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Marshall Plan: Science Literacy

Assessment Report (2005-2006): General Education Component Area

Submitted: March 5, 2007

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I. BACKGROUND

A. Status of Science General Education

With the exceptions of the extensive science requirements in the Colleges of Science and Nursing & Health Professions general education science requirements in non science areas at Marshall University range from seven to 12 hours. In 1995 a requirement for an integrated science course was included in the Marshall Plan. Now, non-science majors meet the science requirement by taking the interdisciplinary integrated science course as a portion of the science requirement which can be completed by taking science discipline-centered courses in biology, chemistry, geology, physics, physical science, and physical geography. The integrated science courses differ from traditional scientific content courses dealing with one narrow sub-discipline in that they are taught with an interdisciplinary approach by focusing content from a minimum of two fields on one area of investigation or science-related issue important in modern society. Since scientific questions and many scientific issues related to the social welfare are growing more complex and multifaceted as scientific knowledge grows, the ISC courses were envisioned as an approach that would empower students with a scientific way of thinking, kindle an interest in understanding science to further lifetime learning, and to allow the development of opinions and the formation of decisions independently of misrepresentation, hype, and hyperbola expressed for or against science in the media.

The ISC courses are designed to enable students to learn how scientific investigation is conducted. Technology and the empirical or statistical analysis of data are woven into the fabric of the courses. Since MTH 121 or higher is required as a prerequisite to ISC courses students have baseline facility in organizing and utilizing empirical data. Students learn about experimental design with adequate sampling, and the requirement inherent in the scientific method that experiments can be repeated yielding similar findings within an acceptable confidence level. Students participate in the process of science by working collaboratively in laboratory or field projects. The need for objectivity and the absence of bias in both data collection and analysis are emphasized. Responsibility for organization of student teams lies with the students with regular progress reports to the instructor who acts as a coordinator and resource. Thus, leadership and collaboration skills are developed. Efforts are made to instill in students the ability to critically analyze information and to make their own determination about the use and reliability of scientific reports because in an every more complex and heavily populated society many of the choices we have to make as citizens and as a nation will be increasingly centered on the impact of science in our every day lives. The College of Science feels secure in our decision to implement a course in the mold of ISC since many educators are advocating the same approach almost a decade after the revision of MU General Education that placed ISC in the Marshall Plan (Alberts, Bruce. 2005. A Wakeup Call for Science Faculty. *Cell*, Vol 123, 739-741.)

B. Integrated Science as a Component of the Marshall Plan

The Science Literacy Proposal approved by the Faculty Senate and President Gilley in fall 1994, SR-94-95- (25) 132(ASCR), was originally stated as follows:

> *Our desire is that all graduates of Marshall University have the necessary mathematical and scientific skills for professional advancement and that they be literate in science. The National Council of Science and Technology Education defines scientific literacy in the following terms:*
>
> 1. *Being familiar with the natural world and recognizing both its diversity and its unity*
> 2. *Understanding key concepts and principles in science*
> 3. *Being aware of some of the important ways in which science, mathematics, and technology depend upon one another.*
> 4. *Knowing that science, mathematics, and technology are human enterprises and knowing about their strengths and limitations*
> 5. *Having a capacity for scientific ways of thinking*
> 6. *Using scientific knowledge and ways of thinking for individual and social purposes*

The above list has been adopted as the Learning Objectives for Science Literacy at Marshall University.

The variety of science content courses available and the extensive breadth of scientific coverage encompassed by the ISC courses provide excellent scientific background and content that will be effective in helping students cope with science-related issues in their every day lives. If the student whose science requirement is 12 hrs wishes to select a group of related courses centered on a specific area, e.g., forensic science the student may take BSC 104, BSC 105 and ISC 105. If a student wished to garner a wide understanding of science the student might take, e.g., BSC 104, CHM 203, and any ISC course. The learning objectives for science general education are flexible enough to allow great freedom in course work selection but specific enough to include key elements in the assessment of students completing an extensive list of grouped individual course that comprise the science requirement. Each content course has its own learning objectives which address most of the learning objective issues. Additional issues not addressed fully by the science content courses are integral to the design of the ISC course component of the MU Plan. Both the general learning objectives for the program and the subset of learning objectives below for the ISC courses cover the diversity of content among the science courses and are measurable by many available assessment tools including ones that provide national baseline standards as well as value added.

C. ISC Courses and Staffing

Since the ISC courses began in 1995 10 courses have been approved by the by Integrated Sciences Curriculum Committee, the College of Science Curriculum Committee, and University Curriculum Committee (see Appendix A). Others, offered as special topics while undergoing course approval, include Tropical Ecology, Man and the River, Medicinal Plants, Living on Earth, and Transportation & the Environment. Courses in the planning stage include Drugs & Disease and Forensic Entomology.

The number of sections to be offered is determined by demand. Offerings are adjusted in consideration of the number of juniors and seniors who register. The number of sections has grown from two in 1996-1997 to 46 in 2005-2006 as students populated the ISC Classes to meet the Marshall Plan. Because completion of a math course is required and one science course is recommended before entering ISC freshmen and sophomores do not frequently register for IST. All students needing ISC to complete graduation requirements have been accommodated by a variety of courses all of which share the essential attributes of ISC although the content varies widely. Since 1995 several exemplary faculty members have retired. New faculty members are being recruited from among the science faculty and together with a cadre of excellent part time instructors the courses are well staffed; however there is a growing trend toward staffing by part time instructors (see Appendix B). A detailed list of courses and sections with information on instructors and enrollments is included (see Appendix C).

D. Attributes of ISC

In order to maintain unity in the design and standards of the diverse ISC courses a set of attributes or template for ISC was developed. Even though the ISC courses differ widely in the issue and areas of science addressed, all the courses share the following characteristics:

1. ISC courses are centered on the universality of science and on issues that are relevant to the present and future lives of the students. When

possible, students are given the opportunity to select the issues to be considered. While a text may be used for reference, ISC courses are not based on a sequence of topics in a textbook.

2. An issue will generally involve more than one scientific discipline and require students to answer empirical questions by designing experiments, gathering data and interpreting results and by consulting sources other than a text, such as: scientific journals, popular scientific magazines, newspapers, magazines, and web sites. In discussing issues students learn the importance of using empirical data as evidence in making an argument for or against a hypothesis.
3. Students may report the results of their scientific enquiry into issues through papers or oral presentations in scientific format, poster sessions or on web sites.

D. Learning Objectives

In 2003-2004 the learning objectives for ISC were restated, and pared down to a manageable number that represented our goals and that could be assessed. Action verbs were used to emphasize student learning. To adequately measure achievement of the learning objectives it was necessary to devise a more sophisticated and more thorough assessment plan.

Upon completion of the ISC component of the Marshall Plan students will:

1. **think** critically
2. **learn** how the scientific method is used and **apply** it to the process of scientific investigation
3. **know** how to distinguish the differences between science and pseudoscience
4. **gather and analyze** data to draw conclusions based on valid interpretation of results
5. **garner** skills and competencies in research, writing, and presentation
6. **acquire** knowledge and gain an understanding of natural science

II. THE ASSESSMENT PLAN

A. Past Assessment Practices

Ideally standardization exams and assessment tools should assess learning outcomes in multiple ways via a carefully-designed, multifaceted, assessment plan. Since Integrated Science is an innovative, interdisciplinary approach to teaching science there are no ideally suited, commercial, standardized exams available to assess programmatic success. When the present author was given the job of writing the Science Literacy Report in 2003-2004, it became clear that the assessment plan for general education was marginally adequate and failed to achieve the level of assessment needed specifically for ISC, the cornerstone of the Science General Education Program.

From among the existing commercial assessment tools there has been heavy reliance on the Science ACT scores as a benchmark for measuring science proficiency of incoming students, success as a mid-level assessment tool, and the Academic Profile Test to measure value added as students pass through the general education science curriculum. The Graduating Senior Survey, an in-house instrument, has been used to provide additional information on the students' perception of the value added to their scientific knowledge and skills as students pass through the science curriculum. There was nothing wrong with the formerly used assessment tools except that they provided only partial measurement of broad objectives. For that reasons extensive effort was designed to developing a multifaceted assessment program using pre-and post-tests with a an Assessment Portfolio designed to assess learning objectives ISC more directly and uniformly

B. The Updated Assessment Plan

A comprehensive assessment plan that includes the formerly used (plain text) and newly developed or adopted tools (bolded text) was implemented (see Table 1). Several tools were added to strengthen the assessment efforts and to more comprehensively measure those learning outcomes that are most central to our mission. These tools involve the addition of several direct means of assessing learning outcomes with stronger assessment based on nationally-normed baseline standards. The Curriculum Learning Assessment Exam was added to measure the value added by the MU educational experience. A portfolio was included in the assessment plan to allow accurate assessment of some specific aspects of the learning objectives that were not addressed specifically by the standardized exams. A pre- and post- test on the use and application of the scientific method were designed. The multiple assessment tools and multifaceted plan implemented including the portfolio items are listed in the Assessment Plan Summary for Science Literacy (see Table 1).

COS is presently in the second year the updated assessment plan but this is the first year data have been included due to the reassignment of the Associate Dean to the role as Interim Dean in 2005-2006. In view of the added role and workload incorporation and reporting of the data was deferred for one year. Thus some of the data reported here represent assessment items collected from fall 2003-fall 2006. However, mid-stream feedback from the effort has already been used to modify the design of classroom projects to better facilitate the incorporation of them into the assessment plan. Assessment Tools D and E are in-house pre- and post- tests designed specifically to assess understanding and application of the scientific method. A pool of questions was assembled to determine baseline information on knowledge and understanding of the scientific method and its application. Feedback from students and scoring patterns of some questions suggested possible ambiguity in phrasing of some items which has been eliminated. So the questions were refined at the beginning of 2006-2007. Efforts were made to refrain from using the same questions for both the pre and post test. Thus, different questions the students had never seen before were used for testing comprehensive facility and application of aspects of the scientific method in the post test. The pre-test is administered very early in the semester before any content is discussed. The post test questions are embedded in an exam in each ISC course and are used as components of the exam for grading purposes and then extracted from the broader exam and graded separately for assessment purposes.

Table 1. Assessment Plan Summary for Science Literacy, revised fall 2006.

Assessment Tool		**Learning Objective***					
		1.	**2.**	**3.**	**4.**	**5.**	**6.**
A.	Pre test/post test on the scientific process	✔					
B. **	**<u>Portfolio Assignment I</u>. Lab Report on the Process of Science. Students will make observations, develop hypotheses, design experiments, collect data, and draw conclusions. Submit as a Word document.**	✔	✔	✔	✔	✔	✔
C. **	**<u>Portfolio Assignment II</u>. Comparative critique of two papers one chosen as an example of science and one as an example of pseudo science. Minimum 3 pages, double spaced submitted as a Word document.**	✔	✔		✔	✔	✔
D. **	**<u>Portfolio Assignment III</u>. Provide a synthesis based on three or more reference sources emphasizing scientific findings and the strength of those findings. Minimum, 3 pages double spaced submitted as a Word document.**	✔	✔		✔	✔	✔
E. **	**<u>Portfolio Assignment IV</u> — Group Presentation or Report Summarizing an Area of Scientific Research. The emphasis is on presentation of scientific information as a stand-alone, kiosk-like presentation or report. Sound argument, clarity, and accuracy of conclusions are emphasized. Presentation in a format that allows wide distribution — PowerPoint, web page, or other appropriate means**	✔	✔		✔	✔	✔
F. ***	**Academic Profiles Test administered to a sample of Marshall University graduating seniors who have completed the science literacy component of the Marshall Plan**	✔					✔
G.***	**Collegiate Learning Assessment (CLA) Test administered to MU freshmen and seniors to determine value added by MU experience**	✔			✔	✔	
H.	Graduating Senior Survey summaries submitted by those responding to the MU questionnaire administered to graduating seniors		✔				

* Numbers refer to the six learning objectives outlined under IV B above.

** Items B-E will comprise a portfolio to be prepared by each student.
*** Nationally normed standardized assessment tools.
**** Items added to the assessment plan in 2003-2004 reported for the first time in this report are bolded.

Items B-E are components of the student portfolio. Some of the portfolio assignments were designed in a manner that allows content to be delivered orally via a presentation, on the web, or in a kiosk-like environment. The organization and use of scientific information to mount arguments and defend positions was examined for both grading and assessment because oral presentation is not an emphasis of this component of the General Education Plan. Collection, organization, and use of information, as well as critical thinking and the quality of the argument were of key importance.

A sample of 20% was routinely identified by a random number generator and examined by an independent panel of judges at the end of the term. Rubrics designed specifically to evaluate the items in the Assessment Portfolio and were used to evaluate achievement of learning outcomes. COS is presently in the second year of the use of the instruments and the expanded assessment plan but this is the first year data have been included in the Science Literacy Report due to the resignation of the former Dean and interim placement of the Associate Dean as Interim Dean during 2005-2006. Thus both years' data will be combined and reported in the present report. However, feedback from the effort has already been used to modify the design of classroom projects to make them more amenable as portfolio items for assessment. Information learned from administering the pre and post test have resulted in the rewriting of the exam question pool from which professors draw questions to decrease ambiguity and to standardize terminology used across the ISC courses.

Several components of the exam can be validly used to assess specific learning objectives of the Science Literacy Assessment Plan. In addition it provides independent evidence supporting the findings of the Academic Profile test, specifically in assessing critical thinking. Learning objectives have been measured in many corroborative ways. Results of this assessment effort are reported in this report for the first time.

This plan, modified from the most recent one introduced in 2004 is much more comprehensive and allows more exacting assessment of specific learning objectives which has been of invaluable benefit in updating and improving the ISC courses.

III. ASSESSMENT RESULTS

A. **Entry Level Assessment Instruments**

The ACT is administered to incoming freshmen at Marshall University. Three portions of the test are especially important in assessing the entry level of students who will take ISC as a part of the science requirement: composite, math, and natural sciences. The table below compares these values for the national Marshall University populations.

The mean ACT for the national population and the Marshall University population of students taking ISC were very close with the MU ISC Student mean ranking at 57.7 and the national mean score ranking at 56.3. Of course the students taking the ACT representing the 2006 data are freshmen during the year covered by this review and are not in an ISC class. However the data for 2005-2006 is within a small percentage of the score for mean for the last three years. If one compares the ISC ACT mean data for one year with National ACT mean score for the past years the relationship described above holds. Clearly the ISC students represent a group that is very similar in academic ability as measured by the ACT to the national average. The mean national MTH ACT score of 20.8 was at the 57.7th percentile while the mean score for the MTH ACT for the ISC population was only slightly lower at 20.1 representing the 57.5th percentile. The mean national NAT SCI ACT score was 20.9 ranking at the 66.7th percentile while the NAT SCI ACT mean for ISC students was a 21.7 at the 59th percentile. In each of the three portions of the exam compared in Table 2, scores for MU ISC students were above the 50th percentile and

Table 2. Comparison of ACT admission scores between the national population and the Marshall University Population. Scores were rounded to the first decimal place. *, **

National Mean Composite ACT	21.1 (56.3)
MU Mean Composite ACT for ISC Student Scores	21.59 (57.6)
National Mean MTH ACT Score for ISC Students	20.80 (57.7)
MU MTH ACT Scores for ISC Students	20.09 (57.5)
National Mean NAT SCI ACT Students	20.90 (56.7)

MU Mean NAT SCI ACT for ISC Students	21.73 (59.0)

* Comparative baseline scores obtained at
http://www.act.org/news/data/06/data.html

** Percentile shown in parentheses

very near the mean values for the nation for present and recent years. Entry mean ACT scores in the three areas listed of students entering Marshall University destined to complete the natural sciences general education program including an ISC course were very comparable with the average for the nation.

A major concern in teaching a required ISC class is whether the student population is able to achieve at the level of MTH appropriate for the course. Analyzing scientific data requires collecting, grouping, summarizing, and in some cases statistical analysis of data. It is essential that ISC students possess a minimal level of math proficiency. The vast majority of students applying to Marshall possesses the prerequisite MTH ACT score of 19.0 and therefore can enroll immediately in MTH 121. Students with MTH ACT 17-19 must complete at least one remedial math course before taking MTH 121. By the time the entering freshmen become juniors and seniors they will all have taken MTH 121 or higher which is a prerequisite to all ISC courses.

Because students must first take MTH 121 as a prerequisite this tends to displace the ISC course to a time later than the freshman year. This allows students to gain early exposure to other general education content science courses because with the exception of Physics 101, Physical Science 109, and Physical Science 110, no math prerequisites exist. Thus, ISC tends to be the last science course taken after students complete the math requirement. This provides a solid science and math foundation upon which to build the required science interdisciplinary course, ISC, required to complete the Marshall Plan. Interdisciplinary courses by their nature place greater demands on students to examine problems and solutions from more than one and sometimes many perspectives. By arranging the curriculum in this way students are in a much better position to learn to think clearly and comprehend how an understanding of science can improve the way they live their every day lives.

B. Mid Level Assessment Instruments

It is possible that an ambitious task such as developing an entirely new multidisciplinary science course to be included as a requirement for all students might result in a much too vigorous course. Students may not have learned to think in a multifaceted, critical manner. Another possibility is that science faculty many of whom teach pre-medical, advanced, or graduate courses might overcompensate and develop a course that is much too lax in an attempt to "lower the bar" for non science majors. If one assumes that outstanding students in all majors should do well in all general education courses a way to determine whether the course difficulty and content are proper for the non-science majors at this level is to compare ISC performance with overall GPA.

In order to learn whether grade in ISC was correlated to academic performance a comparison of the overall GPA and the grade in ISC were was carried out for all students completing the course in 2005-2006 (Table 3). There appeared to be a decreasing tendency for students to earn a

Table 3. Comparison of overall GPA and grade in ISC of students completing the course 2003-2004*

	Total	**A**	**B**	**C**	**D**	**F**	**I**	**W**
GPA Mean 2005-2006	3.0 n=888	3.3 n=459	2.9 n=282	2.69 n=34	2.6 n=6	2.3 n=22	2.6 n=7	2.72 n=32

* Data from a BERT query of Banner.

lower average ISC grade as the overall GPA declined for those students making A, B, C, D, or F. Stated another way, one could say that there is a positive close correlation between grade received and overall GPA. With some of the grading categories the number in the sample size was so small one can not overspend the interpretation but a similar situation was reported in the Science Literacy Reports for 2003-2004 and 2004-2005. Thus, grade in ISC tends to mirror or reflect the overall level of academic achievement, a finding that is not surprising and one that supports the hypothesis that the course is of about the correct level of difficulty but representing a challenge because it is designed to cause the students to think and to reason.

Since the course was developed with the concept that students would have completed MTH and typically their other science requirements a study was conducted of the relationship between earned hours and ISC performance in those students completing the course in 2003-3004. If students with 100 or more hours consistently do better in ISC than the few sophomores and freshmen who are able to enter, the finding would be of great importance in the justification of the structure that tends to select more advanced students who have completed their math and other science courses before allowing them into ISC. Furthermore, this information would be very valuable for advisors placing students in ISC. The results of this study are shown below in Table 4:

Table 4. Comparison of the earned hours and grade of ISC students completing the course in 2005-2006*

	Total	A	B	C	D	F	I	W
Mean Hours 20005-2006	109.6 n=869	109.4 n=459	112.1 n=282	109.0 n=61	128.8 n=6	93.3 n=22	113.9 N=7	100.6 n=51

* Data from Institutional Resources

Upon careful perusal of the results a correlation between the total earned hours and earning a passing grade is not possible to overlook. 802 of the students who had earned >100 hrs made A, B, or C. Those making F averaged 93.3 hours completed. These results mirror the trends observed in 2003-2004 and 2004-2005, however among this group of students 64 students with average hours accumulated >100 earned I or W. In past years the students earning I or W had earned <100 hours. Based on three years of data it is clear that a negative correlation exists with regard to the success of students taking ISC early in their college career. A few freshmen and sophomores are able to take ISC because they may have completed MTH 121 in the first semester or because they had dual credit courses or college courses while in high school. But because the numbers of students with low numbers of hours who are unsuccessful are small and apparently some students who have >100 hours may not be able to complete the course, additional prerequisites are not warranted at this time. The problem identified can best be addressed through advising. Although these students can take ISC it is our recommendation that in the future advisors recommend strongly against it. ***This is a significant finding that***

will be shared with the other colleges, associate deans, and advisors. They will be encouraged to suggest that ISC be taken as a junior or senior after taking math, science, English, and communications.

If the results of the previous two graphs are considered collectively it would appear that a profile of a successful ISC student is for the student to have completed >100 hrs with GPA >2.6. Since the attrition rates at MU suggest a falling off in retention past the junior year with only 42% (data not shown) of the students graduating after six years, the apparent high number of higher grades in ISC can be better understood. If the people with the greatest ability, who are motivated to complete the degree, take ISC as a junior or senior after passing all of the needed background courses they comprise a group that would be expected to have been subjected to strong selective pressure and therefore to represent a capable group. It is therefore more probable that a greater proportion of students with outstanding abilities are taking ISC than would be found in some of the other science courses, i.e. BSC 104 typically taken earlier in the college career, often in the first semester. Thus, it is reasonable and expected that the population of students taking ISC late in the academic career would be successful, providing a plausible explanation for the observation.

C. Exit Level Assessment Instruments

1. Objective pre- and post- tests were advised to ascertain the degree to which scientific method learning objectives were met by the ISC classes. This key science class is usually the last one taken by students and many of the goals of science literacy in general education hinge on its success. The mean score on the post-test was increased significantly by the lecture and lab experience in ISC. The data indicate success in achieving this most important learning objective in any science general education program.

Table 5. Value added to understanding and application of Scientific Method in ISC courses as measured by Pre- and post- tests.

Pre-test Scientific Method, N=28	Post-test Scientific Method, N=308
34%	87%

2. Assessment Portfolio analysis was conducted using rubrics tailored to the learning objectives and the assignments used to measure them. The Assessment Portfolio consists of items B-E listed in Table 1 and Rubrics in Appendices F-I were used to evaluate the achievement of learning objectives for each portfolio assignment. For simplicity, the summary of data are reported in Appendices F-I. The evaluation of the four portfolio items show remarkable consistency although the sample is a composite of smaller samples from many classes that were evaluated anonymously by a team of evaluators with means determined that included work submitted over two years. In each category and the mean composite score for each portfolio

item was evaluated as being very near 3—competent. It is also reassuring that the extensive portfolio reinforces assessment results from other assessment tools at entry, mid-level, and the results from the two standardized test measuring exit standards.

3. The Academic Profile Test was used as a nationally normalized baseline assessment instrument (see Table 6). Because of its broad coverage the academic profiles components of the report are suitable for evaluating the Science General Education Component of the curriculum and the ISC component of the Marshall Plan as compared to similar programs at other institutions. The two measures that are most important for the assessment effort in this study the Skills Dimension Sub-scores. Since this is the principal means of comparing the Marshall University program to the baseline information for the nation, data are provided for five years to illustrate trends. The most obvious point that can be made is that our MU scores for both critical thinking and natural sciences vary in a narrow range around 115, or the 50th percentile. The minor variation seen from year to year is likely random variations and probably would not have been statistically significant if the testing service had provided that information. The significant conclusion is that over the past five academic years the exit scores on standardized tests providing national baseline information suggest that students completing ISC, typically the last science or math course taken, score at about the 50th percentile or about average for the nation. This would be consistent with the statement, "The level of potential for entering freshmen at Marshall University and the realized skills and knowledge base of exiting seniors are both at or near average" for the nation. We feel justifiably secure in the fact that our students are able to consistently score at or very near the 50th percentile on the Critical Thinking and Natural Science Skills Dimension Sub-Scores of the Academic Profile Test indicating that our students are just as capable in science as their counterparts across the country.

Table 6. Critical Thinking and Natural Sciences Skills Dimension Sub-scores*

	2001-2002 N=420	2002-2003 N=583	2003-2004 N=637	2004-2005 N=584	2005-2006 N=283
Critical Thinking	110.34 (49.6)	110.18 (49.7)	113.19 (49.2%)	110.5 (50.7)	110.9 (50.9)
Natural Sciences	114.34 (49.6)	114.18 (49.9)	114.20 (49.6)	114.0 (50.4)	14.2 (49.7)

* Data from the 2005-2006 Academic Profile Report

** Percentile shown in parenthesis

Since the Integrated Science courses serve as the cornerstone of the Science General Education Program at Marshall University results from two questions on the Graduating Senior Survey were examined over the last five years to observe trends in the student perception of the value of science courses taken (see Tables 7 and 8). The significant conclusions that can be seen in Table 7 is that very consistently in each of the five years included over 50% of the students completing the survey strongly agreed or agreed with the statement that "The science courses taken increased the student's understanding of the scientific process." Relatively few, less than 7%, of the students in each of the five years strongly disagreed with the fact that the courses were not useful. Consistently >40% of the students in the five years covered in Table 8 agree or strongly agree with the statement that "This course conveyed scientific processes more completely than other science courses I took." These results reflect the strong value placed on the courses by students.

Table 5. Graduating senior responses to the statement, "I believe that the science courses I took increased my understanding of the scientific process."

Scales	2000-2001 N=292		2001-2002 N=327		2002-2003 N=302		2003-2004 N=278		2005-2006 N=253	
SA	62	21.7%	76	23.2%	62	21.7%	76	23.2%	60	23.7%
Agree	99	34.6%	109	33.3%	99	34.6%	109	33.3%	86	34.0%
Neutral	68	23.8%	91	27.8%	68	23.8%	91	27.8%	61	24.1%
Disagree	39	13.6%	37	11.3%	39	13.6%	37	11.3%	33	13.0%
SD	18	6.3%	25	4.3%	18	6.3%	25	4.3%	13	5.2%

Table 6. Graduating senior responses for those students who took and took an Integrated Science Course to the statement, "This course conveyed scientific processes more completely than other science courses I took."

Scales	2000-2001 N=292		2001-2002 N=259		2002-2003 N=275		2003-2004 N=259		2005-2006 N=213	
SA	33	15.6%	56	21.6%	33	15.6%	56	21.6%	42	19.7%
Agree	40	18.9%	57	22.0%	40	18.9%	57	22.0%	52	24.4%
Neutral	88	41.5%	84	32.4%	88	41.5%	84	32.4%	73	34.3%
Disagree	32	15.1%	41	15.8%	32	15.1%	41	15.8%	26	12.2%
SD	19	9.0%	21	8.1%	19	9.0%	21	8.1%	20	9.4 %

3. **The Collegiate Learning Assessment (CLA) Test** was used to test freshmen and seniors during 2004-2005 and 2005-2006 academic years. This test assesses value added to key higher order skills of students: critical thinking, analytical reasoning, problem solving, and written communication. Data from both years is presented and the source and year from which the data are drawn are indicated.

The correlation between the mean ACT scores and mean CLA scores for freshmen (blue) and seniors (red) are shown in Fig. 1. The lines represent the best fit linear regression the data. The lines define the expected freshman and senior score based on the performance of all other schools tested. A of a blue dot above the line represents "better than average" score and a blue dot below the blue line represent "worse than average score". A similar statement could be made for the red data representing seniors. Institutions are considered to be "at" the expected performance level if the dot representing the institution is within one standard deviation of the line. For both freshmen and seniors the dots are not more than 0.1 deviations from the line. The distance between the dot representing freshman performance and the one shown for senior performance represents value added by the educational experience. The performance of both freshman and senior MU students is "about average" when compared to students at other institutions, given our mean ACT/SAT admission scores. Thus, the impact of an educational experience at MU is at the expected level and represents significant growth in those aspects of learning measured by the exam.

The histograms in Fig. 2 provide a more visual concept of placement of MU freshmen and seniors among comparable institutions. The black squares represent scores of MU seniors, freshmen, and value added by the MU educational experience. In each case the MU score is on or at the zero line indicating how closely our students perform to the expected level.

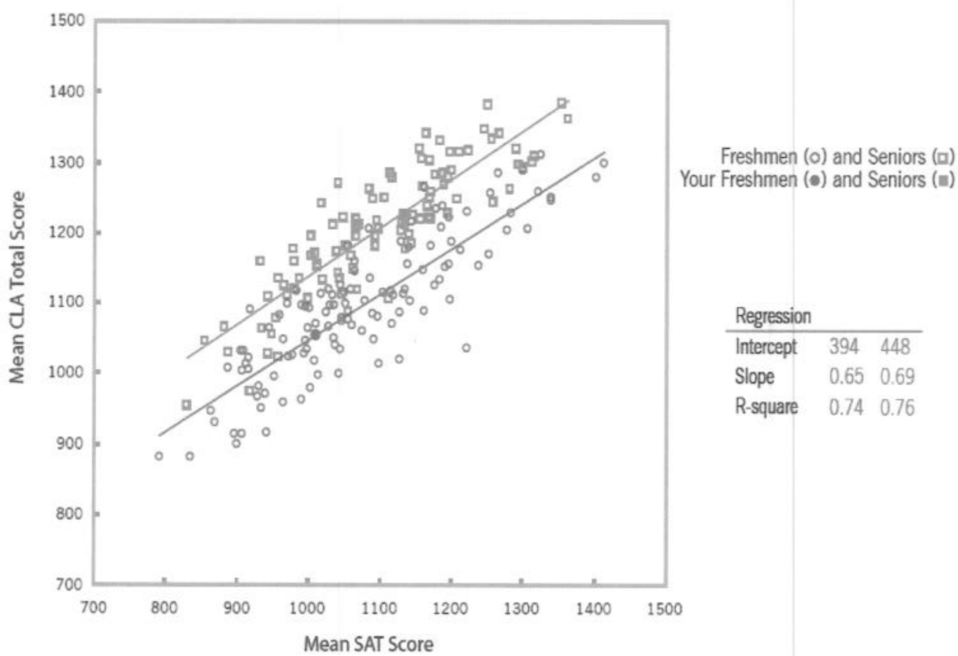
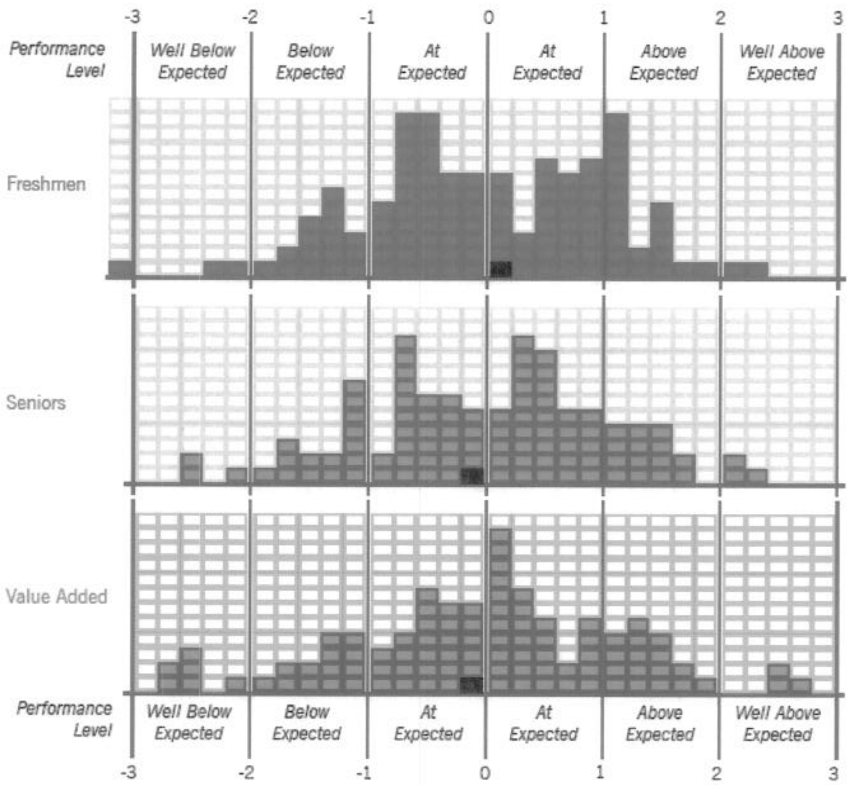


Figure 1. Deviation scores for MU freshman (blue solid dot) and seniors (red solid dot) –given their ACT/SAT Scores—whether those deviations were well above, above, at, or below or well below what would be expected. For MU scores students are at the expected level.



Each solid rectangle represents one CLA school. Solid black rectangles (■) represent your school as applicable within the distribution of actual minus expected scores for freshmen (■) or seniors (■) or estimates of the actual value added (■) between freshmen and senior years.

Figure 2. Distribution of schools by actual minus expected scores (in standard errors) and performance levels.

As already started in the discussion of Figs. 1 and 2 the expected performance of MU freshmen and seniors is at the expected level. The breakdown of the subcomponents of the CLS exam is presented in Table 7. Examination of the subcomponents allows the recognition of performance of each component of the scoring process that is used to determine the overall CLS score. This information would be invaluable in narrowing down poor performance to specific areas and would be useful in identifying those areas that needed attention. Thus efforts could be concentrated on specific problems in order to "close the loop". However all of the subcategories measured have deviation scores well within the plus or minus one standard deviation range and thus the scores are at the expected level. The overall expected score was thus not calculated by one or two higher marks masking the negative effect is of one or two subcomponents. The only flaw in the data was in the Analytical Writing Component for seniors where there was not a large enough sample size to generate statistical data necessitating the reporting of N/A. Statistically MU students performed at the expected levels in all areas.

	Freshmen		Seniors	
	Deviation Score	Performance Level	Deviation Score	Performance Level
Performance Task	-0.4	At	0.4	At
Analytic Writing Task	0.2	At	N/A	N/A
Make-an-Argument	0.7	At	-0.2	At
Critique-an-Argument	-0.4	At	-0.8	At
Total score	0.0	At	-0.1	At

Deviation (residual) scores are reported in terms of the number of standard error units the school's actual mean deviates from its expected value.

Table 7. The breakdown of the subcomponents of the CLS exam.

The science general education and the ISC component of the Marshall Plan in particular has learning objectives reflected in the assessment goals of CLS. This test provides a second direct measure of nationally-normed performance after the Academic Profile Test in areas addressed by the ISC objectives, principally critical thinking. It is encouraging that the predictive assessment of the ACT/SAT, Academic Profile Test, and Collegiate Learning Assessment Test yield results that reinforce the validity and reproducibility of the tests as assessment tools. Thus, incoming MU students are representative of the nation, our freshmen perform at the same statistical level as the rest of the nation, and the value added by the MU educational experience is comparable to that contributed by other comparable institutions of higher learning. MU is doing well in building those skills developed by the science general education component of the curriculum considering the funding limitations.

IV. Conclusion and Plans for the Current Year

The present assessment report is exhaustive. It is the collective end product of a two year effort. Since such a large and thorough effort has been expended recently a more modest assessment program will operate for the upcoming year. One factor entering into this decision is the possible significant revision of general education at Marshall University. We are now moving past the tenth year of the implementation of the Marshall and maybe it should be reexamined. All evidence suggests the present science general education system is functioning well and achieving its learning objectives. Rather than begin a more intense effort for assessment of science general education it seems to be prudent to continue with the present assessment practices to keep the curriculum on the right course until the revision process is completed.

Appendix A

Integrated Sciences (ISC) Course Descriptions

200 Energy: from photosynthesis to steam engines. 4 hrs.
Relationships between present and historic levels of energy consumption and human population growth are examined. Issues compare energy use and technology of class members to comparable populations in developing countries. (PR: MTH 121 or higher, except MTH 400 and MTH 401)

201 Biotechnology. Biotechnology explores scientific, political, economic, and ethical aspects of recombinant DNA technology and genetically altered organisms. Class projects include DNA manipulation and analysis, forensic studies, and Internet exploration. (PR: MTH 121 or higher, except MTH 400 and MTH 401)

202 Freshwaters of the World. The course discusses the physics, chemistry, geology, and biology of freshwaters, its importance for all living things, and the need for conservation and pollution-prevention of this invaluable resource. (PR: MTH 121 or higher, except MTH 400 and MTH 401)

203 Doing Science: The Central Paradigms. Students will investigate the nature of science by studying several of it's central theories and other issues. Students will gather and interpret evidence and research original and secondary sources. (PR: MTH 121 or higher, except MTH 400 and MTH 401)

204 Global Warming. 4 hrs. Model the social, economic, and scientific data using algebra as it relates to global warming. (PR: MTH 121 or higher except MTH 400 r MTH 401)

205 Who-done-it: Introduction to Forensic Science. The relationship between scientific process and crime solutions will be examined. Particular attention will be given to use of DNA technology and probability theory in criminal justice system. (PR: MTH 121 or higher, except MTH 400 and MTH 401)

206 Living in Space. A space science courses that explores NASA-directed research. Students will compare "ground based" investigations in plant science, physics, geology, human behavior and physiology with the results from space flight experiments. (PR MTH 121 or higher, except MTH 400 and MTH 401)

207 Coal Science. Examines the importance of coal to industrialized nations and the operation of the John Arnos power plant. There is an assessment of the impact oaf mining activities on the environment. (PR: MTH 121 or higher, except MTH 400 and MTH 401)

208 Evolution: Process of Change. The issue of evolution is investigated. Topics from the Big Bang to the evolution of viruses are considered. Emphasis is on environmental, genetic, and molecular mechanisms governing change. (PR MTH 121 or higher, except MTH 400 and MTH 401)

209 Chemistry in the Home. An introduction to basic concepts of chemical science as it applies to materials commonly found within the household. Students will be expected to learn how to evaluate potential hazards of such materials.

210 Science & the Visual Arts. An overview of how science and mathematics contribute to the visual arts. Emphasis on perspective, proportion, scientific topics in art, mathematically based art forms, and artist's materials.

Appendix B

ISC Sections Offered and Staffing Data

September 12, 2006

H. W. Elmore

Year	# Sections/year 01-06*	Percentage Fulltime Permanent Staff
199601-06	2(0)	100%
199701-06	17(0)	100%
199801-06	16(0)	100%
199901-06	17(1)	94%
20001-06	28(4)	85.7%
200101-06	28(7)	75.0%
200201-06	34(16)	52.9%
200301-06	38(18)	52.6%
200401-06	38(23)	39.5%
200501-06	42(31)	26.2%
200601-06	46(30)	34.8%

* Sections taught by part time or full time temporary faculty are listed in parentheses.

Appendix C

Courses, Sections, # of Faculty, and to students by year, 1990-9993

Semester	ISC Course numbers	# Different Courses	Total # Sections	Total # Faculty	Total # Students
199901	200,202,203,206,280, 281,282	7	10	7	222
199902	200,202,204,205,206, 280	6	10	7	229
199903-6	200,202,203,204,205,207*,280, 280	8	8	10	198
200001	200,202,203,208,280, 281	5	8	6	181
200002	202,203,204,205,208, 281,282	7	11	8	277
200003-6	200,202,204, 205,207*,280	6	6	8	207
200101	202,203,205,208, 280,281,282	7	12	8	290
200102	204,205,280,281,282,283	6	13	11	279
200103-6	200,202,204,205,207,208,280,281,282	9	11	12	247
200201	200,204,205,280,281,282,283	9	15	9	337
200202	200,204,205,280,281,282,283	7	18	19	397
200203-6	200,201,202,204,205,207,280	7	12	14	278
200301	200, 202, 203, 205, 206, 208, 280, 281,282,283	10	15	14	337
200302	200, 204, 205, 280, 281, 282, 283	7	18	19	397
200303-6	200, 201, 202, 204, 205, 207, 280	7	12	14	278
200401	202, 205, 280, 281, 282, 283	6	13	7	315
200402	202, 202, 204, 205, 281, 283	7	16	10	356
200403-6	201, 202, 204, 205, 281, 282, 283	7	10	9	206
200501	205, 280, 281, 282, 283	5	13	6	329
200502	204, 280, 281, 282, 283	5	18	10	421
200503-6	200, 201, 204, 205, 280, 281, 282	7	14	10	226

Appendix D

Integrated Science

Scientific Method Pre-test

1) An experiment:
   A) assesses the value of the initial observation
   B) identifies and eliminates all mistakes that occur in the formation of the hypothesis
   C) only has value if it can prove the hypothesis
   D) justifies the problem-solving approach that the scientist uses to formulate the theory
   E) measures the level of probability that a variable will influence the observed results

2) When using the Scientific Method, a scientist would first:
   A) decide what he or she wanted to prove
   B) make an observation in nature
   C) only consider some things worthy of studying
   D) be certain that the experiment is designed to prove their hypothesis
   E) propose a Scientific Law

3) A tentative explanation that can be tested with experimentation is called a:
   A) hypothesis
   B) principle
   C) doctrine
   D) theory
   E) law

4) The role of an experiment is to:
   A) aid the researcher in formulating the correct hypothesis
   B) prove the hypothesis
   C) make observations that explain the theory
   D) rigorously test the hypothesis
   E) gather data quickly enough to win the race to discovery against other scientists

5) Which of these is **not** true of the Scientific Method?
   A) A tested hypothesis can be proven, accepted and studied further.
   B) A tested hypothesis can be modified and studied further.
   C) A tested hypothesis can be rejected but still provide meaningful information.
   D) A tested hypothesis can be constructed once you know what is to be proven.
   E) A tested hypothesis is the only valid pathway to a Scientific Theory.

6) An initial observation of a phenomenon in nature is related to which part of the Scientific Method?
   A) the use of a control for an experiment
   B) the rejection of a hypothesis
   C) the statistical analysis of data
   D) the formation of a Natural Law
   E) the planned outcome of an experiment

7) Commonly, commercials purport to depict scientific experiments with the message that the dramatic results that prove that you-the consumer-would buy their product. In one classic commercial, a leopard was presented with two steaks; one wrapped in Brand A plastic wrap, and the other wrapped in Brand B plastic wrap. The leopard sniffed the steak in Brand A and showed no apparent interest, but when it sniffed the steak wrapped in Brand B it voraciously began to devour the second steak. The viewer was left with the impression that Brand A seals so tightly that the aroma of the steak could not reach the nostrils of the hungry leopard. As a scientist, viewing the commercial and basing your action on your knowledge of the scientific method would your:
   A) immediately purchase Brand A
   B) purchase Brand B because the commercial is clearly biased against Brand B
   C) marvel at the good and proper use of science in commercials
   D) be amazed that the hypothesis was supported by an experiment with a sample size of one
   E) be skeptical since the experiment was obviously flawed

8) The Scientific Method:
   A) may be used to test generalizations
   B) can be applied to matters of politics, religion, culture, ethics or art appreciation
   C) is immutable in its interpretation
   D) represents knowledge that is absolute and unconditional
   E) all of the above statements are true

9) The steps of the Scientific Method, up to and including the formation of the hypothesis, allows scientists to:
   A) immediately confirm the hypothesis and elevating it to the position of Theory
   B) relieve themselves of any responsibility if the hypothesis proves to be incorrect
   C) predict the observations that will occur through experimentation if the hypothesis is correct
   D) justify proposals of similar hypotheses without going through those initial steps
   E) discredit the theories of other scientists who oppose their views

10) The steps of the Scientific Method after the formation of the hypothesis allows scientists to:

A) gather data to support or refute the original hypothesis

B) propose that the broad hypothesis be accepted as a theory after repeated attempts to disprove it have proven fruitless

C) go back and modify the hypothesis after experimentation provides additional data

D) abandon the hypothesis if experimentation disproves it

E) any of the above choices would be correct

Appendix E

Integrated Science

Scientific Method Pre-test

1. Which of the following is the textbook definition of a *hypothesis*?
   A. a statement proposing a relationship between two or more concepts
   B. a statement consisting of an educated guess about two variables that affect a phenomenon
   C. a statement that is empirically specific about some phenomenon
   D. a careful observation
   E. a proper conclusion

2. The scientific process:
   A. always begins with theory and ends with research
   B. always begins by observing a phenomenon about which a question arises
   C. always starts with research, out of which theories are built
   D. is an orderly procedure for making systematic observations

3. What is a *null* hypothesis?
   A. an uneducated guess about the nature or direction of a relationship
   B. state that there is an indirect relationship between the variables
   C. suggest an inverse relationship between two variables
   D. states that there is no relationship between an observation and an explanation of the observation
   E. a bad hypothesis

4. Which of the following statements about the scientific method is incorrect?
   A. A scientific hypothesis is a proposed explanation for a given set of observations.
   B) A scientific fact is a hypothesis so firmly supported by evidence that it is assumed to be true.
   C) A scientific theory is a set of organized, interrelated ideas that logically explain a phenomenon.
   D) A scientific fact can never be challenged through experimentation.
   E) Once a theory is in place it is automatically law.

5. Which of the following is <u>not</u> true of the scientific method?
   A. The hypothesis must be a measurable statement.
   B. The first step in the method is law formation.
   C. Theories are based on the results of many researchers' experiments.
   D. Library research to find out what is already known on the subject is an important final step in writing scientific law.
   E. Experiments are designed to rigorously test the validity of the hypothesis.

6. Which of the following represents the weakest scientific statement:
   A. law
   B. theory
   C. hypothesis
   D. model

7. Which word included in a question cannot be answered by science:
   A. when
   B. why
   C. what
   D. how

8. When trying to find a explanation to an observation, it is best to have:
   A. one hypothesis
   B. two hypotheses
   C. three hypotheses
   D. as many as possible

9. A particular event was determined to be described by the expression
   Rainfall = -0.00125 Year + 17.546. This expressions best represents:
   A. an hypothesis B. a theory C. a law D. a model
   Answer: D. a model

10. Newton's formula for gravity is considered:
    A. an hypothesis B. a model C. a theory D. a law

11. The first step in the scientific method is to:
    A. make predictions B. develop hypotheses
    C. make observations D. setup experiments

12. Data collected using an instrument during an experiment yielded results that showed significant scatter. Which of the following is not likely the cause of the scatter:
    A. improper calibration B. inexperience in using the instrument
    C. fluctuations in temperature during the experiment
    D. random variations in the property being measured

13. The best hypothesis is one that:
    A. only can be correct B. can be proven false
    C. allows for no experimentation
    D. need not permit prediction

Appendix F

Summary of data from the Rubric for ISC Portfolio Assignment I — Lab Report on the Process of Science. Students will make observations, develop hypotheses, design experiments, collect data, and draw conclusions.

Scoring System — Place the proper value or mark in the box beside the item addressed by the statement.

Outstanding	4
Competent	3
Not Yet Fully Competent	2
Incompetent	1
Omitted	0
Does Not Apply	X

Observations leading to hypothesis accurate and clearly stated.	3
Hypothesis is clearly articulated.	3.60
Hypothesis is testable.	3.62
Materials are described in detail as to type, size, or mass and expressed in metric units, if applicable.	2.92
Variables are clearly described and grouped correctly as independent, dependent, or controlled.	3.23
Data is expressed clearly in metric units on a chart or graph if appropriate.	3.02
Experiment is well designed and sample size adequate.	2.83
Results show a clear, well written representation of data.	2.70
Conclusion clearly supports or rejects the hypothesis.	2.79
Conclusions drawn do not overextend the data.	2.56
Mean	3.02

Appendix G

Summary of data from the Rubric for ISC Portfolio Assignment II — Comparative critique of two papers one chosen as an example of science and one as an example of pseudo science. Minimum 3 pages, double spaced submitted as a Word document.

Scoring System — Place the proper value or mark in the box beside the item addressed by the statement.

Outstanding	4
Competent	3
Not Yet Fully Competent	2
Incompetent	1
Omitted	0
Does Not Apply	X

Chooses appropriate characteristics for comparison. 4 Selects important features or attributes that provide thorough and valid insight into comparison. 3 Selects characteristics that can provide for a meaningful comparison. 2 Selects characteristics that provide for a partial comparison of the items. 1 Selects characteristics that are not important and don't lead to insightful conclusions.	3.25
Identifies similarities and differences between two or more items. 4 Accurately selects all major similarities and differences for each item. 3 Selects similarities and differences for each item. 2 Makes some errors in identifying major similarities and differences. 1 Makes many errors in identifying major similarities and differences.	2.91
Uses the identified similarities and differences to reach important conclusions or insights. 4 Draws insightful and thoughtful conclusions from the similarities and differences. 3 Draws some thoughtful conclusions from the comparison. 2 Isn't clear about the significance of the comparison. 1 Does not get far beyond noting similarities and differences.	2.66
Identifies success or failure to meet standards of Scientific Method 4 Identifies elements of hypothesis, experimentation, and conclusion in both references. 3 Fails to identify element of one key element of the scientific method. 2 Grapples with key elements of scientific method but fails. 1 Fails to identify difference between science and pseudoscience	3.0
Mean	2.95

Appendix H

Summary of data from the Rubric for ISC Portfolio Assignment III — Provide a synthesis based on three or more reference sources emphasizing scientific findings and the strength of those findings. Minimum, 3 pages double spaced submitted as a Word document.

Scoring System — Place the proper value or mark in the box beside the item addressed by the statement.

Outstanding	4
Competent	3
Not Yet Fully Competent	2
Incompetent	1
Omitted	0
Does Not Apply	X

A thesis statement makes the purpose of the essay clear. The main point of the essay is articulated in the first paragraph in a clear thorough manner.	**3.12**
Background information is provided to illustrate the importance of the essay topic. References from several sources are used to provide a well synthesized body of knowledge constituting the body of the manuscript.	**3.0**
The scientific arguments are based soundly on the scientific method and do not extend into the realm of speculation unless it is stated clearly, possibly in the discussion or summary, that a new or unique direction might be suggested.	**2.30**
The current up-to-date interpretation and most recent references providing the newest findings are used unless points are included for historical context. The arguments are current, plausible, and well supported.	**2.62**
The content of the essay is the work of the student and represents a clear synthesis of the data regarding the subject with sufficient reference material woven into a single coherent presentation.	**3.0**
The summary or conclusion reflects a condensed treatment of the body of the content of the essay. The summary provides a synthesis of understanding that draws from several reference and articulates conclusions well.	**2.50**
Mean	**2.75**

Appendix I

Summary of data from the Rubric for ISC Portfolio Assignment IV — Group Presentation or Report Summarizing an Area of Scientific Research. The emphasis is on presentation of scientific information as a stand-alone, kiosk-like presentation or report. Sound argument, clarity, and accuracy of conclusions are emphasized. Presentation in a format that allows wide distribution — PowerPoint, web page, or other appropriate means

Scoring System — Place the proper value or mark in the box beside the item addressed by the statement.

Outstanding	4
Competent	3
Not Yet Fully Competent	2
Incompetent	1
Omitted	0
Does Not Apply	X

Organization 4 Information presented in logical, interesting sequence which audience can follow. 3 Information presented in moderately logical order. 2 Audience has difficulty following presentation because the presentation jumps around. 1 Audience cannot understand presentation because the sequence of information in very confusing.	3.20
Knowledge 4 Full knowledge of subject areas is demonstrated. 3 Moderate understanding of subject area is demonstrated and some facility demonstrated in the points made. 2 Full grasp of subject areas is lacking and interpretation is confused. 1 Understanding of subject area is rudimentary and facility in making points is weak.	3.10
Key Assumptions and Ideas 4 Identifies and considers other (all) important perspectives and positions that are important to the analysis 3 Identifies and questions the validity of the assumptions and addresses the ethical dimensions that underlie the issue 2 Does not question or seek to determine the validity of assumptions that underlie the issue, or does so superficially. 1 Merely repeats information, denies evidence without and confuses associations and correlations with cause and effect.	2.50
Visual Aids	3.30

4 Visual aids explain and reinforce the presentation. 3 Visual aids relate to the presentation. 2 Occasionally uses visual aids that rarely support the presentation 1 Uses superfluous visual aids or no visual aids	
Clarity and Understanding of Scientific Content 4 Strength of the arguments based on scientific conclusions is strong, convincing, and understandable 3 Some question remains about validity or strength of argument and the presentation is not absolutely clear. 2 Argument is shaky but cannot be completely dismissed based on the confusing presentation 1 Argument is without substance and the points of the presentation are not clearly stated nor the reasoning understandable.	2.90
Mean	3.0