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Engineering Cultures: Comparing Student Learning in Online and Classroom Based Implementations*

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Engineering Cultures is a course that was developed primarily to prepare United States' engineering students to effectively collaborate and communicate with engineers from other countries. In order to reach a broad audience, two versions of this course have been developed and offered: an online and an in-class version. The schools participating are Virginia Polytechnic Institute (VT) and the Colorado School of Mines (CSM). In this article, the results of an investigation that compares the learning outcomes and student perceived usefulness of the two designs are reported. The assessment instruments used in this investigation were multiple-choice content pre and post tests, essay pre and post tests, and a self-report end of semester survey. Differences in learning between the two courses were not detected on the pre to post multiple-choice content test; however, differences were detected, with in-class students displaying greater increases, between the pre and post essay exam. This indicates that the learning outcomes measured through the essay exam, which included analysis and synthesis, were better supported through classroom based instruction than the online instruction.

Keywords: assessment; global engineering; on-line learning

INTRODUCTION

FOR COMMUNICATION ACROSS CULTURES to be effective, engineers need to be able to understand and communicate with each other [1]. As Qamhiyah summarizes, 'It is essential for engineering students to graduate from the United States engineering educational institutions with the affirmed ability to design anywhere, manufacture anywhere, and the training necessary to collaborate effectively with their peers from international engineering educational institutions'[2]. Although Qamhiyah specifically references U.S. education, this statement holds true regardless of the country in which the engineer is trained. Furthermore, according to the criteria set forth by the Accreditation Board for Engineering and Technology (ABET) [3] all engineers need to be aware of global issues and, as of 2007, ABET is accrediting universities outside of the U.S. In summary, the need for international collaboration has resulted in new demands on the educational system for training future engineers [4]. *Engineering Cultures* is a college level course offered at Virginia Polytechnic Institute (VT) and the Colorado School of Mines (CSM) that is designed to provide students with a basis for global competency [5].

The Engineering Cultures course is based on the work of Downey and Lucena [5] who completed interviews concerning engineering work with engineers from different countries. Based on these interviews, Downey and Lucena created instructional modules and two versions of the Engineering Cultures course: online and classroom based. Both versions are designed to teach future engineers how the culture of engineering differs across various countries. The countries discussed through these modules are: France, United Kingdom, Germany, the former Soviet Union, Russia, United States, and Japan. Although these countries share many underlying similarities, the role and expectations of engineers are different; these roles have evolved through the histories of the countries in which the engineers reside. A detailed description of the Engineering Culture's curriculum, both online and classroom based, has been previously published [5]. With the exception of face-to-face interaction, the Engineering Cultures' online curriculum seeks to have all the elements of classroom based instruction [5] and uses an approach that is consistent with prior literature [6, 7].

There are many recognized student benefits to online instruction and those that are consistent with the design of the online Engineering Cultures' curriculum are discussed here. Many online courses are designed such that students can complete the course wherever and whenever they choose, as long as they have access to the internet. Conflicts with work and other components of their

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lives all but disappear. If a student does not have a solid hour to attend a weekly lecture, he or she may assemble small increments of time toward course completion [8]. Some studies [8–10] have even found that online students perform better than their classroom based counterparts on standardized assessments. This outcome, however, is likely to be dependent on both the method of online implementation and the measurement instrument.

Based on prior literature, a number of disadvantages to online learning have also been identified. Since there is no set schedule for online courses, some students lack the motivation to complete the required materials. Online students may also experience difficulties accessing online programs [11] or may miss the personal element that is common to the classroom [12]. These negative components of online instruction are often reflected through lower student satisfaction ratings with respect to online instruction when compared with classroom based courses [13].

Given the conflicting evidence concerning online instruction, further research is necessary when implementing an online design. In this investigation, the authors focus on student learning gains and satisfaction within a single course when that course is offered in an online format and a classroom based version. The course is an engineering elective, Engineering Cultures, and is being offered at VT and CSM. The research questions are as follows.

1. Is there a measurable difference in students' factual knowledge gains in Engineering Cultures based on pre and post test scores when students complete the online or in-class versions of the course?
2. Is there a measurable difference in students' abilities to analyze and synthesize information as measured by a pre and post essay exam of students who completed the online or in-class versions of the course?
3. Is there a measurable difference in student satisfaction based on the responses to an attitudes survey when students completed the online or in-class versions of the course?

METHODS

This section describes the methods that were used in this investigation, including a discussion of the course, subjects, and instruments. This section concludes with a brief summary of the analysis techniques.

Course

The *Engineering Cultures'* curriculum begins with a challenge to a common U.S. student misconception that engineers throughout the world share a common philosophy and culture with respect to engineering. This discussion is followed by six modules designed to present the differences that were identified through an extensive interview process [5] between engineers who were trained in the following nations: United States, France, British, Germany, the former Soviet Union, and Russia. The ordering of these modules as is listed here does not necessarily reflect the order in which they were implemented in a given section of the course. Although all sections covered the same materials, instructors had the option of defining their order. The learning outcomes of the course are to increase students' knowledge that differences exist in how engineers are perceived and the role that they serve in society based on the country in which they practice. Also, the course seeks to develop students' abilities to compare the impact of cultural differences on engineering experiences, outcomes and decision making.

The online version of Engineering Cultures includes videos of a professor lecturing and electronic copies of all reading and writing assignments. There is no textbook for Engineering Cultures, the readings are collections of publications [5]. There is also a discussion board where students interact with each other and hold online discussions concerning the course material. The students were required to attend a scheduled one-hour, weekly online discussion concerning the course. Based on this, it may be argued that the given course is a hybrid of online instruction since the students did not have complete flexibility in terms of when they completed the course requirements. With the exception of this scheduled one hour each week, the remaining components of the course could be completed at the students' discretion. The in-class sections of Engineering Cultures differ only in that students attend an actual lecture and participate in classroom discussions. Each in-class course instructor also had the option of sponsoring online discussions. A detailed description of the Engineering Cultures course, curriculum and expected learning outcomes is available in Downey et al. [5].

Subjects

The subjects in this study are students who completed either the online or in-class version of Engineering Cultures at VT or CSM during the academic years 2004–2006. Four different instructors taught the in-class version of the course, two of whom also taught online sections. In-class versions of the course at VT were offered during the fall of 2004 and 2005 and on-line versions were offered in the spring of 2005 and 2006. At CSM, only in-class versions were offered and these were taught in the fall and spring of 2005. Although the participants changed each semester, the universities where Engineering Cultures was being taught did not. It is unlikely that over the course of this three year study that the basic demographics of these schools varied greatly. Therefore, the assumption is made here that each semester the sample is drawn from the same population. At VT, Engineering Cultures is a sophomore level course and at CSM, it is a junior level course.

Table 1. Scoring rubric for pre/post essay assessment

0	1	2	3
The essay characterizes engineering work as entirely technical, showing no awareness of national differences between engineers in France, Britain, and/or Germany	The essay shows awareness of differences in language and customs between French, British, and/or German engineers but does not recognize national differences related to engineering work.	The essay describes national patterns of engineering knowledge and engineers' identities in France, Britain, and/or Germany but does not explain how these patterns are important in engineering work.	The essay describes national patterns of engineering knowledge and engineers' identities in France, Britain, and/or Germany and explains how these patterns are important in engineering work.

Instruments

For the purpose of evaluating students' change in knowledge from the beginning to the end of the course, a pre and post multiple choices test was developed. This assessment was administered the first and last weeks of the course. Both the pre and post versions shared identical questions and were designed to measure student understanding of the course content and change in their knowledge over the course of the semester. A complete copy of this instrument can be found in the Appendix at the end this paper. Recognizing that multiple choice assessments are primarily effective for measuring the lowest level of Bloom's Taxonomy [14], knowledge, essay exams were also administered at the beginning and end of the course, which were designed to measure levels four and five, analysis and synthesis. The statement of the essay exam was:

> As an American engineer, you have been invited by Airbus Industries in Toulouse, France to help design an 'environmentally sustainable and socially responsible' manufacturing plant. The design team includes engineers from France, Germany, and United Kingdom because Airbus is jointly owned by companies from those countries. How prepared are you to enter this work situation? What knowledge and capabilities do you have and what do you lack? [5]

Student responses to this question were scored using the scoring rubric that is displayed in Table 1. A score of '1' using this rubric indicates that the student has acquired appropriate factual knowledge. A score level of '2' indicates that the student is able to explicitly analyze national patterns in engineering and a score level of '3' indicates that the student is able to synthesize differences with respect to engineering among the countries. The design of this scoring rubric reflects the measurement of levels one, four and five of Bloom's Taxonomy.

At the conclusion of the course, students were given a self-report survey. The closed response statements/questions that comprised this instrument are displayed in Table 2. All students were asked to respond to the first six statements/questions; only students that completed the online version were asked to respond to the last three statements/questions. The response categories for the first five statements were strongly disagree, disagree, agree and strongly agree. These same response categories were used for statements seven and eight. The response categories for question six was as follows: (a) Take another humanities/social science elective but not this one, (b) definitely take this course, (c) Try to fit this course in your schedule. If you can't, then take another humanities/social science elective, and (d) don't bother taking any humanities/social science courses. The response categories for question nine were: CD or online format. Students also responded to the following open-ended questions: 'What can we do to FURTHER IMPROVE this course to enhance student learning? Please be as specific as possible.' and 'What should we do again when we teach this course to further support student learning?'

Analysis

To acquire a baseline with which to compare online and in-class versions of the course, both a pre content test and pre essay were completed by participating students during the first week of classes. Post test, post essays and the self-report survey were administered during the last week of classes.

To determine if the post test performances differed significantly between online and in-class versions, an analysis of covariance (ANCOVA) was completed. This analysis technique allows the two groups, online and in-class, to be equated based on the covariate of the pre test score. A backwards elimination process was then used to identify an appropriate model for the data [15]. Semester could not be considered as a factor in this analysis, because the online and in-class versions of Engineering Cultures were not offered within a given school during the same semester. Caution must be used in the interpretation of the results to this analysis, given that random assignment was not possible and a quasi-experimental design was used.

To measure the change in essay scores calculated by the rubric, a chi-square test was performed on the change in the students' scores from the beginning to end of Engineering Cultures. The changes in students' scores were grouped into two categories, 'Increase' and 'Decrease/No Change'. The 'Increase' category includes a count of the scores that increased by one, two, or three points from the beginning to the end. The 'Decrease/No Change' category includes students who had the same scores from beginning to end as well as those

Table 2. Self-report survey

Statement/Question number	Question
1	I gained significant knowledge from this course about engineers in the world.
2	I am better prepared to meet and work with engineers from different countries.
3	I now have a better understanding of how my perspective as an engineer is different from those of engineers from other countries.
4	After learning about engineering and engineers in the world, I will now be more likely to have a satisfying career as an engineer.
5	I will now be better at working with people who define problems differently than I do.
6	If a friend were to ask you whether they should take this course, which of the following would most accurately reflect your response?
7	I enjoyed the online experiences in this course.
8	I believe I learned more in the online version of the course than I would have learned in a classroom version.
9	Most of the course used the CD format for lectures. The Japan module used the online format for lectures. Which of these did you prefer?
Response categories for statements: 1–5, 7 & 8	(a) Strongly disagree, (b) Disagree, (c) Agree, (d) Strongly disagree
Response categories for question 6	(a) Take another humanities/social science elective but not this one, (b) Definitely take this course, (c) Try to fit this course in your schedule. If you can't, then take another humanities/social science elective, (d) don't bother taking any humanities/social science courses.
Response categories for question 9	(a) CD, (b) Online format

that decreased by one, two, or three points. Once again, due to the use of a quasi-experimental design, caution must be used in the interpretation of results.

For the first eight closed-response statements on the survey, scores were grouped according to 'Agree' which includes 'Strongly Agree' and 'Agree,' and 'Disagree' which includes 'Disagree' and 'Strongly Disagree'. For the first five questions, a chi-square test was performed to determine whether the proportion of students who answered 'agree' for the online course was the same as the proportion who provided this answer in the in-class version. A similar approach was used to compare the response categories for question 6. For the remaining statements/questions, only summary statistics are provided since these statements/questions were only administered to online students. Questions with no answer or an inapplicable answer were not included in the analysis. Responses to the open-ended questions were examined in a qualitative manner.

RESULTS

In this section, the results of this investigation are discussed. This begins with a discussion of the response rate and is followed by the results of the pre/post content test, pre/post essay and the self-report survey.

Response and retention rates

Table 3 displays the sample size for each instrument. This is divided based on pre and post assessments. By comparing the number of responses to the pre test to the number of responses to the post test, it can be concluded that over 95% of the students that completed the pre test also completed the post test. Since the post test was administered in the last week of classes, it can be assumed that over 95% of students were retained until the final week.

Pre and post tests

The mean pre and post test scores and the mean

Table 3. Numbers of students who completed the instruments: pre vs. post

		Multiple-choice		Essay	
Instructor	**Version**	**Pre**	**Post**	**Pre**	**Post**
Instructor one	Online	194	185	121	117
	In-class	64	63	41	39
Instructor two	Online	105	102	83	82
	In-class	47	45	34	27
Instructor three	In-class	44	41	29	27
Instructor four	In-class	—	—	45	38

of the difference (gain score) are presented in Table 4. Specifically, this table displays means for the following subgroups: Online, In-class, Instructor one, Instructor two, and Instructor three. Only data from VT were included in this analysis, since CSM did not offer an on-line version of the course.

To further investigate the difference between the online and in-class versions, the analysis is narrowed in Table 5 to include only the pre and post test means for Instructors one and two. These instructors taught both versions of the course. Based on this descriptive data, there appears to be little difference in the gain scores from pre to post test. This was investigated further using an ANCOVA.

Before an ANCOVA can be completed, the assumptions of the model need to be verified. For details concerning the verification process, see Parkhurst [16]. The initial analysis used the full model, which included as factors: Instructor (one or two), version (online or in-class), and the interaction between instructor and version. Semester was not included in this analysis, since both versions of Engineering Cultures were not offered within the same semester at a given school. The pre test score was used as a covariate and the post test scores as the measured response. Backwards elimination was then used to narrow the factors considered in the model [15] and Table 6 summarizes the results of the initial ANCOVA as well as the subsequent results of the backward elimination process. Based on this process, it can be concluded that once post test scores are adjusted based on the initial differences in pre test scores, there is no detectable difference in post test scores based on version or instructor. In other words, students are making comparable gains from pre to post test regardless of whether they completed the course online or in-class or under the direction of Instructor one or Instructor two. This is a positive finding in that the students in the online course are making comparable gains to students in the classroom based version.

Pre and post essays

In this section, the results of the analysis of the pre and post essays are discussed, using a chi-square test for significance. Verification of the appropriateness of the assumptions of the chi-square can be founding in Parkhurst [16]. The following were examined: versions of the course, differences due to instructors, and differences between CSM and VT. With the purpose of ensuring inter-rater reliability, approximately 20% of essays were double scored with an acceptable agreement of 80% or better. Overall, approximately 90% of in-class students increased their rubric score while only 75% of online students

Table 4. Means for pre and post tests

Category	Pre test	Post test	Gain score	*n*
All	13.768	18.805	5.037	284
Online	13.471	18.636	5.165	196
In-Class	14.429	19.182	4.753	88
Instructor one	13.798	18.867	5.069	152
Instructor two	13.757	18.910	5.153	106
Instructor three	13.635	18.019	4.384	26

Table 5. Means for pre and post test: Instructor one and two

Instructor	Version	Pre test	Post test	Gain score	*n*
Instructor one	In-class	14.809	19.789	4.98	38
Instructor one	Online	13.461	18.559	5.098	114
Instructor two	In-class	14.688	19.479	4.791	24
Instructor two	Online	13.485	18.744	5.259	82

Table 6. ANCOVA for instructor, version and interaction

	Source	*F*	*p*-value
Analysis 1	Pre test	49.70	0.000*
	Instructor	0.01	0.512
	Version	1.05	0.682
	Instructor*Version	0.30	0.344
Analysis 2 (Instructor*Version Removed)	Pre test	96.52	0.000*
	Instructor	0.08	0.782
	Version	0.39	0.535
Analysis 3 (Instructor Removed)	Pre test	96.75	0.000*
	Version	0.37	0.544

increased their rubric scores from pre to post essay. Based on a chi-square test, these percentages were found to be significantly different with $p = 0.000$. In other words, a larger proportion of students in the in-class version displayed increases from pre to post essay than on-line students.

The next analysis focuses on differences between instructors. Approximately 73% ($n_{\text{instructor 1}} = 156$), 78% ($n_{\text{instructor 3}} = 109$), 93% ($n_{\text{instructor 3}} = 27$) and 95% ($n_{\text{instructor 4}} = 38$) of instructor one's, two's, three's and four's students, respectively, displayed increases in their rubric score from pre to post essay. A chi-square test indicated that these percentages differed significantly with $p = 0.007$. It should be noted, however, that instructors three and four only taught in-class versions of the courses whereas instructors one and two taught both in-class and online versions of the course. Therefore, the differences found between the instructors could be attributed to the differences found between the different versions of the course. To examine this possibility, the analysis was narrowed to include only in-class versions of the course. Approximately 85% ($n_{\text{in-class, instructor 1}} = 39$), 89% ($n_{\text{in-class, instructor 2}} = 27$), 93% ($n_{\text{in-class, instructor 3}} = 27$) and 95% ($n_{\text{in-class, instructor 4}} = 38$) of instructors one's, two's, three's and four's students, respectively, displayed increases from pre to post essay when restricting the analysis to in-class students. Some of the cells in this analysis had an expected value of less than five, preventing a valid statistical comparison between these percentages. Based on the descriptive statistics, however, much of the variation in these percentages appears to be accounted for once the online courses were removed.

Instructors one and two each taught both online and in-class versions of the *Engineering Cultures'* course. For instructor one, approximately 85% ($n_{\text{in-class, instructor 1}} = 39$) and 70% ($n_{\text{online, instructor 1}} = 117$) of in-class and online students, respectively, displayed an increase in their essay scores. A comparison between these percentages was found not to be statistically significant, with $p = 0.061$. For Instructor two, approximately 89% ($n_{\text{in-class, instructor 2}} = 27$) and 76% ($n_{\text{online, instructor 2}} = 82$) of in-class and online students, respectively, displayed an increase in their essay scores. This difference was also not found to be statistically significant with $p = 0.142$.

A final comparison was made between VT and CSM with respect to increases from pre to post essay. Approximately 77% of VT ($n = 292$) students and approximately 95% of CSM ($n = 38$) students increased their scores from pre to post essay. Using a chi-square, this resulted in a $p = 0.012$. There was a statistically significant difference between the percentages of students that displayed an increase between the two schools. When only in-class students are considered, 88% and 95% of VT ($n = 93$) and CSM ($n = 38$) students, respectively displayed an increase. This could not be statistically compared, because the expected values at CSM for some cells were less than five. However, the descriptive statistics indicate that a portion of the identified difference between the two schools may be accounted for based on the version on the course.

Self-report survey

Statements one through five, which are displayed in Table 2 on the self-report survey, were administered to both online and in-class students. Question six was also administered to both groups. The remaining statements/questions (seven, eight and nine) were administered only to the online students. The two open-ended questions were administered to all students. Table 7 summarizes the results, separated according to the online and in-class versions for statements one through five. Based on these descriptives, there appears to be little difference between the evaluation of online and in-class students with respect to this course. For each statement, a chi-square analysis was completed to determine whether the percentage of students who agreed with a given statement was the same for the online and in-class versions. For question six, a similar analysis was completed for the respective response categories. The assumptions of the chi-square analysis were verified before the analysis was completed and details of the results of the verification process can be found in Parkhurst [16]. No statistically significant difference was found for any of the statements/questions. The results of this analysis are summarized in Table 8. As this table

Table 7. Responses to survey statements 1–5

Question number	Version	Agree	Disagree
1	In-class ($n = 170$)	92.4%	7.6%
	Online ($n = 229$)	95.2%	4.8%
2	In-class ($n = 171$)	94.2%	5.8%
	Online ($n = 229$)	95.6%	4.4%
3	In-class ($n = 151$)	93.4%	6.6%
	Online ($n = 230$)	92.1%	7.9%
4	In-class ($n = 149$)	83.2%	16.8%
	In-class ($n = 229$)	80.3%	19.7%
5	In-Class ($n = 169$)	90.0%	10.0%
	In-class ($n = 229$)	93.6%	7.4%

Table 8. Chi-square summary, survey statements/questions 1–6

Questions	Chi-squared value	*p*-value
1	1.396	0.237
2	0.452	0.501
3	1.412	0.235
4	0.493	0.482
5	0.865	0.352
6	0.622	0.430

Table 9. Summary of responses to survey statements 7 and 8 (online)

Question number	Agree	Disagree
7 (n = 229)	79.9%	20.1%
8 (n = 229)	52.4%	47.6%

indicates, there were no significant findings with respect to the percentage of students' responses that fell within the different response categories in the online and in-class courses.

Statements seven, eight and nine were only administered to online students. The responses to the first two of these statements are summarized in Table 9. As this table indicates, the majority of online students positively evaluated their online instructional experience. The final statement, nine, asked the students whether they preferred a CD format for lectures or an online format. The majority of students (n = 222, 68%) preferred the online version.

In response to the two open-ended questions, students who completed the in-class version frequently commented on the benefits of small group and classroom discussions. One student explained their experiences as follows, 'I liked this class because I didn't just feel like an anonymous person being lectured to, but had an opportunity to participate.' Many of these students further stated that, when available, the online discussion board was of little use. Students in the classroom version also commented on the benefits of visiting lecturers who had worked in the various countries that were under investigation; this type of special classroom event was not possible in the online version of the course. In contrast, the online students credited their learning to the readings and the viewing of the video taped lectures.

DISCUSSION

Based on the results of the ANCOVA's completed on the post test scores with pre test as the covariate, it can be concluded that neither instructors nor course version had a statistically significant impact on students' performances on the post test. In other words, no difference was found in student performances between those that completed the online and the classroom based versions of the course. This is a positive finding in that both versions of Engineering Cultures, regardless of instructor, supported the attainment of the learning outcomes as measured through the multiple choice instrument. A similar result did not occur with respect to the pre and post essay exam. Based on the chi-square analyses, it appears that in-class students were more likely to increase their rubric score from pre to post essay than were online students. A statistically significant difference was also found among the different instructors and schools when comparing the percentage of students who increased their score from pre to post essay. However, once the online courses were removed from the analysis, the descriptive statistics indicated that the performance gap narrowed between teachers and schools. This supports that it is the nature of the online course that is contributing to the witnessed differences in student increases rather than the impact of having a given instructor or attending a given institution.

The results of this study indicate that both versions of the course were successful in supporting students' growth in factual knowledge as measured by the pre and post test (the lowest level of Bloom's Taxonomy). However, responding to the essay required the higher order skills of analysis and synthesis (the fourth and fifth level of Bloom's Taxonomy). The online version of Engineering Cultures was not as successful in supporting students' advancements with respect to these learning outcomes. One conclusion that can be drawn is that video taped lectures and online discussions are not as effective in promoting the higher order skills of analysis and synthesis as are classroom based lectures and discussions. Support for this conclusion is provided through the students' responses to the open-ended questions on the self-report survey.

Another interesting result of this investigation is that there were no statistically significant differences between the online and in-class students' responses to the first five statements on the self-report survey. In response to the sixth question, there was no significant difference in the proportion of students that would recommend the online or in-class version to a friend. The final three statements/questions on the survey were administered only to online students and the majority of students' responses indicated positive support for the online version of the course. Based on these responses and the students' responses to the open-ended questions, there is no evidence to support that the students perceived learning differences between the two versions of the course. Yet, measurable learning differences did exist. This inconsistency between the students' self-reports and the statistical results highlight a general concern with respect to studies that rely solely on self-report. Students are not unbiased judges of their own learning. In this study, the majority of online students indicated that they learned more in

the online version than they believe they would have learned in a classroom based version; the statistical evidence indicates that the reverse is more likely to be true. Reliance solely on self-report in this investigation would have rendered very different interpretations and would have resulted in invalid conclusions.

In response to the first research question, there was no measurable difference between students' factual knowledge gains between the online and in-class versions of Engineering Cultures. There were, however, measurable differences in students' abilities to analyze and synthesize information as was measured by the pre and post essay and scoring rubric. Furthermore, students completing the two courses displayed little difference in their level of course satisfaction.

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APPENDIX

* Indicates correct answer.

1. In France, engineering constitutes an occupation with
   - A. a status roughly equal to artisan workers
   - B. a status below doctors and lawyers
   - C. highest status for those who work in industry
   - D. highest status for those who work in government*
2. In France, engineering became linked to the state for the purpose of
   - A. bringing society in line with nature*
   - B assuring uniformity of thought
   - C. to protect engineering secrets
   - D. revealing the genius of the French people
3. After the 18th century, engineering education in France increasingly became a system
   - A. Revealing natural merit by objective measures
   - B. With mathematics at its center
   - C. Applying rational mechanics to analysis
   - D. All of the above*

4. How is progress understood in German culture?
   A. as an emphasis on ever-increasing standard of living
   B. as a focus on the individual
   C. as the emancipation of the human spirit*
   D. as a system where Germans earn more vacation than Americans
5. Under the 2nd Reich _____ became the source of progress and the key vehicle for achieving a unified nation.
   A. education
   B. industry*
   C. agriculture
   D. mathematics
6. Corporations in Japan often _____ .
   A. compete
   B. collaborate*
   C. merge
   D. go bankrupt
7. In the 1980's, the American view of international relations shifted from images of military struggle to economic competition. This shift was connected to a growing fear of what nation?
   A. Canada
   B. Soviet Union
   C. China
   D. Japan*
8. People who believe that their own culture is superior to all others can be characterized as _____ .
   A. media-driven
   B. multicultural
   C. ethnocentric*
   D. congenial
9. The dominant image of competitiveness in the United States is based on _____ .
   A. the family
   B. individualism*
   C. teamwork
   D. good vs. evil
10. The majority of engineering schools in the U.S. have established _____ designed to improve the levels of recruitment and retention of minority and women students.
   A. technology initiatives
   B. relaxed graduation requirements
   C. new research facilities
   D. minority engineering programs*
11. The Morrill Land Grant Act of 1862 was described as "An Act Donating Public Lands to the several States and Territories which may provide Colleges for the Benefit of _____ and _____ Arts."
   A. Literary, Mathematical
   B. Scientific, Dramatic
   C. Technical, Non-Technical
   D. Agriculture, Mechanic*
12. The United States viewed the Soviet launch of Sputnik as an achievement of _____ .
   A. engineering
   B. capitalism
   C. science*
   D. consumerism
13. What concept describes the dominant image of British engineering?
   A. Theory
   B. Quality
   C. Craftsmanship*
   D. Cost
14. What historical event introduced the concept of "merit" into French engineering and education?
   A. The Enlightenment
   B. D-Day
   C. French Revolution*
   D. The Crowning of Louis XIV
15. Which of the following cultural "elements" does not represent the German emphasis on quality?
   A. 18th and 19th Century Classical Music
   B. The Ultimate Driving Machine (BMW)

C. National Socialism (Nazism)
D. Subsistence Agriculture*

16. Which of the following is generally considered a success of the former Soviet Union?
    A. collectivization of agriculture
    B. rapid industrialization*
    C. comprehensive environmental protection
    D. unification of peasants and workers
17. Which of the following is NOT a way that westernization is changing Japanese culture?
    A. Generational tension
    B. Changes in industry
    C. Greater focus on the individual
    D. Rejection of all Western products by the Japanese Government*
18. Which of the following would NOT be found in a Japanese engineering office?
    A. Cubicles*
    B. Uniforms
    C. Exercise music
    D. Large open work space
19. Match the economic/political philosophy with the attribute that best describes it (correct answers indicated here by common prefix).

C. Communism	A. Laissez-faire economics
B. Socialism	B. State-run economy
D. Anarchism	C. Party-run economy
A. Capitalism	D. Decentralization of power and control

20. Place the following Russian/Soviet governments in order from least recent to most recent (correct order indicated by numbering).
    4. Stalinist USSR
    3. Leninist USSR
    2. Provisional Government
    1. Tsarist Russia
21. In U.S. companies, engineers working in manufacturing typically have a higher status than those working in design.
    A. True
    B. False*
22. The Communist Party became weaker under Stalin.
    A. True
    B. False*
23. How did British engineers traditionally learn to be engineers?
    A. At traditional universities like Oxford and Cambridge
    B. At apprenticeships supervised by mechanics and engineers*
    C. At middle school taught by engineering faculty
    D. In factories as salaried employees
24. In what area of government did 19th century British engineers have a strong role?
    A. Executive branch
    B. Military endeavors
    C. Colonial projects*
    D. Local construction
25. Where do British students train today to become engineers?
    A. On the shop floor
    B. at Oxford
    C. at Cambridge
    D. at polytechnics*