to my learning goals. By comparison to Azerbaijan, the United States was ranked 36th in science on PISA 2006. Azerbaijan is a former Soviet republic that gained independence in 1991. It is slightly smaller than the state of Maine and the population as of January 2008, was about 8.6 million people who are 93.4 percent Shi'a Muslim. As religion and culture often affects opinions concerning education and career plans and Islam is often closely tied to education and issues concerning gender, for the purposes of this study, girls are being excluded. There is a reason to be interested in science in Azerbaijan, however, as the country's main exports and industries are petroleum and natural gas and one of their polytechnic universities is dedicated to ongoing petroleum industry research. Unfortunately, unemployment in the country also ranges between 15 and 20 percent. In light of these issues and connections to student achievement, this study will ask the following research questions concerning Azerbaijan in an effort to determine if there is a correlation between the poor performance of Azerbaijan and the attitudes reflected on the student survey: 1) For boys in Azerbaijan, is there a relationship between expressed enjoyment of learning about science and having a father who was in a science-related career? (Chi-Square Test of Association); 2) For boys in Azerbaijan, is there a difference in science interest based on access to the Internet and having a quiet place to study? (2-Way ANOVA); and 3) For boys in Azerbaijan, is there a relationship between enjoyment of learning about science, liking to read about science, and being glad to do science problems (Multiple Regression)?

Methods

Sample Size, Data Collection and Data Analysis

The data sample used for analysis comes from the Student Questionnaire for PISA 2006. was a seven section, 37-question survey given to those students taking PISA in an effort to obtain not only demographic data about the testing sample but a more complete snapshot of the advantages and disadvantages that students may have that might impact learning in the area of science and create a clearer understanding of why countries have the international assessment results they do.

In the case of this study, data was collected from 2,685 male students from Azerbaijan. It is important to keep in mind that not all students answer every question. In cases where students did not answer a question, students were taken out of the sample before a test was run.

Results

Chi-Square Test of Association

The question asked for the Chi-Square Test of Association was the following: For boys in Azerbaijan, is there a relationship between expressed enjoyment of learning about science and having a father who was in a science-related career? This question was asked because I hypothesized that the boys who had fathers who worked in the science-related industries in Azerbaijan (perhaps oil) may be more exposed to science in general and the father's work may "come home" perhaps creating an avenue for bonding between fathers and sons. Another reason I chose fathers for this question rather than mothers was the religion of the country – Islam. As boys grow older, they often have less contact with their mothers and more contact with the males in the family.

Unfortunately, when I ran the Chi-Square Test with the sample provided by the data, I did not find a relationship between these two variables. The p-value in the test I ran was a .276 which is definitely over .05 so it is not statistically significant. Therefore, I would retain a null hypothesis which would state that there is no relationship between the two variables. For this particular test, there were 2,229 valid responses that were considered. Possible reasons for the 456 missing cases could either be that the respondents did not have a father present in their lives or could not articulate their father's career field.

Table 1 – Chi-Square Test of Association

	Value	**df**	**Asymp. Sig (2-sided)**
Pearson Chi-Square	17.749	15	.276
Likelihood Ratio	19.376	15	.197
Linear-by-Linear Assoc.	3.502	1	.061
N of Valid Cases	**2229**		

Two-Way ANOVA

The question asked for the Two-Way ANOVA test was the following: For boys in Azerbaijan, is there a difference in science interest in Azerbaijan based on access to the Internet and having a quiet place to study? I hypothesized that in terms of academic subjects, the interest in science could be enhanced and increased by having access to the Internet. In addition, having a quiet place to study could increase academic achievement so I thought this might also be a

good variable to test. I did suspect that these two variables may test out differently due to Azerbaijan's high unemployment rate.

When the test was run, the data showed that the variables had a completely opposite response from the students. Many male students in Azerbaijan were fortunate enough to have a quiet place to study but few comparatively had access to the Internet. Because of this, homogeneity of variance cannot be assumed. In the case of my data, the test I ran is more conservative and it would be harder for me to reject the null hypothesis. In addition, because of the test results I found with my data, there was no interaction between the variables, meaning that there may not be any difference in science interest based on having access to the Internet and/or having a quiet place to study. Because it is difficult to reject the null hypothesis, I am reluctant to say there is no connection between science interest and these things but I suspect that this is probably the case.

Table 2 – Two-Way ANOVA

Source	***df***	***F***	**η**	***p***
Quiet Place	1	4.481	.002	.034
Internet	1	3.656	.002	.056
Quiet Place x Internet	1	.416	.000	.519
Error	2181			

Multiple Regression

The question asked for my Multiple Regression test was the following: For boys in Azerbaijan, is there a relationship between enjoyment of learning about science, liking to read about science and being glad to do science problems? I hypothesized that students who choose

to read about science and enjoy completing science problems would enjoy learning new concepts in science. As an experienced teacher of English, I know that students who do not like a subject usually do not select to read about that subject. For example, a student who does not like baseball generally does not choose to read books about baseball in their leisure time.

Before starting any multiple regression tests, the first calculation that had to be completed was a power analysis. In the test I am conducting, I only have three predictors – enjoyment of learning about science, liking to read about science and being glad to do science problems. Since I have a total sample size of 2,685 students, that gives me more than enough of a sample to meet the estimation for power at .95 with an effect size of .25 and an α of .05. Given my predictors and those conditions, I would only need a sample of 4.05 but easily meet the requirements.

In the previous two tests, I assessed enjoyment of science by creating a composite variable for all items in one question, #16 of the student questionnaire. These items included: items asking to what degree students had fun learning science topics, their enjoyment level for completing science problems, student enjoyment level for reading about science and finally, student enjoyment level for gaining new knowledge about science. After working with the composite variable and finding that there were issues with my data because of the use of the composite, I tried the multiple regression tests again this time only using the variable for enjoyment of gaining new knowledge about science. I chose this variable because in my head it seemed the closest to the concept I wanted to convey and it was least likely to be influenced by other things including classroom teaching styles, resources, and mathematical aptitude.

In reviewing the diagnostic tests related to the multiple regression data, the tests conducted find that the data regarding enjoyment of learning about science, reading about science, and completing science problems seems to have a normal distribution as demonstrated

on a histogram. The plot of the standardized residual is less conclusive, however, as there are gaps along the regression line of the residual that make me question the normality of the residual. I would be more comfortable calling this result a medium violation of normality but realize that violations of this assumption often have little impact on substantive conclusions for large sample sizes.

Linearity and homoscedasticity of the data can be determined by looking at the scatterplots. I think this data is linear although the relationship seems to have a strong negative relationship because of the way the plot appears. In the case of homoscedasticity, the data sample employed for this mini research study does seem to be homoscedastic because it does looks like I would be able to draw a clear line through the data and I could probably say that the points are spread fairly evenly around that line. Even so and in light of my conclusion, I suspect a larger, more complete scatterplot might give a more accurate picture.

In regards to multicollinearity, my results for VIF do not concern me for this dataset because my values of 1.000 and 1.186 are much smaller than 10. However, it should be noted that this data did generate Tolerance values of 1.000 and .843, which does makes me concerned about multicollinearity. Without multicollinearity in the data, assessment of the unique role of each independent variable becomes difficult and can become impossible. In terms of outliers and influential data points, Cook's distance and Leverage were not applicable to this set of data, however, using the studentized deleted residual, there are outliers in this data. I did attempt to take out the outliers and re-run the multiple regression test but because this dataset is so large, taking them out did not seem to have much impact on the result.

I chose to run the data using a stepwise selection procedure since I believed that it would be better than running either a forward or backward selection alone and since I only had two

independent variables, this may give the data an opportunity to remove the variable that no longer held significance.

Table 3: Summary of Block Regression Analysis for Variables Predicting Male Students Enjoyment of Learning about Science (N=2,449)

Variable	**B**	**SE B**	**β**
Step 1			
Sci enjoyment-sci problems	.434	.017	.469
Step 2			
Sci enjoyment -sci problems	.326	.017	.352
Sci enjoyment -reads science	.291	.018	.293

In terms of answering my multiple regression question, the tests on the data lead me to believe that it is possible to use the PISA 2006 data to predict interest in science for boys in Azerbaijan based on responses to science-based questions. Given the student answers to questions regarding reading about science and doing science problems, I would have to say that these things perhaps are related to each other. In addition, the fact that I have a very large student sample and a good number of students responded that they enjoy reading about science and doing science problems (more than 79 percent and 84 percent respectively) I think making the leap to saying "Reading about science and enjoying the completion of science problems is a strong predictor of an interest in science for male students of PISA age in Azerbaijan" is probably acceptable.

Discussion and Conclusions

In terms of the tests discussed above, I believe that some of my choices were good tests to conduct an analysis. In the case of the Chi-Square Test of Association, perhaps the items I chose to put together were too dissimilar and in hindsight, I should have chosen things that would have produced a different result. Education and student interest is often affected by other things besides student motivation. Economics, political climate, culture, and religion can all also have a bearing on student choices of curriculum, motivation, and achievement. That was one of the reasons that girls were not addressed in this mini research study. By not using a dataset that contained girls, I removed a variable that might be affected by cultural and religious influences. This does not mean that boys are not influenced by these factors but traditionally in society men have held the seats of power and have often been allowed education and rights where women sometimes have not. Even when women have been given rights in culture, sometimes other influences also get in the way.

In terms of my other two tests, I do believe that the tests I conducted were good choices to use for analysis but again, I do think that there are far more variables that one should consider before making any grand statement on the state of any educational idea in Azerbaijan. Aside from the reasons noted above, Azerbaijan has only participated in one administration of PISA and did not fare so well. The country did participate in PISA 2009 but at the time of this writing, the report is not yet available. It would be interesting to see where Azerbaijan came in this time around and it would also be an interesting comparison to see if there were possibly two surveys that could be compared. The question in my mind at present is whether or not Azerbaijani students still perceive science in the same way or better than they did in 2006, providing that a survey was done with the 2009 assessment and it contained either the same or comparable

questions. In three years, the political situation has also changed slightly in the country so this would also be an interesting comparison to see if students perceive things as better or worse as there are questions on this survey about possessions, educational level of parents, and occupation of parents.

Reflection on the Process

This mini research study gave me a chance to practice working with data and with the SPSS program. I liked the idea of working with one main set of data where everything was connected to one main idea as I often need things to connect to something else in order for them to 'click' in my learning. This does seem to be the case with topics that are mathematical in nature; I need to be able to apply them to something that I can understand, something in my world so to speak. The task also helped me review the processes of ANOVA, chi-square, and multiple regression and although I will certainly never claim to be an expert in these areas, I do understand how these ideas are put together in quantitative research. Over the last few months, I have noticed that I have become more attentive to polling and survey data that I do read in my daily life; in my personal life I have always been interested in current events and the news and as I read various news media I now find myself paying much more attention to the validity and sampling done with opinion polls and surveys. I have come through this process with a better conceptual understanding of the ideas that go into quantitative research methods and I have developed a healthy respect for the use of advanced mathematical and statistical calculations to make predictions about a population.

References

Background note: Azerbaijan [Fact sheet]. (n.d.). Retrieved from U.S. Department of State website: http://www.state.gov/r/pa/ei/bgn/2909.htm

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Appendix 1: Chi-Square Test of Association SPSS Results

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
ENJOYSCI * Father science-related career	2229	83.0%	456	17.0%	2685	100.0%

ENJOYSCI * Father science-related career Cross tabulation

			Father science-related career		
			No or indeterminate	Yes	Total
ENJOYSCI	1.00	Count	196	22	218
		Expected Count	192.6	25.4	218.0
		Std. Residual	.2	-.7	
	1.20	Count	117	20	137
		Expected Count	121.0	16.0	137.0
		Std. Residual	-.4	1.0	
	1.40	Count	227	31	258
		Expected Count	227.9	30.1	258.0
		Std. Residual	.0	.2	
	1.60	Count	230	17	247
		Expected Count	218.2	28.8	247.0
		Std. Residual	.8	-2.2	
	1.80	Count	215	26	241
		Expected Count	212.9	28.1	241.0
		Std. Residual	.1	-.4	
	2.00	Count	407	47	454
		Expected Count	401.0	53.0	454.0
		Std. Residual	.3	-.8	
	2.20	Count	178	27	205
		Expected Count	181.1	23.9	205.0
		Std. Residual	-.2	.6	
	2.40	Count	121	20	141
		Expected Count	124.6	16.4	141.0
		Std. Residual	-.3	.9	

	2.60	Count	86	16	102
		Expected Count	90.1	11.9	102.0
		Std. Residual	-.4	1.2	
	2.80	Count	57	10	67
		Expected Count	59.2	7.8	67.0
		Std. Residual	-.3	.8	
	3.00	Count	68	14	82
		Expected Count	72.4	9.6	82.0
		Std. Residual	-.5	1.4	
	3.20	Count	19	4	23
		Expected Count	20.3	2.7	23.0
		Std. Residual	-.3	.8	
	3.40	Count	12	1	13
		Expected Count	11.5	1.5	13.0
		Std. Residual	.2	-.4	
	3.60	Count	8	0	8
		Expected Count	7.1	.9	8.0
		Std. Residual	.4	-1.0	
	3.80	Count	5	0	5
		Expected Count	4.4	.6	5.0
		Std. Residual	.3	-.8	
	4.00	Count	23	5	28
		Expected Count	24.7	3.3	28.0
		Std. Residual	-.3	1.0	
Total		Count	1969	260	2229
		Expected Count	1969.0	260.0	2229.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	17.749[a]	15	.276
Likelihood Ratio	19.376	15	.197
Linear-by-Linear Association	3.502	1	.061
N of Valid Cases	2229		

a. 6 cells (18.8%) have expected count less than 5. The minimum expected count is .58.

Appendix 2 – Two-Way ANOVA SPSS Results

Warnings

Post hoc tests are not performed for Possessions study place Q13c because there are fewer than three groups.

Between-Subjects Factors

		Value Label	N
Possessions study place Q13c	1	Yes	1892
	2	No	293
Possessions Internet Q13f	1	Yes	385
	2	No	1800

Descriptive Statistics

Dependent Variable:High interest in science

Possessions study place Q13c	Possessions Internet Q13f	Mean	Std. Deviation	N
Yes	Yes	.5343	.49954	350
	No	.4929	.50011	1542
	Total	.5005	.50013	1892
No	Yes	.6571	.48159	35
	No	.5310	.50001	258
	Total	.5461	.49872	293
Total	Yes	.5455	.49858	385
	No	.4983	.50014	1800
	Total	.5066	.50007	2185

Levene's Test of Equality of Error Variances[a]

Dependent Variable:High interest in science

F	df1	df2	Sig.
40.132	3	2181	.000

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + ST13Q03 + ST13Q06 + ST13Q03 * ST13Q06

Tests of Between-Subjects Effects

Dependent Variable:High interest in science

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1.506[a]	3	.502	2.010	.110	.003
Intercept	136.499	1	136.499	546.601	.000	.200
ST13Q03	.721	1	.721	2.887	.089	.001
ST13Q06	.781	1	.781	3.127	.077	.001
ST13Q03 * ST13Q06	.200	1	.200	.799	.371	.000
Error	544.648	2181	.250			
Total	1107.000	2185				
Corrected Total	546.154	2184				

a. R Squared = .003 (Adjusted R Squared = .001)

Appendix 3: Multiple Regression SPSS Results

Descriptive Statistics

	Mean	Std. Deviation	N
Sci enjoyment - New knowledge Q16d	1.81	.792	2449
Sci enjoyment - Like reading Q16b	1.96	.797	2449
Sci enjoyment - Sci problems Q16c	2.18	.855	2449

Correlations

		Sci enjoyment - New knowledge Q16d	Sci enjoyment - Like reading Q16b	Sci enjoyment - Sci problems Q16c
Pearson Correlation	Sci enjoyment - New knowledge Q16d	1.000	.433	.469
	Sci enjoyment - Like reading Q16b	.433	1.000	.396
	Sci enjoyment - Sci problems Q16c	.469	.396	1.000
Sig. (1-tailed)	Sci enjoyment - New knowledge Q16d	.	.000	.000
	Sci enjoyment - Like reading Q16b	.000	.	.000
	Sci enjoyment - Sci problems Q16c	.000	.000	.
N	Sci enjoyment - New knowledge Q16d	2449	2449	2449
	Sci enjoyment - Like reading Q16b	2449	2449	2449
	Sci enjoyment - Sci problems Q16c	2449	2449	2449

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Sci enjoyment - Sci problems Q16c	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	Sci enjoyment - Like reading Q16b	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Sci enjoyment - New knowledge Q16d

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.469[a]	.220	.219	.700
2	.540[b]	.292	.291	.667

a. Predictors: (Constant), Sci enjoyment - Sci problems Q16c

b. Predictors: (Constant), Sci enjoyment - Sci problems Q16c, Sci enjoyment - Like reading Q16b

c. Dependent Variable: Sci enjoyment - New knowledge Q16d

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	337.265	1	337.265	688.413	.000[a]
	Residual	1198.828	2447	.490		
	Total	1536.093	2448			
2	Regression	448.556	2	224.278	504.428	.000[b]
	Residual	1087.537	2446	.445		
	Total	1536.093	2448			

a. Predictors: (Constant), Sci enjoyment - Sci problems Q16c

b. Predictors: (Constant), Sci enjoyment - Sci problems Q16c, Sci enjoyment - Like reading Q16b

c. Dependent Variable: Sci enjoyment - New knowledge Q16d

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1 (Constant)	.859	.039		22.166	.000					
Sci enjoyment - Sci problems Q16c	.434	.017	.469	26.238	.000	.469	.469	.469	1.000	1.000
2 (Constant)	.523	.043		12.284	.000					
Sci enjoyment - Sci problems Q16c	.326	.017	.352	19.015	.000	.469	.359	.324	.843	1.186
Sci enjoyment - Like reading Q16b	.291	.018	.293	15.821	.000	.433	.305	.269	.843	1.186

a. Dependent Variable: Sci enjoyment - New knowledge Q16d

Excluded Variables[b]

Model	Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
					Tolerance	VIF	Minimum Tolerance
1 Sci enjoyment - Like reading Q16b	.293[a]	15.821	.000	.305	.843	1.186	.843

a. Predictors in the Model: (Constant), Sci enjoyment - Sci problems Q16c

b. Dependent Variable: Sci enjoyment - New knowledge Q16d

Collinearity Diagnostics[a]

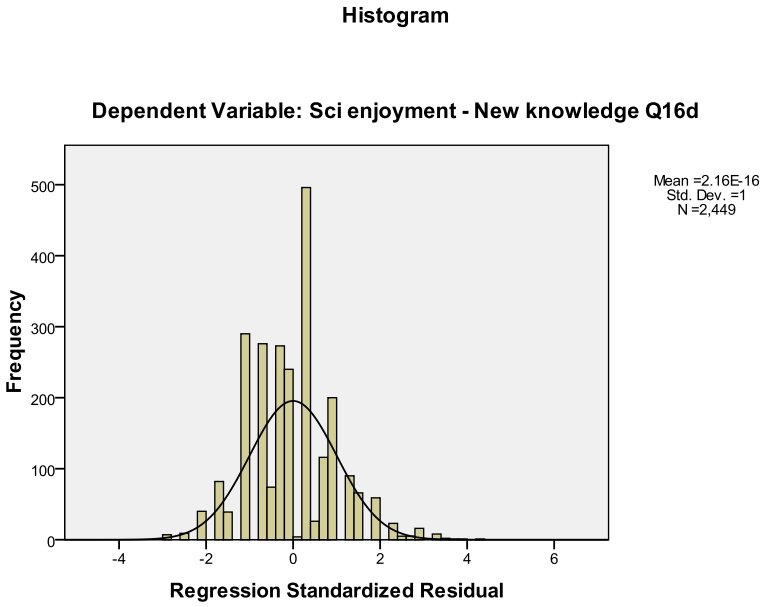
Model	Dimension	Eigenvalue	Condition Index	Variance Proportions		
				(Constant)	Sci enjoyment - Sci problems Q16c	Sci enjoyment - Like reading Q16b
1	1	1.931	1.000	.03	.03	
	2	.069	5.290	.97	.97	
2	1	2.849	1.000	.01	.01	.01
	2	.084	5.838	.02	.53	.84
	3	.067	6.522	.97	.46	.15

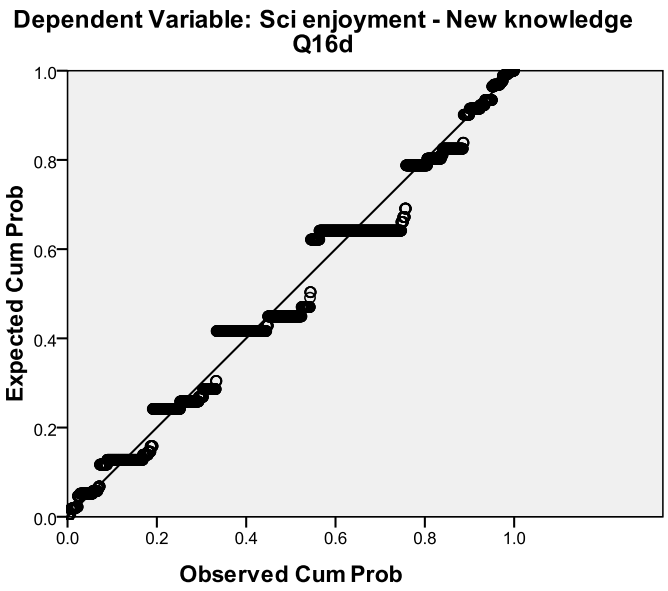
a. Dependent Variable: Sci enjoyment - New knowledge Q16d

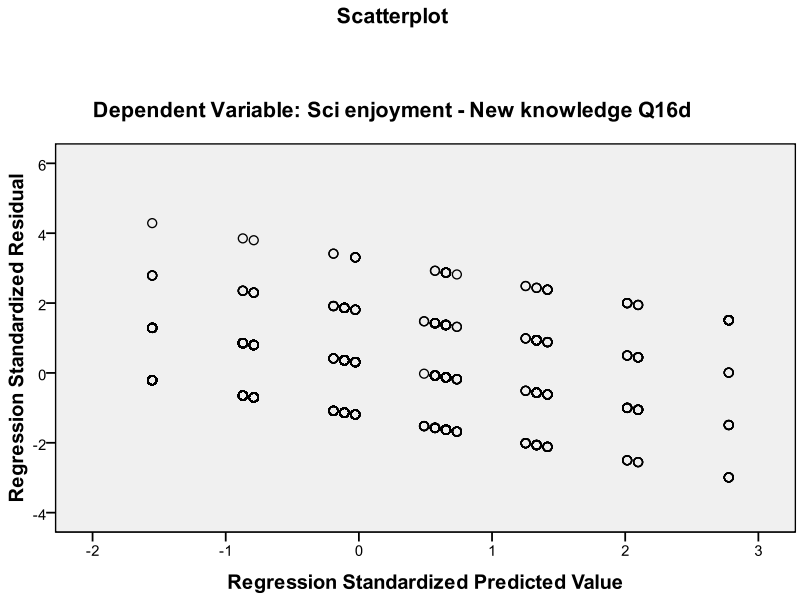
Residuals Statistics[a]

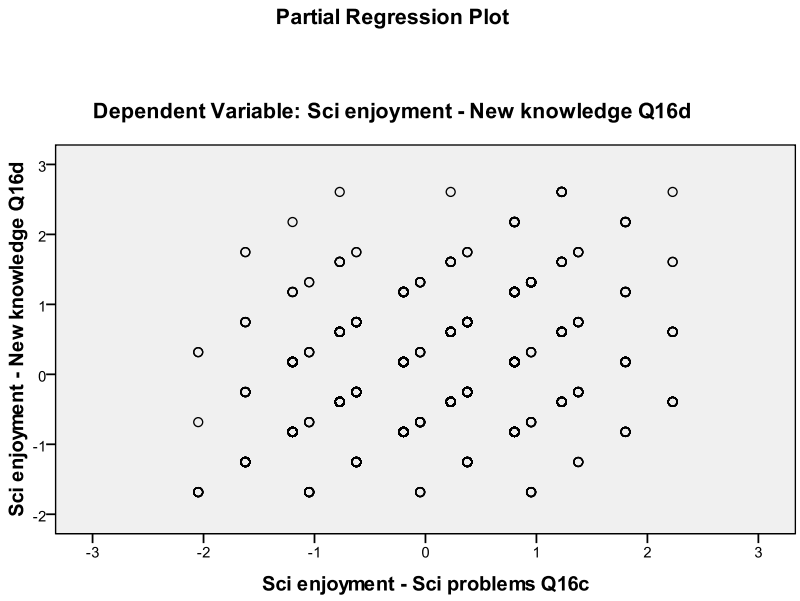
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.14	2.99	1.81	.428	2449
Std. Predicted Value	-1.552	2.777	.000	1.000	2449
Standard Error of Predicted Value	.014	.051	.022	.007	2449
Adjusted Predicted Value	1.14	3.00	1.81	.428	2449
Residual	-1.994	2.859	.000	.667	2449
Std. Residual	-2.991	4.288	.000	1.000	2449
Stud. Residual	-2.996	4.291	.000	1.000	2449
Deleted Residual	-2.002	2.863	.000	.668	2449
Stud. Deleted Residual	-3.001	4.306	.000	1.001	2449
Mahal. Distance	.066	13.366	1.999	2.119	2449
Cook's Distance	.000	.011	.001	.001	2449
Centered Leverage Value	.000	.005	.001	.001	2449

a. Dependent Variable: Sci enjoyment - New knowledge Q16d


Histogram
Dependent Variable: Sci enjoyment - New knowledge Q16d
Mean =2.16E-16
Std. Dev. =1
N =2,449
Frequency
Regression Standardized Residual


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Sci enjoyment - New knowledge Q16d
Expected Cum Prob
Observed Cum Prob


Scatterplot
Dependent Variable: Sci enjoyment - New knowledge Q16d
Regression Standardized Residual
Regression Standardized Predicted Value
6
4
2
0
-2
-4
-2
-1
0
1
2
3


Partial Regression Plot
Dependent Variable: Sci enjoyment - New knowledge Q16d
Sci enjoyment - New knowledge Q16d
Sci enjoyment - Sci problems Q16c
3
2
1
0
-1
-2
-3
-2
-1
0
1
2
3