AC 2011-1588: EMBEDDING LIFELONG LEARNING SKILLS INTO A FIRST-YEAR ENGINEERING COURSE THROUGH INTRODUCTION OF AN INDEPENDENT RESEARCH PROJECT AND INFORMATION LITERACY SKILLS

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Embedding Lifelong Learning Skills into a First-Year Engineering Course through Introduction of an Independent Research Project and Information Literacy Skills

1. Introduction

The ABET, Inc. (ABET) criteria for accrediting engineering programs requires that a program have documented evidence that engineering graduates demonstrate a recognition of the need for, and the ability to engage in lifelong learning, identified as program outcome 'i'.[1] As with all of the program outcomes, ABET does not define lifelong learning or provide guidelines for assessing achievement of lifelong learning skills. Besterfield-Sacre et al.[2] identified key attributes of lifelong learning as part of an NSF-funded Action Agenda study (listed on the Engineering Education Assessment Methodologies and Curricula Innovation website[3]). These attributes included the ability to:

- demonstrate reading, writing, listening, and speaking skills;
- demonstrate an awareness of what needs to be learned;
- follow a learning plan;
- identify, retrieve, and organize information;
- understand and remember new information;
- demonstrate critical thinking skills; and,
- reflect on one's own understanding.

When introducing lifelong learning skills into the engineering curriculum at Grand Valley State University, there were multiple considerations. How should lifelong learning skills be defined by this program? What courses and assignments already embody these concepts and skills in some way, implicitly or explicitly? What existing programs, courses, or assignments could be revised or augmented to introduce lifelong learning skills more explicitly and measurably? At what point in the curriculum should lifelong learning skills be introduced, and how often?

This paper reports on a work in progress where ABET program outcome 'i' is introduced in a first-year course through the use of an independent research project, focusing on the ability to seek out and effectively use information, and demonstration of information literacy skills. The effort is a collaboration between the faculty in the School of Engineering and the University Libraries.

2. Background

Institution and programs. The efforts described in this paper are part of a required, first-year course in the Bachelor of Science in Engineering programs (approximately 650 total undergraduate engineering students) at Grand Valley State University (GVSU), a large Master's-granting university in Grand Rapids, Michigan. The School of Engineering (SOE) offers degrees in five engineering programs, including computer, electrical, interdisciplinary, mechanical, and product design and manufacturing engineering. The engineering degree programs share a relatively common curriculum for the first two years, during which the students are designated as pre-engineering and take six engineering courses that are common to all programs. All engineering programs require secondary admission after completing the first two years of the curriculum, and require both a cooperative education experience incorporated throughout the upper-division of the degree program and an interdisciplinary senior capstone design project.

The mission of the School of Engineering, and the faculty within the engineering programs at GVSU, is centered on excellent engineering education. Tenured and tenure-track faculty teach at the first-year level, including the course that is the focus of this study. There are no graduate students teaching in the undergraduate program. Also, the class size for lecture and laboratory sections are intentionally kept small, even during the first-year, in order to be consistent with the mission of the School. Laboratory sections are geared to be between ten and fifteen students.

Lifelong learning in the curriculum. A rubric was developed to assess students on the demonstration of knowledge and awareness of lifelong learning, of application of skills consistent with, and of behavior associated with someone who is a lifelong learner. Performance indicators constituting evidence that lifelong learning is occurring included:

- recognition of the need for further education and self-improvement;
- recognition of the necessity of continuing professional development as a requirement for maintaining professional registration;
- recognition of the value of membership in an appropriate professional organization;
- participation and assumption of leadership roles in professional and technical societies available to the student body;
- engagement in professional/personal development activities (professional organizations, conferences, workshops, training, licensure, publishing work, etc.);
- demonstration of an ability to understand, interpret, and apply learned materials and concepts in a format different from that taught in class;
- demonstration of the ability to find, evaluate, and use information obtained through independent research to solve problems or complete tasks/assignments;
- demonstration of the ability to seek information from a variety of sources and show discernment in the use of information; and
- demonstration of the ability to complete a task or project without guidance.

Introduction, emphasis, and reinforcement of lifelong learning skills and abilities is mapped across the curriculum, beginning with the first year and culminating with the senior capstone project. The lifelong learning concept is initially introduced and assessed in the first year in a required measurements and data analysis course. Lifelong learning is reinforced and assessed in the second year in a material science course and a cooperative education preparation course. During the third and fourth years, assessment occurs during a required cooperative education program. Finally, during the fourth year, this concept is emphasized and assessed in the senior capstone project. From the first year to the fourth year, the concept is developed using scaffolding processes developed from the works of Vygotsky[4] and self-determination theory[5] through use of self-selected projects and problem-based learning (as discussed in Svinicki[6]). Overall, this approach to assessment at the program curriculum level is largely in concert with the principles outlined by Culver, McGrann, and Lehmann[7] in their discussion of preparing engineering students for ABET criteria a-k.

Engineering Measurement and Data Analysis course (EGR 220). The focus of the effort reported on in this paper is a required, first-year course that is common to all of GVSU's undergraduate engineering degree programs. The Engineering Measurement and Data Analysis (EGR 220) course is a 1-credit, laboratory-based course. It complements a co-required, 2-credit, lecture-based course, Statistical Modeling for Engineers (STA 220). The Engineering Measurement and Data Analysis course is taught by SOE faculty while the Statistical Modeling for Engineers course is taught by faculty from the Statistics Department, housed in the College of Liberal Arts and Sciences. Statistical concepts and theory are introduced and assessed in the lecture-based modeling course. The measurement and data analysis lab introduces basic engineering and science concepts, and conducts associated tests and experiments for the purposes of taking measurements for data collection. Students demonstrate understanding of statistical concepts and theory by applying that knowledge to make meaning of the data obtained from the tests and experiments. Weekly work products include written laboratory reports. Students also make two oral presentations in the course, including one that is the focus of this study, a 5-7 minute presentation at the end of the course on an independent research effort related to the course content.

From the course syllabus, the objectives of EGR 220 indicate that the student should be able to:

- demonstrate a basic understanding and skills in using concepts, methods, and techniques for making common measurements needed in engineering;
- demonstrate a basic understanding of conducting engineering experiments;
- manage and describe graphically, and with appropriate summary statistics, data obtained in scientific and engineering contexts;
- develop an appropriate statistical model for data obtained in scientific and engineering contexts;
- interpret statistical analysis for data obtained in scientific and engineering contexts;
- write technical reports of various forms to communicate information obtained from scientific and engineering experiments; and,
- prepare and give technical oral presentations.

The statistical and data analysis content of EGR 220 includes descriptive statistics, graphical representation of the data and data summarization, introduction to probability, distributions, inferential statistics including creation of confidence intervals and use of hypothesis tests, introduction to statistical process control, gage reproducibility and repeatability analysis, and propagation of uncertainty in calculations using measurements. Engineering concepts that are introduced to apply the statistical and data analysis concepts range from analyzing basic circuits to investigating engineering stress and strain. Tests and experiments are conducted that introduce the student to instruments and tools such as calipers, micrometers, digital multi-meters, mass balances, and tensile testers. As with the other foundation courses in the first two years of the curriculum, pre-engineering students from all five degree programs are co-mingled in the course.

The EGR 220 course has some challenges because a number of foundational concepts are introduced in this course including data analysis/statistics applied to engineering concepts, engineering measurements and proper data reporting, conducting engineering tests and developing testing procedures, technical writing, and formal presentations. This is presented within the constraints of a 1-credit, laboratory-based course that meets once per week. Depth of coverage of all topics is sacrificed for the goal of using introductory experiences to provide a foundation for subsequent courses in the curriculum.

Introduction to lifelong learning in EGR 220. The performance criteria used for assessment of ABET program outcome ‘i’, that BSE graduates recognize the need for, and have an ability to engage in, lifelong learning, has been mapped in EGR 220 to three outcome indicators: 1) ability to independently define an area of information need, 2) ability to use effective strategies to search in appropriate sources, and 3) ability to evaluate material found for the information relevant to their need. School of Engineering faculty recognized that in significant respects certain skills encompassed by this interpretation of the ability to engage in lifelong learning are not unique or particular to engineering as a discipline, but are central to information literacy (IL) skills instruction offered by the University Libraries (hereafter may be referred to as the Library). This view is supported and expanded upon by Oxnam[8]. The basis for a collaboration was recognized in this intersection of ABET accreditation criteria and information literacy competencies taught by the Library across the curriculum, and the Engineering Liaison Librarian was invited into conversation with the EGR 220 Coordinator.

The timing of the collaborative discussions between the School of Engineering and the Library was fortuitous. The SOE wished to experiment with introduction of an explicit information literacy component into EGR 220, Measurment and Data Analysis, in the second semester of 2009-10. The Library had recently developed and adopted a document intended for use by both library faculty and teaching faculty, “Information Literacy Core Competencies”, the “ILCC” document. The intent in developing the ILCC was to adapt and mold the “Information Literacy Competency Standards for Higher Education” adopted by the Association for College and Research Libraries (ACRL) in 2000[9] into a document tailored to the local environment. The ILCC is a scaffolded framework of skills goals and learning objectives that are not discipline-specific, that are generally reflective of elements of the institution and its particular mission and values, and that can be selected from for incorporation into assignments, courses, and curricular programs explicitly and measurably[10]. For each of six Skills Goals areas, Learning Objectives are defined at three levels: General Education and Basic Skills Courses, Major Program, and Graduate Programs. A clear path lay for defining IL instruction associated with a target assignment in EGR 220 to include selected ILCC skills goals and Basic-level learning objectives that matched with desired lifelong learning skills interpreted to fulfill ABET program outcome ‘i’. ABET program outcomes relating to professional responsibility and ethics (‘f’) and effective communication (‘g’) could also be part of this intersection between the School of Engineering’s program accreditation needs and the Library’s newly refreshed information literacy focus.

3. Literature Review

ABET criteria recognize and promote the awareness that engineering professionals must be able communicators, both verbally and in writing, and that lifelong learning skills in conjunction with good communication skills are necessary to function effectively in a complex and competitive work environment. A certain amount of study has been devoted over the years in regard to how, how well, when (or if), and from whom engineering students learn these skills.

Lifelong learning and information literacy. Culver, McGrann, and Lehmann[7] provide an excellent overview of the goals of the ABET a-k criteria in relation to the real challenges facing students and academic institutions: academic institutions must matriculate not-yet-fully-mature adolescents, and in the course of a 4- or 5-year curriculum, foster growth in their knowledge, skills, and attitudes, ideally graduating students who are prepared to progress successfully into professional work or graduate studies. These authors give particular attention to lifelong learning and "soft" skills which have not historically been the explicit goal of engineering education. Oxnam[8] provides a detailed look at the intersection of ABET engineering program evaluation criteria and essential IL skills endorsed by the Association of College and Research Libraries (ACRL) and the American Association for Higher Education (AAHE). She concludes that substantial correlation exists between the two, and that the challenge lies in achieving integration of IL skills into existing curricula, courses, and assignments so as not to further expand students' load of courses and requirements. Tyron, Frigo, and O'Kelly[11] describe the development of a scaffolded set of IL competencies tailored to Grand Valley State University, and the expectation that the competencies will be further tailored as appropriate within each academic department to suit the needs of the discipline and the local curriculum. Designing competency-based curriculum-integrated instruction strategically into a program is ideal according to Nerz and Weiner[12] in a 2001 ASEE Conference "Best Paper." While IL instruction may often only rise to the level of course-integrated instruction which falls short of its goal, nonetheless, the authors conclude that collaboration between teaching faculty and librarians, and critical evaluation of students' information competencies, can lead to successful IL integration into existing course requirements without requiring major shifts in the established curriculum.

Faculty-librarian collaboration for information literacy. Collaboration between librarians and teaching faculty has been proposed and explored in the literature for several decades; Black, Crest, and Volland[13] summarize much of it, and describe development of their own model at Towson University for fostering librarian-faculty collaboration to build an IL infrastructure across the university's curriculum (engineering and sciences are not specifically addressed). Investigations by Leckie and Fullerton[14] in the late 1990s explored faculty attitudes and practices in regard to science and engineering IL instruction, and concluded (in part) that information literacy is critical for college students, and must be tailored within disciplines and strongly course-related to be meaningful and effective. The authors identify librarians as obvious potential collaborators, warning that they must be flexible in regard to a range of pedagogical preferences and approaches among engineering faculty; and a balance should be sought between classroom IL instruction and fostering user self-sufficiency and self-directed learning through development of help screens, pathfinders, etc. Deardon, et al.[15] further discuss relationship-building and the exploration of shared and complementary teaching and learning interests with teaching faculty as revealed by a survey carried out in the Faculty of Science, Engineering, and Technology at the University of Tasmania.

Information literacy instruction and engineering students. Curl[16] outlines a model for IL instruction that gives a nod to Krishna Subramanyam's circular model of scientific and technical literature production and consumption from the 1970s, and adapts it to the realities of engineering students' curricular and future professional needs. The goal of IL instruction for engineering students must be, in her view, the production of information-savvy professionals, rather than "little librarians" (p. 459), and that the circular production/consumption model "embeds the scientific and technical literature firmly in the community that produces it" (p. 463). Palmer and Tucker[17] describe a project to design and integrate a semester-long sequence of activities into a first-year engineering and technology course, targeted for the first semester as a part of transitioning students into university-level study; they discuss assessment of their initial results. The University of Pittsburgh has made a considerable investment in IL skills integration into their Freshman Engineering Program, through collaboration among engineering faculty, engineering librarians, and advising services, as reported by Callison, Budny, and Thomes[18]. During two semesters, students are lead through a variety of researching and writing exercises, culminating in the second semester in submission to, and presentation at, a university conference; students experience every phase of the production of a professionally researched, prepared, and presented paper. Williamson[19] probes the issue of personality and vocational typologies in relation to IL instruction for engineering students, and makes suggestions to librarians about approaching instruction planning; she stresses logic, objectivity, hands-on opportunities, and appealing both to "engineers' practical, competitive natures and their intellectual interests" (p. 15). Reflecting Williamson's conclusions, Hsieh and Knight[20] explore the choice of instruction styles in a comparison of lecture-based learning and problem-based learning (PBL) in IL instruction for first-year engineering students, and conclude that problem-based learning leads to better outcomes among engineering students. They note also that because PBL is a less structured instructional method than lecture-based, it is generally wise to include additional time for immediate reflection and synthesis during sessions, instead of postponing that process until after the session.

4. Methodology

Assignment overview. Students in EGR 220 are assigned a final project and presentation that is intended to provide them with an opportunity to demonstrate understanding and mastery of the course objectives by applying knowledge obtained to a topic of interest to each student. Students are expected to deliver presentations on their topics from a perspective of teaching the topic to classmates. The objectives of the final project are:

- To demonstrate an understanding of several (more than two) concepts investigated throughout the course of the semester;
- To demonstrate the ability to connect concepts investigated throughout the semester to students' contemporary interests in engineering;
- To demonstrate the ability to find, evaluate, and use information obtained through independent research to complete tasks/assignments (from the perspective of demonstrating skills needed for life-long learning); and,
- To demonstrate good oral presentation techniques on a technical topic.

Students are asked to select a topic that makes the assignment personally interesting to investigate and exciting to present to others. Ultimately, the assignment should advance the students' understanding of their topics, along with the understanding of those who are hearing the presentation. The scope of topics that can be proposed is purposely open-ended to allow freedom in selection of what to present. Students may conduct their own tests, or may locate and use existing data sets. Obtaining and analyzing existing data found through research is required if data is not obtained through conducting their own tests. In either case, students are expected to research background information for their topics and provide documentation in the presentation (in the form of a 'References' slide at the end of their presentation slides) to support the content. Finally, students are required to use inferential statistics as part of the data analysis during the presentation.

Presentations are individual assignments and are targeted to be 5-7 minutes in length. An overview and discussion of how to effectively give a technical presentation are provided by the instructor in class in advance of the student presentations. A grading rubric for assessing the presentation (see Appendix A) is provided to the students in advance so that expectations for success are clearly understood.

The Engineering Liaison Librarian conducts an IL workshop at a time prior prior to the students' presentations. Ideally, in conjunction with the workshop the final presentation assignment is formally announced to the students. Following the workshop, students are given an assignment to prepare a 1-2 page description of their proposed final presentations, including:

- the specific topic of the presentation and clearly defined problem statement
- a clearly defined data set that will be used to discuss the topic
- a clearly stated means of presenting data used (e.g. tables, table contents, etc.)
- a description of the three primary means that will be used in analyzing the data
- 2-3 primary 'take-aways' for the audience
- identification of 2-3 primary resources that will be used to obtain and/or support the data/information

In addition, students are required to submit an outline of the presentation including proposed slide titles, slide order, and content.

Instructional approach for IL. The first iteration of this collaboration occurred in the second semester of 2009-10 (winter 2010). Eight sections of Measurement and Data Analysis totaled approximately 80 students. Rather than re-assign scarce class time in this one-credit course to in-class IL sessions (and eight repetitions of the same lesson plan for the librarian), it was decided to schedule five 60-minute workshops at various days and times during a two-week period, and require students in all sections to choose and attend a workshop session. The librarian prepared a lesson plan based on selected ILCC learning objectives specifically as they related to the assignment to gather and analyze a data set, and to prepare and deliver a 5-7 minute oral presentation with projected slides. The workshops were scheduled for 2-3 weeks prior to formal announcement of the assignment to the students (although the assignment had been mentioned in most sections in reviewing the syllabus for the semester). The students' presentations were delivered during the final regular class session of the term for each section. As there was no final exam planned for the course, and no subsequent meetings of the class sections, students were given time at the beginning of the presentations class session to complete electronic course evaluations and separate IL workshop evaluations.

The workshop evaluation asked students to indicate whether they had been able to select a workshop session that fit their schedule, whether they felt that the length and level of content was suitable, comments on strengths and weaknesses of the workshop, recommendations for improvement (both in general and specifically in relation to their presentation assignment), and concluded with a prompt to indicate the extent to which they believed that information literacy skills such as those presented in the workshop would be important to them in the course of their college education, and in their future professional lives. Approximately 60% of students submitted workshop evaluations. The librarian attended presentations in four of the eight sections and observed 51 students presenting. Student evaluation responses and the instructor and librarian observations were used to consider changes and revisions for the next iteration of this effort.

Changes for the second iteration of the course in the fall 2010 semester were driven by student, instructor, and librarian input from the preceding winter semester. Adjustments focused on better integration of the IL content and the target assignment with one another. Logistically, we decided that with only four sections and two instructors in the fall semester (and a total of 35 students), we would try using 60 minutes of a class (i.e. 3-hour lab) session in each section for the IL instruction. The formal introduction of the assignment was made by the instructor in the same class session as the IL instruction was given. The IL instruction was somewhat re-focused to more specifically highlight engineering-related resources and to avoid redundancy with Basic-level instruction many students may have already encountered in non-engineering courses (in particular a required first-year Writing Department course). In the first iteration, a specific need had been identified to help students successfully locate sources of data sets they could analyze using the statistical skills they were learning in the co-required lecture-based statistics course. To meet this need, sources of statistics were discussed in the lesson, and links were provided in the online LibGuide (library guide or pathfinder) for First-Year Engineering[21].

In the second iteration (fall 2010) we made our first attempt to gauge learning not only by application of the assignment rubric used by the section instructors while observing the final presentations, but also by using a pre-test and post-test. These short 10-item tests were revised for local use from Hsieh and Knight [20]; the post-test also re-iterated the prompt from the winter 2010 workshop evaluation to indicate the extent to which students believed that information literacy skills such as those presented in the workshop would be important to them in the course of their college education, and in their future professional lives. The pre-test was taken by each student at the beginning of the class session in which the IL instruction took place, electronically via the university's course management system, Blackboard. The post-test was administered through Blackboard as well, and was taken by students at the beginning of the class session in which they were making their presentations. Thus, there was a three-week interval between receiving instruction and taking the post-test, during which students were expected to be applying concepts and techniques covered in the IL instruction in the process of carrying out their research and preparing their presentations.

In both winter 2010 and fall 2010 lesson plans were built predominantly around three of the GVSU ILCC competencies[10], with specific emphasis and examples related to requirements and expectations of the final presentation assignment:

- Skills Goal III. Evaluate Sources / Learning Objective: Know the difference between scholarly and other types of resources. *Emphasis on trade journals in addition to scholarly journals vs. popular magazines.*
- Skills Goal V. Use Information Ethically / Learning Objective: Cite sources appropriately. *Emphasis on giving credit, increasing presenter credibility, and on including credits for borrowed images as well as citations and references for borrowed text.*
- Skills Goal VI. Develop Subject Knowledge / Learning Objective: Be aware of subject-specific resources (e.g., subject guides, subject specific databases, liaison librarians, etc.). *Emphasis on Summon search engine, Knovel database, Engineering LibGuides.*

Instruction was lecture-based, largely in order to accommodate delivery of a large amount of information in a limited amount of time, 50-60 minutes. Instruction took place in a computer lab, and students were able to follow along at their own stations. The librarian used a combination of prepared slides and live demonstration projected at the front of the room, and students were called on by the librarian throughout the session to respond to questions. The pre- and post-tests were broad general indicators of basic IL knowledge and skills; four of the ten questions could be associated with the three ILCC learning objectives that the IL sessions emphasized.

5. Results and Discussion

Review of project presentations. The project presentations under the current format were first conducted during the winter 2010 semester (January-April). Eight course sections were taught by six different faculty instructors, with a beginning enrollment of 91 students. The average score for presentations was 84.6 (median of 86.0) with a standard deviation of 13.2 using the grading rubric in Appendix A. Broad topic areas included arms and ammunition, automotive, aviation, electronics, energy, environment, manufacturing, modeling, physiology, robotics, sports, and testing and materials. Examples of presentation titles were:

> "An investigation into tire pressure: The effects, the danger, and the facts"
> "Stress and strain: Ansys vs. Instron"
> "Poisson model and probabilities"
> "True randomness: An analysis of potential biases in random number generators"
> "Flight of a balsa wood plane"
> "Do swimming pools cause differences in swim times?"

Approximately 50% of students conducted their own experiments, while the other 50% obtained external data through research for the data analysis components of the project. Over one half of the presentations included a final references slide. Of those that did not include a reference slide, some did not include images or textual/factual content requiring citation, particularly for those who conducted their own experiments. The number of references cited ranged from one to ten, with four references being the mode and three references being the median. Approximately 50% of those providing references used formatting that was consistent with a style guide (i.e. APA, MLA, etc.), while the other 50% followed no particular standard, or simply resorted to providing a list of internet URLs with no textual content to inform the reader. Also, there were few uses of internal references or image credits on the slides for the presentations.

An evaluation of the IL workshops was completed by 51 (56%) of the students in the course. The most important feedback obtained from the evaluation was that the workshop could be more effectively coordinated with the presentation assignment. First, there could be more collaborative preparation of both the assignment and the workshop so as to mesh objectives and learning outcomes with an appropriate and effective learning experience in the workshop. Second, the workshop sessions should occur at a point in the semester when students have already received the presentation assignment (in winter 2010, the IL workshops preceded the submission of proposed problem statements and presentation outlines). Student responses indicated that the workshop content could be informed and improved both by better tailoring the content to the course and assignment and by improving the instructor's (librarian's) approach to delivering the content. It was determined that more opportunity for students to do hands-on exploration and active learning, at the likely cost of imparting less content in a lecture format, would be appropriate for a delivery design change. Respondents nearly unanimously agreed that the kinds of skills covered in the workshop were going to be of moderate importance or very important both in their academic careers and in their future professional careers, irrespective of their level of satisfaction with the workshop experience.

The second offering of the course occurred in fall 2010 (September-December), with four course sections taught by two faculty instructors (just one instructor, the coordinator and co-author, in common with the winter 2010 sections of the course), and with 39 students initially (35 completed the course). The average score for the independent project presentation was 88.7 (median 91.0) with a standard deviation of 7.1. Broad topic areas included arms and ammunition, automotive, aviation, computation, electronics, health and medicine, manufacturing, packaging, sports, and testing and materials. Examples of presentation topics included:

"Shot size of shotgun ammunition"
"Most effective method to count brass forgings and fittings for customer shipping from manufacturing companies"
"Internet speed data analysis"
"Putting statistics at the Masters"
"Comparison of speeds of transmission of text messages"
"Effects of temperature on bounce height of bouncy balls"

Approximately 69% of students conducted their own experiments, while the other 31% obtained external data through research for the data analysis components of the project. There was a 38% increase in students conducting their own experiments over the previous semester. This was presumably due to instructors encouraging this option, and will be a requirement for the next offering of the course (winter 2011). Having students conduct their own experiments is more aligned with the goals of the course, and also helps students begin to develop skills in experimental/test design (a component of ABET program outcome 'b'). Students will be required to submit a test plan/procedure for the data collection component of the project to supplement the final presentation.

Over one half (57%) of the presentations did not include a final reference slide. This was a 14% decrease in the number of students providing references. This was likely due to two factors: 1) the increase in student-led experimental studies and a continued disconnect with the need for corroborating, researched background information in this situation, and 2) less buy-in to this effort by the other faculty member teaching the course this semester, and thus less emphasis on the lifelong learning component when communicating with students. The number of references cited ranged from one to five, with two references being the mode and the median. Eighty percent of those providing references used formatting that was consistent with a style guide (i.e. APA, MLA, etc.), while the other 20% followed no particular standard, or simply resorted to providing a list of internet URLs with no textual content to inform the reader. One student used internal references and image credits on the slides for the presentations.

Assessment for lifelong learning. A rubric was developed to specifically assess demonstration of lifelong learning skills as represented by demonstration of the ability to independently find, evaluate and use information to effectively complete an assignment. The elements that were rated included:

- ability to effectively conduct internet or library searches;
- ability to find, evaluate and use information independently; and,
- ability to apply course concepts in an independent manner.

The lifelong learning rubric is included as Appendix B. The rubric used a four-point scale, with one point representing no ability demonstrated and four points representing strong ability demonstrated. In winter 2010, a sample of 28 student presentations was assessed using the lifelong learning rubric. The average overall score was 2.98 (out of 4.00) with a standard deviation of 0.57. Students were able to successfully apply course concepts to their research (average score of 3.29). However, the abilities to conduct internet or library searches (average score of 2.82) and to find, evaluate and use information independently (average score of 2.82) were not demonstrated as strongly.

In fall 2010, a sample of 10 student presentations was assessed using the lifelong learning rubric. The average overall score was 2.50 (out of 4.00) with a standard deviation of 0.48. Students again were able to fairly successfully apply course concepts to their research (average score of 3.10), but the ability to conduct internet or library searches (average score of 2.20) and the ability to find, evaluate and use information independently (average score of 2.20) again were not demonstrated as strongly. In fact, scores in these latter areas were significantly lower than those for the prior semester assessment. This was likely a direct result of more students performing tests to obtain their own data and not connecting the importance of corroboration of information in the form of valid references. This is a key modification that will be made with the next iteration of improving the assignment and course to meet this program outcome

Pre-test and post-test results. In the second iteration of this collaborative effort, in fall 2010, a pre-test (Appendix C) and post-test (Appendix D) were administered to all students in the course (~35) for assessment of learning in relation to the IL workshop. Each test consisted of ten questions. Questions on the pre-test and post-test were pairs linked by content or subject matter, and were modeled after the tests used by Hsieh and Knight[20]. The pre- and post-test questions reflected a range of basic IL concepts and skills, in the areas of defining a topic, locating and gathering information, evaluating sources, awareness of the information life-cycle, and using information ethically.

The pre-test average score was 77.1% with a standard deviation of 10.7%. The question that scored the lowest (pre-4; only one student, 3.0% of all students, answered correctly) asked students to identify where to find authoritative information about an engineering process. Conversely, all (100%) of the students correctly answered the pre-test question (pre-8) regarding the importance of citing work of others used in a paper.

The post-test was given to the students just prior to delivery of their presentations, and posed higher-level, application-based questions loosely related to the IL content delivered during the workshop, and to the requirements and expectations of the presentation assignment. The average score on the post-test was 71.0% with a standard deviation of 15.3%. It was encouraging that the application-based post-test question that was mapped to the pre-test question with the lowest score (pre-4), improved from 3.0% correct response (pre-test) to 44.1% correct responses (post-test, post-2). That post-test question was still the lowest scored question, but 14 more students (40%) answered correctly after the IL workshop.

Comparing pre-test and post-test scores on the linked question pairs most directly associated with the ILCC skills goals and learning objectives, no particular pattern emerges of increase, decrease, or stability of scores (see Table 1). This could be the result of insufficiently tested contents of one or both tests, or inadequate coordination between the two tests. Since the

ILCC Skills Goal / Learning Objective	Associated Pre-Test / Post-Test Question Pairs	Pre-Test / Post-Test Scores (% correct responses)
III. Evaluate Sources / Know the difference between scholarly and other types of resources.	pre-9 / post-4 pre-10 / post-9	57.1% / 76.5% 88.6% / 50.0%
V. Use Information Ethically/ Cite sources appropriately.	pre-8 / post-5	100.0% / 52.9%
VI. Develop Subject Knowledge / Be aware of subject-specific resources (e.g., subject guides, subject specific databases, liaison librarians, etc.).	pre-4 / post-2	2.90% / 44.1%

Table 1. ILCC Skills Goals and Associated Pre-Test / Post-Test Questions

IL session content was not designed to "teach to the test," the post-test itself may be a poor measure of what students learned and retained from the IL session three weeks previously. In a future iteration we will consider developing a post-test which is more tightly aligned with the IL session lesson plan and content; this might involve revising the pre-test as well.

Student attitudes toward IL. The IL instruction evaluation (winter 2010) and the IL post-test (fall 2010) both included a pair of attitudinal statements for students to respond to:

- "In my current academic work, I believe that information literacy skills (such as the abilities to knowledgeably identify types of information, effectively locate relevant information, accurately and critically evaluate usefulness of information, and ethically use information from other sources in my own research) will be important."
- "In my future professional work, I believe that information literacy skills (such as the abilities to knowledgeably identify types of information, effectively locate relevant information, accurately and critically evaluate usefulness of information, and ethically use information from other sources in my own research) will be important."

Likert-scale response options included Very Important, Of Moderate Importance, Of Little Importance, Not At All. In winter 2010, about half of students in the course (51 of ~80) submitted the evaluation at the end of the semester; of those, 48 responded to the attitudinal prompt. A heavy majority rated IL skills in relation to their current academic work and their future professional work as "Of Moderate Importance" or "Very Important" (46 of 48). In fall 2010, all students were expected to complete the post-test in Blackboard, and all did so (33 of 33). Again, a heavy majority rated IL skills in relation to their current academic work and their future professional work as "Of Moderate Importance" or "Very Important" (31/33 and 32/33, respectively). Irrespective of their performance on pre- and post-tests, or on the lifelong learning assessment performed on a random sample of presentations, by this measure students professed a belief in the significance of possessing IL skills.

6. Conclusions and Next Steps

Our effort to build lifelong learning skills, with information literacy being one facet, into the School of Engineering undergraduate curriculum at GVSU is represented in this paper with discussion of intentional redesign of one key assignment in one required course. The School of Engineering and the GVSU Library share an awareness of the value in working toward a strategic approach to introducing growth and development processes such as acquiring lifelong learning skills and IL skills. The School of Engineering has a plan in place to foster ABET criterion 'i', development of lifelong learning skills, at multiple key points throughout the undergraduate engineering curriculum. In time we hope to do the same specifically with IL skills in the engineering curriculum, as advocated by Nerz and Weiner[12].

Meanwhile, we look ahead to further refinements we can make in the EGR 220 course. We want to find the most effective balance between drawing first year engineering students into an awareness and appreciation for information literacy skills in their present and future circumstances, while keeping the specific expectations and requirements of a 1-credit lab course within reason. We believe that at present we have a viable platform in the format of 50-60 minute IL instruction kicking off an independent research project which is the culmination of a common foundational course in the first year. Assessment results indicate that this approach has been successful for demonstrating attainment of lifelong learning skills with first-year engineering students. Areas for further adjustment include tailoring of specific IL session content, moving from lecture-based to problem-based-learning IL instruction, and local development of pre- and post-tests to more tightly integrate ILCC learning objectives with the School of Engineering's efforts to address ABET criterion 'i'.

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Appendix A

Final Presentation Rubric
EGR220 Lab - Winter 2011
Student:
Topic:

Instructor:
Lab Section:

QUALITY / CRITERIA		No Proficiency(0) / Limited Proficiency (1)	Some Proficiency (2)	Proficient (3)	High Proficiency (4)	Points Scored
Content	**Organization / Coherence**	topic not clear; presentation is choppy and disjointed; does not flow; development of topic is vague; no logical order	concept and ideas are loosely connected; lacks clear transitions; flow and organization are choppy	most information presented in logical sequence; generally very well organized but better transitions needed	topic clearly stated and developed; specific examples are appropriate; conclusion is clear; flows together well; good transitions; succinct but not choppy; well organized	
	Connection to Course Materials	no connection to topics covered in course, or incorrect use/application of course concepts	made one or two simple connections to course concepts	made two or three clear connections to course concepts	tied in several key concepts covered in course to the presentation topic	
	Subject Knowledge	student does not have grasp of information; student cannot answer questions about subject	student is uncomfortable with information and is able to answer only rudimentary questions	student is at ease with expected answers to all questions, but fails to elaborate	student demonstrates full knowledge (more than required) by answering all questions with explanations and elaboration	
	Proper Use of Independent Research	Student demonstrates no ability to find or utilize information independently; no documented sources	student seeks information from outside sources, but uses few resources and primarily non-technical sources; improper source documentation	student seeks information from multiple sources, including technical reports and papers; proper citation of sources	student seeks information from a variety of sources and shows discernment in use of information; proper citation of sources	
Format	**Structure**	no concept of appropriate presentation structure; missing more than two key components (title, intro, outline, body, conclusions, Q/A slides); too many slides	missing two key presentation components; too many slides for time	covers most of important components, but missing one important piece	effectively covers all important components of a presentation (title, intro, outline, body, conclusions, Q/A); appropriate number of slides for time	
	Style	font too small and type hard to read; multiple font size and style changes throughout; cannot read graphics; poor use of color schemes	little or no use of bulleted lists; font size too small; graphics hard to read; slide design is distracting	fairly easy to read text and graphics with one or two exceptions; appropriate slide designs	font type and size is consistent and easy to read; good use of bullets and graphics; slide design makes it easy to read	
	Use of Words/ Grammar	large blocks of text (too wordy); slides and/or handouts have four or more spelling errors and/or grammatical errors	text is fairly wordy; slides and/or handouts have three spelling errors and/or grammatical errors	minimizes amount of text for the most part; slides and/or handouts have no more than two spelling errors and/or grammatical errors	uses short, simple phrases; slides and/or handouts have no spelling errors and/or grammatical errors	
Speaking Skills	**Elocution / Voice**	inaudible or too loud; rate very slow/fast; speaker seemed uninterested and used monotone; several misuses of words/pronunciation errors	some mumbling; uneven rate; little or no expression; a few misuses of words/pronunciation errors	clear articulation but not as polished; little or no misuse of words/pronunciation errors	poised, clear articulation; proper volume; appropriate rate; enthusiasm; confidence; correct, precise pronunciation	
	Eye Contact / Body Language	no eye contact; simply reads notes/slides; physical mannerisms demonstrate nervousness and are distracting	little eye contact, mostly reading of notes/slides; fair amount of fidgeting or distracting mannerisms	good use of eye contact but still relies on notes/slides more than not; little or no fidgeting; good posture	student engages audience with good eye contact, seldom using notes/slides to speak from; good posture; no fidgeting	
	Professionalism	student not dressed appropriately; effort is minimal; not engaged in topic; not familiar with A/V; no concept of room layout	minimal effort to dress up; appears to not have practiced much; fumbles entering and exiting; stands in one spot	dressed well; fairly smooth in presentation, including set-up and exit; uses the room fairly well; mostly keeps attention of audience	dressed professionally; well-practiced; engages audience in the topic; easily sets-up and transitions; uses the layout of the room effectively	
Length		too long or too short; three minutes or more under or over the allotted time	within three minutes of allotted time	within two minutes of allotted time	within one minute of allotted time	
					Total Points:	

Rev: 1/03/11

EGR220_W11_Final_Presentation_Rubric.xls

Appendix B

EGR 220 – Engineering Measurement & Data Analysis
Winter 2011

Student Name: ____________________

Performance Indicators for Outcome (*i*)

Outcome (*i*): The student demonstrates a recognition of the need for, and ability to engage in, life-long learning.

Operational definition: The student demonstrates that he/she:

- has the ability to independently find, evaluate, and use information to effectively complete an assignment.

Outcome element	1 Below Performance Expectations	2 Progressing to Performance Criteria	3 Meets Performance Criteria	4 Exceeds Performance Criteria	Score
Internet or library searches	Demonstrates no ability to search the Internet or library resources and distinguish quality resources	Demonstrates limited ability to search the Internet or library resources and distinguish quality resources	Demonstrates an ability to search the Internet or library resources and distinguish quality resources	Demonstrates extensive ability to search the Internet or library resources and distinguish quality resources	
Ability to find, evaluate, and use information independently	Students demonstrate no ability to find or utilize information independently.	Students seek information from outside sources when necessary, but use few sources and primarily non-technical sources.	Students seek information from multiple sources, including technical reports and papers.	Students seek information from a variety of sources and show discernment in the use of information.	
Ability to apply course concepts in an independent manner	Cannot connect course content to project in a meaningful way	Makes some connection of course content to project, but makes errors in application of concepts	Connects course content to project but makes minimal or superficial meaning of the applied concepts	Connects course content to project , and makes appropriate applications with meaningful outcomes	
				AVERAGE SCORE:	

Appendix C

EGR 220 Library Skills Session Pre-test
Fall 2010
['*' = correct answer]

1. To locate books in a library you must search:
   __ Amazon.com
   __ Library Catalog
   __ IEEE Xplore database*
   __ Google.com

2. What is the best way to search for books on a given topic?
   __ Author or Title
   __ Publisher or call number
   __ ISBN
   __ Keyword or Subject*

3. When you're looking for a specific book or article that the GVSU Library doesn't own, the following is true:
   __ You have to buy it for yourself.
   __ The Library will buy it for you.
   __ You can request it through Document Delivery at no cost.*
   __ You have to do without it.

4. When looking for authoritative information about a new engineering process, it is best to begin with:
   __ Encyclopedias (print or online)*
   __ Books (print or online)
   __Journals (print or online)
   __ A Google search

5. How would you choose terms for your search?
   __Write out a few detailed sentences about your topic
   __Create a list of related keywords
   __ Brainstorm a list of synonyms for your keywords
   __ All of the above*

6. In an online database, which search “operator” below would retrieve the greatest number of records?
   __OR*
   __NOT
   __AND
   __It makes no difference

7. When using an electronic journal database for the first time, you should:
   __ Type in a subject and see what happens.
   __ Click on online help features to learn its scopes and how it works then perform a search according to the tips.*
   __Click on "Expert Search" because you are now in college.
   __Give up and use the Internet.

8. It is important to cite work of others you use in your papers to:
   __ To prove that your work has a solid, scholarly basis
   __ To show the research you have done and allow others to locate the material themselves
   __ To give credit to the author and avoid plagiarism
   __ All of the above*

9. What is the best way to find a scholarly journal article on a given topic?
   __ Page through print volumes of academic journals.
   __ Search a general Web search engine like Google or Yahoo.
   __ Search a print index or periodical database like Academic Search Premier or JSTOR.*
   __ Search the online library catalog

10. Which of the following material takes the shortest time to publish?
   __ Book (print or online)
   __ Scholarly journal (print or online)
   __ Trade journal (print or online)
   __ Internet news*

Appendix D

EGR 220 Library Skills Session Post-test
Fall 2010
[‘*’ = correct answer]

1. A student consulting a librarian says, “This summer was too hot. I wonder if it is because of global warming?” What might be the thesis statement of a paper on this topic? **(pair with pre-test question 5)**
   __ It was too hot this summer.
   __ Global warming is causing the mean temperature of the earth to rise, which could have disastrous effects on the ecology of the planet.*
   __ Did global warming cause abnormal heat around the planet?
   __ Watch out for giant squid this summer; they now take up more space than humans because of global warming.
   __This paper will be about the effects of global warming.

2. Where should you begin your search for information on global warming if you don’t really know too much about it? **(pair with pre-test question 4)**
   __ A book located through the GVSU Library online catalog.
   __ A web site found on the Internet.
   __ A journal from electronic journal database.
   __ An overview article from the *Encyclopedia of Environmental Science and Engineering*, 5th ed., copyright 2006.*

3. Your friend is searching a database for information for an Environmental Science paper on waste management. Using the search terms “waste management”, she finds more than 8500 articles. Would you advise her to: **(pair with pre-test question 6)**
   __ Use the terms "waste management" AND "environment" *
   __ Start working through all 8500 articles.
   __ Type the question, "What is waste management?"
   __ Talk to your relative, who is a garbage man.

4. Which source would have more scholarly worth for a collegiate research paper? **(pair with pre-test question 9)**
   __ *U.S. News & World Report*
   __ *Journal of Medieval History**
   __ The Knighthood, Chivalry, and Tournaments Resource Library (www.chronique.com)
   __ The movie *King Arthur*

5. Is it plagiarism to use an outline of a paper found on the web if you have the permission of the creator? __Yes* __ No **(pair with pre-test question 8)**

6. You are asked by your professor to write a paper on new energy sources using nanotechnology, which is the best way to start your search? **(pair with pre-test question 2)**
   __ Search under the professor's name to see if he/she has written any books on the topic
   __ Use "Livermore National Laboratories" as the search term since nanotechnology is one of Livermore National labs' research areas.
   __ Use "Energy" and "nanotechnology" as search terms to perform a keyword search*

7. Does the GVSU Library own the following item: **(pair with pre-test question 1)**
   Clingman, Dustin. *Practical Java Game Programming*. Hingham, Mass : Charles River Media, 2004.
   __ Yes. It is an electronic journal article.
   __ Yes. It is an electronic book.*
   __ Yes. It is a chapter of a print book.
   __ No, the library doesn't own it.

8. What is the title of Chapter 10 of *Handbook of Materials for Product Design* (C. A. Harper, editor, 2001), found in the Knovel database? **(pair with pre-test question 7)**
   __ Front Matter
   __ Fundamentals
   __ Metallic Finishes and Processes*
   __ Ferrous Metals

9. You heard that ATT is coming out with a new type of cellular phone next week. You want to read more information about it. Where would you be most likely to find information? **(pair with pre-test question 10)**
   __ Books (print or electronic)
   __ Scholarly journal (print or online)
   __ Trade journal (print or online)
   __ Internet news site*

10. Your professor recommends a particular book that would significantly strengthen your presentation. The GVSU Library doesn't own the book. What's your best option, since there's still three weeks until your write-up is due? **(pair with pre-test question 3)**

__ See if anyone you know maybe has it
__ Ask the Library to buy it ASAP
__ Place a free Document Delivery request*
__ Ignore your prof's recommendation, and lose points on your presentation

11. <u>In my current academic work,</u> I believe that information literacy skills (such as the abilities to knowledgeably identify types of information, effectively locate relevant information, accurately and critically evaluate usefulness of information, and ethically use information from other sources in my own research) will be important.

   1. Not at all
   2. Of little importance
   3. Of moderate importance
   4. Very important

12. <u>In my future professional work,</u> I believe that information literacy skills (such as the abilities to knowledgeably identify types of information, effectively locate relevant information, accurately and critically evaluate usefulness of information, and ethically use information from other sources in my own research) will be important.

   1. Not at all
   2. Of little importance
   3. Of moderate importance
   4. Very important