Developing a Faculty Consensus on Program Learning Goals and Objectives Using Collaborative Concept Mapping Software

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Abstract *— Developing a collaborative consensus on learning goals and objectives among the faculty of a university department is a critical element in the overall assessment strategy of a program. Not only is this consensus necessary in order to successfully "close the loop" in curriculum assessment and drive real curriculum change, but the enthusiastic buy-in of the entire faculty is central to the development of a collaborative, sustainable, and meaningful curriculum assessment process. While this is a difficult task for departments of any size, developing such a collaborative consensus is even more difficult in broad, interdisciplinary programs that have a large number of faculty with diverse backgrounds. This paper describes the development of a novel technique to obtain collaborative consensus on the learning goals and objectives of a broad, interdisciplinary program, the Integrated Science and Technology Program at James Madison University. The technique involves the use of server-based collaborative concept mapping software (Concept Systems Incorporated, Ithaca, NY) to gather unbiased, uniform feedback from the faculty, and to promote participatory discussions about the underlying learning goals and objectives of the program. Everyone has an equal opportunity to express opinions, openly and anonymously, together and independently. This makes each participant a stakeholder in the process and its outcome. This software-based technique is being used to guide the faculty toward a collaborative consensus on program learning goals and objectives, and is being incorporated into an ongoing, sustainable curriculum assessment process.*

Index Terms *— Concept mapping, curriculum assessment, learning goals, learning objectives.*

BACKGROUND

The Integrated Science and Technology (ISAT) Department at James Madison University (JMU) is a broad, interdisciplinary program with a large number of faculty that have diverse academic and industrial backgrounds. With 45 full-time faculty and an undergraduate student body of approximately 600 students, this unique program empowers students to analyze and solve real-world, human problems by integrating scientific, technological, business, and social aspects of these problems, and to communicate innovative solutions to a diverse audience. The ISAT BS Program prepares students to excel in a complex, technological world by empowering, inspiring, and motivating them to become critical thinkers and lifelong learners able to provide multidisciplinary solutions to scientific and technological challenges with sensitivity to social, ethical and global considerations. Reference [1] describes this relatively new program (founded in 1993), its curriculum, and its educational pedagogy in more detail.

Administering such a broad, integrated curriculum requires a faculty with a similarly broad set of academic and experiential backgrounds. For example, the 45 faculty in the ISAT department hold 36 different types of terminal PhD degrees, as listed in Table I. Furthermore, the majority of the faculty have previous work experience in industry, government labs, or non-profit institutions. Developing consensus on the underlying learning goals and objectives of such a broad, interdisciplinary program from among such a large, diverse faculty is clearly a challenge.

A new method was developed to obtain collaborative consensus on the learning goals and objectives for this broad, interdisciplinary program. The method involves the novel use of server-based collaborative concept mapping software (Concept Systems Incorporated, Ithaca, NY [2]-[3]) to gather unbiased, uniform feedback from the faculty, and to promote participatory discussions about the underlying learning goals and objectives of the program.

While collaborative concept mapping software has been used in the assessment of educational programs and training in a business context [4]-[5], and can be considered as an alternative approach for analyzing open-ended survey responses [6], it is typically not applied to developing collaborative consensus on the learning goals and objectives in university-based academic programs.

TABLE I
DOCTORAL DEGREE AREAS OF ISAT FACULTY MEMBERS

Aerospace Engineering	Environmental Sciences	Natural Resources
Agricultural & Extension Education	Environmental Toxicology	Natural Sciences
Biochemistry	Genetics	Nuclear Engineering
Biomedical Engineering	Geography	Pharmacology/Neuroscience
Biophysics	Higher Education	Physics/Applied Physics
Botany	Industrial Engineering	Plant Pathology
Chemical Engineering	Jurist Doctor (Law)	Political Science
Chemical Physics	Logic & Philosophy of Science	Solid State Physics
Computer Engineering	Materials Science	Statistics
Computer Science	Mechanical Engineering	Technology Education
Electrical Engineering	Microbiology	Theoretical & Applied Mechanics
Environmental Engineering	Molecular Biology	Theoretical Biology

Application of collaborative concept mapping software as part of our assessment process gave all faculty an equal opportunity to express opinions, openly and anonymously, together and independently, in the establishment of the program learning goals and objectives. This made each participant a stakeholder in the process and its outcome. This software-based technique is being used to guide the faculty toward a collaborative consensus on program learning goals and objectives, and is being incorporated into an ongoing, sustainable curriculum assessment process.

ASSESSMENT PROCESS

During the 2002-2003 academic year, the ISAT Assessment Committee determined that further progress in "closing the loop" between assessment and curriculum improvement required that the assessment instruments and results be more closely related to specific program goals and objectives. The first step in this process, an agreed upon set of program goals and objectives, is mandatory before any further progress can be made. The original ISAT program goals and objectives had been written more than 10 years ago, and were not necessarily reflective of the current program structure and assessment methodology. A Goals and Objectives Task Force consisting of members of both the Assessment Committee and the Curriculum and Instruction Committee was formed to shepherd the process of goals and objectives revision. The task force identified the Concept Systems' collaborative concept mapping software package as an instrument that could be used to:

- gather input from the entire faculty
- generate a two-dimensional "concept map" to cluster objectives into logical groups (i.e., goals)
- spatially represent relationships between individual program goals and objectives
- rank the relative importance of individual goals and objectives

This "concept map" was seen as a tool for rapidly integrating the views of a large, diverse faculty with a minimum amount of face-to-face meeting time. Another very positive factor was that the software considers each faculty member's input equally, thus avoiding bias in interpreting the results.

The task force began with a review of our current list of program goals and the ABET program criteria [7] to create a working list of goals for the ISAT program (Appendix A, Tables I-III). Objectives were then written for each goal, with reference to both the historical objectives of the program and the objectives of the existing curriculum. This process resulted in a working list of 10 unique goals, and a total of 120 individual learning objectives. The 120 objective statements were randomly ordered and entered into the Concept Systems' software. A user account was created for each faculty member, and the software was loaded onto the college's network server. Faculty were given a month to complete their evaluation of the objectives. Faculty input included an individual ranking from 1 (low) to 5 (high) of the relative importance of each objective, and an individual grouping of the objective statements into "bins" to indicate their impression of how the objectives clustered together to form goals. Faculty had the opportunity to form as many or as few "bins" as they felt was appropriate, place any number of objective statements in each "bin", and discard statements they felt did not belong in the final groupings. The overall participation rate in this voluntary process, of the 39 faculty directly involved in the ISAT degree program, was 67%.

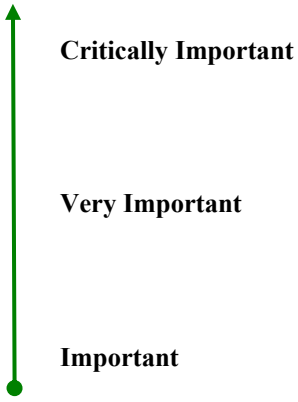
Following the faculty's input, point maps and concept maps were drawn by the software application to depict the consensus "clusters" of the objective statements to form program goals. Additional analysis included calculation of the average relative importance value of each individual objective and each goal cluster. Correlation of results between different demographic groups within the department was also performed.

ASSESSMENT RESULTS

First, a consensus point map of the sorted objectives, shown in Figure 1, was created by the software application. On this point map, the distance between any two points indicates the degree to which there is a strong correlation between these two objectives. In other words, proximity indicates that the two objectives most probably support the same overall goal. To aggregate the objectives (points) into logical program goals, a series of cluster maps were calculated by the software application in which the number of clusters or "discrete islands" was varied from 8 to 12. A cluster map with 11 discrete clusters, shown in Figure 2, was found to best represent the groupings apparent in the point map. Each cluster was named based on the names that individuals assigned to their clusters during the sorting phase of the evaluation. Finally, the relative importance of each goal cluster was determined by averaging the individual importance of each objective statement in each cluster. Relative importance is represented in Figure 3 by the height of each cluster in the final map. The consensus list of 11 goal topics is given in Table II with the relative importance ranking range for each goal. Note that since importance was measured on a 1-5 scale, all 11 goals were determined to be relatively important by the faculty (all scoring above 3), with two goals standing out as being of critical importance (scoring above 4). The goals with the highest overall importance ratings were Problem Solving and Effective Communication. This affirmation of two of the basic premises of the ISAT program was very encouraging, and helped validate the concept mapping process.

TABLE II
CONSENSUS PROGRAM GOAL TOPICS WITH RELATIVE IMPORTANCE RAKINGS

Program Goal Topic	Relative Importance
Problem Solving Effective Communication	4.00 – 4.25
Science Principles Computer Skills Research Competence	3.75 – 4.00
Teaming Skills Measurement Skills Professional Development	3.50 – 3.75
Ethics Management Skills	3.25 – 3.50
Social Systems & Institutions	3.00 – 3.25



Individual objectives for each goal topic are listed, along with their consensus relative importance rankings, in Appendix B. The overall importance of each goal cluster, and that of individual objectives within each cluster, showed remarkable agreement among the faculty. High correlations between goal importance ratings were found for every faculty group comparison except that of entering faulty (less than 3 years of service) and faculty who have been in the department for more than 8 years. Specifically, a correlation coefficient of r=0.39 was calculated between the responses of new faculty and more senior faculty. While both groups ranked Problem Solving as the goal with the highest relative importance, differences in perceived relative importance were evident in the other 10 goals. For example, the new faculty ranked Professional Development as the second most important goal and Computer Skills as the fifth most important goal, while the more senior faculty ranked Computer Skills second and Professional Development seventh. Since the ISAT program is only 10 years old, these differences may indicate a cultural difference between the faculty who originally founded the program and those who entered the department after it was well established. These differences may also be indicative of the influence of external cultural and societal changes that may ultimately influence the academic goals and objectives of the program.

Comparison of essentially all other demographic groups within the department yielded relatively high correlation coefficients. For example, a correlation coefficient of r=0.89 was calculated between faculty with prior non-academic experience and those with only academic experience. This is an indication of the strong interdepartmental communication channels within the department and the remarkable amount of agreement among such a diverse faculty on the basic goals and

objectives of the program. Reconsidering the new faculty example in the context of the high correlation among other demographic groups in the department may indicate the presence of a "learning curve" for new faculty to discern such a complex, diverse program and be able to effectively articulate its fundamental goals and objectives.

FIGURE 1
INITIAL CONSENSUS POINT MAP OF SORTED OBJECTIVES

FIGURE 2
CLUSTER MAP RELATING SORTED OBJECTIVES TO CONSENSUS GOALS

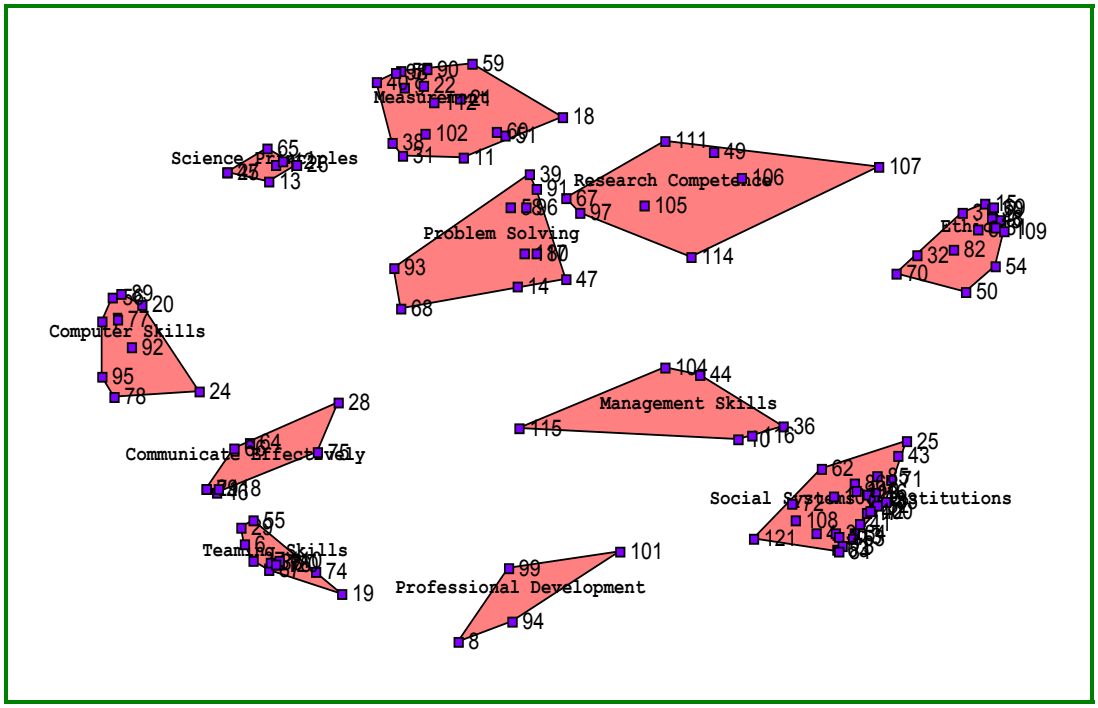
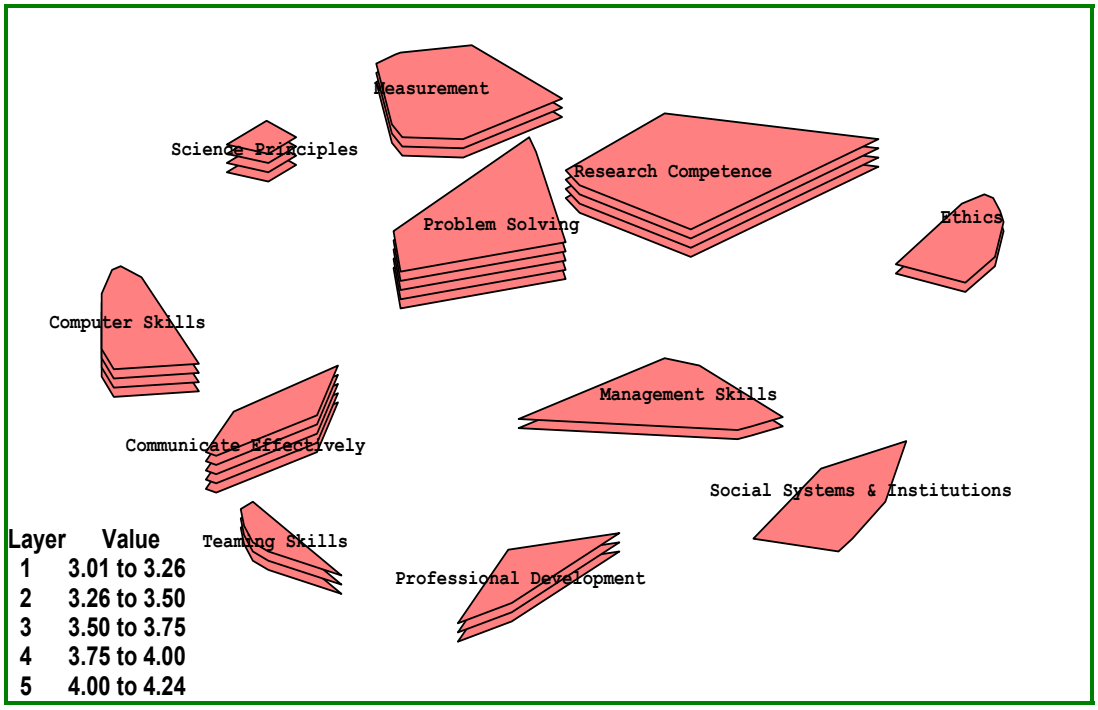


FIGURE 3
FINAL CONSENSUS CLUSTER MAP OF GOALS WITH ASSOCIATED RELATIVE IMPORTANCE RANKINGS



NEXT STEPS

Results of this analysis were shared with the faculty in a ½-day retreat in which each goal cluster was reviewed by a faculty working group for validation of the program output in terms of both the goal topics and the associated objectives for each goal. Full sentence goals were written for each cluster, and objectives were worded in measurable language and, in come cases, consolidated or eliminated based on overall importance ratings. Adjustments were made based on this faculty input and a final listing of the consensus goals and objectives was generated. A draft of the resulting goals and objectives list is included in Appendix C. Note that this refinement reduced the number of goals from 11 to 10, and reduced the overall number of objectives from 120 to 89. A mapping of the 11 original goal topics to the 10 final goal statements is shown in Figure 4. The Task Force will present these modifications to the faculty for final validation and vote early in the fall 2004 semester.

In the 2004-2005 academic year, the ISAT Assessment Committee will incorporate the results of the Goals and Objectives Task Force into a revised assessment plan that will allow for "closing the loop" on the assessment process to improve curriculum. They will begin by considering each objective and determining whether we are adequately assessing the objective with our current assessment instruments. Next they will modify existing assessment instruments, or develop new assessment tools, for those objectives that are not being adequately assessed. Mapping of program objectives to specific course objectives will also be initiated. This will require input from the entire faculty, and a process for accomplishing this efficiently, effectively, and fairly will be developed by the committee. The committee will be assisted by an interactive assessment website that is being developed by a student team to facilitate gathering and disseminating program assessment information among the faculty.

Although this process will occupy a great deal of time and energy, it is clear that these activities are necessary to define the future direction of assessment and curriculum modification in the ISAT department. Developing a collaborative consensus on learning goals and objectives among the faculty is a critical element in our overall assessment strategy. Not only is this consensus necessary in order to successfully "close the loop" in curriculum assessment and drive real curriculum change, but buy-in of the entire faculty is central to the development of a collaborative, sustainable, and meaningful curriculum assessment process. It is anticipated that the development and implementation of new assessment instruments based on this exercise will not be complete until spring 2006.

FIGURE 4
MAPPING OF THE 11 ORIGINAL GOAL TOPICS TO THE 10 FINAL GOAL STATEMENTS

Original Goal Topic	Final Goal Statements
Science Principles	ISAT graduates apply and integrate fundamental principles of mathematics, physical science, biological science, and technological principles.
Measurement Skills	ISAT graduates can design experiments; select measurement methods; and collect, analyze and interpret data appropriately.
Research Competence	ISAT graduates are familiar with research design principles and apply them in actual research projects.
Teaming Skills	ISAT graduates work effectively as part of a multidisciplinary team.
Problem Solving	ISAT graduates can identify, formulate, analyze, and solve technological problems and understand their societal implications.
Ethics	ISAT graduates know the theoretical foundations of ethics, and use this knowledge to reason typical ethical problems.
Effective Communication	ISAT graduates communicate effectively on social, scientific, and technical matters.
Social Systems & Institutions	ISAT graduates can analyze science and technology issues informed by broader global, political, economic, and social contexts.
Professional Development	ISAT graduates are autonomous, self-directed learners who recognize the need for lifelong learning.
Computer Skills	ISAT graduates use the computer as an effective problem solving tool.
Management Skills	*This goal topic was eliminated and associated objectives were distributed among several other goal statements.*

It is important to note that the exercise described in this paper, from inception of the concept mapping idea to the final goals and objective verification exercise, took less than one academic year to complete. A high-quality, consensus product was developed with 12 task force meetings, 1 hour per faculty member of on-line response time, and 2 hours of group faculty meeting time. Fair, unbiased input was gathered in a minimal amount of time with essentially no conflict. It was essential that a good quality initial list of objectives be developed as input to the concept mapping software, and a considerable amount of task force time was spent preparing an exhaustive and unbiased list. Furthermore, open and enthusiastic participation from the faculty was also essential. While this paper describes developing program goals and objectives in a broad, interdisciplinary program that has a large number of faculty with diverse backgrounds, the authors feel that the process described here could be implemented by almost any department of any size, in any discipline or interdisciplinary field of study.

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REFERENCES

[1] Kander, R., G., " A Successful Experiment in Curriculum Integration: Integrated Science and Technology at James Madison University", *Proceedings of the 33rd ASEE/IEEE Frontiers in Education Conference,* November 5-8, 2003, Boulder, CO.

[2] Trochim, W., M. K., "An Introduction to Concept Mapping for Planning and Evaluation", *Evaluation and Program Planning*, 12, 1989, pp. 1-16.

[3] Trochim, W., M. K., "Concept Mapping: Soft Science or Hard Art", *Evaluation and Program Planning*, 12, 1989, pp. 87-110.

[4] McLinden, D., J. and W. M. K. Trochim, "From Puzzles to Problems: Assessing the Impact of Education in a Business Context with Concept Mapping and Pattern Matching", *Evaluation Systems and Processes*, American Society for Training and Development, Alexandria, VA, 1998.

[5] McLinden, D., J. and W. M. K. Trochim, "Getting to Parallel: Assessing the Return on Expectations of Training", *Performance Improvement*, 37, 8, 1998, pp. 21-26.

[6] Jackson, K. and W. M. K. Trochim, "Concept Mapping as an Alternative Approach for the Analysis of Open-Ended Survey Responses", *Organizational Research Methods*, 5, 4, October, 2002, pp. 307-336.

[7] ABET Engineering Accrediting Commission, "Criteria for Accrediting Engineering Programs", ABET Incorporated, *www.abet.org*, November, 2003, pp. 1-2.

APPENDIX A: INPUT GOALS STATEMENTS

TABLE I
ORIGINAL ISAT PROGRAM GOALS (CIRCA 1993)

1. **Technically Literate.** Students should be intelligent and critical consumers of scientific and technical information.
2. **Technical Communicators**. Students should have the ability to express themselves clearly on scientific and technical matters orally and in writing.
3. **Problem Solvers**. Students must have analysis and problem-solving skills to be successful scientists and technologists.
4. **Philosophically Grounded**. Students should understand the underlying assumptions of science, the structure and status of scientific theories and explanations, and the epistemological foundations of science and engineering.
5. **Methodologically Sound**. Students should be familiar with the processes of science and engineering, and how to monitor, control, and improve them.
6. **Aware of Non-technical Contextual Issues**. Students must learn to appreciate legal, ethical, and societal issues while understanding that economic factors often govern and constrain scientific and technical research and development.
7. **Computer Literate**. Students should develop computer skills enabling them to collect, manipulate, and analyze data and information, formulate and test hypotheses, model and simulate processes and systems, and create deliverables reporting their findings.
8. **Grounded in Basic Science**. Students should have broad knowledge of the basic fields of science and engineering.
9. **Technical Generalists**. Students should appreciate the unity of science across all its disciplines.
10. **Aware of Current Issues**. Students should be familiar with some important contemporary issues in science and engineering.

TABLE II
ABET GENERAL PROGRAM CRITERIA [7]

a. an ability to apply knowledge of mathematics, science, and engineering
b. an ability to design and conduct experiments, as well as to analyze and interpret data
c. an ability to design a system, component, or process to meet desired needs
d. an ability to function on multidisciplinary teams
e. an ability to identify, formulate, and solve engineering problems
f. an understanding of professional and ethical responsibility
g. an ability to communicate effectively
h. the broad education necessary to understand the impact of engineering solutions in a global and societal context
i. a recognition of the need for, and an ability to engage in lifelong learning
j. a knowledge of contemporary issues
k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

TABLE III
TASK FORCE GENERATED WORKING LIST OF PROGRAM GOALS

Goal A. ISAT graduates apply and integrate fundamental principles of mathematics, physical and social science, and technological principles
Goal B. ISAT graduates communicate effectively
Goal C. ISAT graduates are problem solvers
Goal D. ISAT graduates understand [their] professional and ethical responsibilities.
Goal E. ISAT graduates are methodologically sound
Goal F. ISAT graduates understand the interaction of science and technology with the global and societal context.
Goal G. ISAT graduates have knowledge of contemporary issues.
Goal H. ISAT graduates work effectively as part of a multidisciplinary team
Goal I. ISAT graduates apply technological tools and instruments effectively
Goal J. ISAT graduates are autonomous, self-directed learners who recognize the need for lifelong learning

APPENDIX B: CONCEPT MAPPING PROGRAM GOALS AND OBJECTIVES OUTPUT

(Number in parenthesis represents the consensus relative importance ranking for each objective.)

Goal Cluster 1: Problem Solving

(4.71) Clearly define and articulate a research problem or question.
(4.50) Identify a problem's essential elements, interactions and transformations, and distill the key goals to be achieved.
(4.42) Choose the source or sources appropriate for answering the research question.
(4.42) Evaluate problem solution alternatives against goals, objectives, constraints and criteria of the problem. Determine how well the proposed solutions solve the problem. Assess the feasibility and political acceptability of each alternative.
(4.21) From a list of possible solutions, select the alternative that best meets the goals and objectives and satisfies all constraints and criteria stated in the definition of the problem.
(4.19) Recognize the variety of information sources available.
(4.19) Critically evaluate all information sources for reliability, validity, accuracy, authenticity, timeliness, and bias.
(4.15) Use logic, expert systems, mathematics, and verbal reasoning to support a solution or hypothesis through a chain of reasoning from premises to conclusions.
(3.83) Select appropriate information retrieval tools.
(3.77) Develop alternative problem solutions using a variety of methods and tools such as problem decomposition, simulations, analogies, deductive reasoning, calculus, or computation, and through the application of scientific principles.

Goal Cluster 2: Effective Communication

(4.44) Clearly and effectively communicate a problem and its proposed solution in the form of oral presentations and written professional reports that document the problem, the solution process, the proposed solution and the expected outcome.
(4.44) Write a clear, concise and complete problem statement identifying needs, stakeholders, interest groups, objectives and target specifications, preferably in quantitative measurable terms.
(4.37) Conceptualize, write, and revise technical reports and professional research papers suitable for professional or general audiences.
(4.08) Compose a variety of typical professional documents (memos, meeting minutes, letters, simple proposals, press releases, executive summaries, etc.).
(4.04) Prepare and deliver oral presentations to professional or general audiences.
(4.04) Write effective titles, captions, labels in order to communicate data and analyses.
(3.90) Recognize and accommodate audience diversity by tailoring written and oral communications appropriately.
(3.54) Effectively use project management skills: critical path, timeline, scheduling, and assigning roles, to facilitate the work of the team.

Goal Cluster 3: Science Principles

(4.33) Illustrate the unifying principles of science, such as the conservation of energy, and their universal applicability across all disciplines.
(4.00) Explain the fundamental principles of life on Earth, including the genetic code, the cell, and the metabolic cycles of living things as they absorb matter and energy, organize their internal structure, eliminate waste, and reproduce.
(3.94) State the fundamental principles governing our environment on Earth including geological forces, such as weather and climate; ecological principles of succession, evolution and biogeochemical cycles; and pollution.
(3.65) Describe the organization of the biosphere, hierarchies of life, the effects of living on the Earth, and the history of life on Earth.
(3.62) Apply the concept of rate of change and cumulative effects to situations arising from various fields of study, and relate it to calculus.
(3.52) Describe the concept of equilibrium in science and technology, including the dichotomies between stable and unstable equilibria in the context of static and dynamic component and system behavior.
(3.31) Discuss the fundamental probabilistic nature of the physical universe and many of the real systems and problems encountered in science, engineering and business.

Goal Cluster 4: Computer Skills

(4.46) Use computers to enter data, acquire measurements directly from instruments, and retrieve information from databases.
(4.33) Use computers for exploratory data analysis, including transforming data, graphing data, producing descriptive statistics, and exploring relationships between variables.
(4.06) Use computers to design and analyze solutions to problems.
(4.04) Use computers to produce graphs, text multimedia, and other formats for reporting findings, stating project plans, and so on.
(3.96) Integrate computers into the day-to-day activities of communicating with peers and instructors, planning and tracking projects, and completing class assignments.
(3.88) Integrate computers into the day-to-day activities of communicating with peers and instructors, planning and tracking projects, and completing class assignments.
(3.87) Select, utilize and defend appropriate data visualizations to communicate data or analysis effectively.
(3.73) Model and simulate processes and systems on computers as a means of generating data and understanding phenomena.
(3.48) Test and evaluate hypotheses using computers.

Goal Cluster 5: Research Competence

(4.29) Effectively gather information relevant to a problem or its possible solution from a variety of archival and electronic sources and clearly state what is known and what is yet to be determined.
(4.29) Report and analyze data in a neutral and impartial manner. This includes recognizing "sins of omission": the deliberate exclusion of data that contradicts a main hypothesis or analytical purpose.
(4.12) Recognize the integrated and interdisciplinary nature of the ISAT curriculum and be familiar with appropriate research tools and information sources in a variety of academic disciplines.
(3.90) Identify practices that constitute fraudulent data collection and reporting and/or the falsification of data.
(3.69) Construct and implement an effectively designed search strategy by using advanced searching techniques and refining the strategy as needed.
(3.58) Identify factors that add bias to popular accounts of scientific or technological issues.
(3.37) Identify research scenarios that involve research misconduct and explain why.
(2.88) Explain the basic procedures for "chain of custody" of research and evidence samples.

Goal Cluster 6: Teaming Skills

(4.21) Display effective interpersonal communication skills in teams or group processes by eliciting/recognizing member contributions, synthesizing opinions, mediating conflicts, and reaching consensus.
(3.94) Organize and facilitate a collaborative writing effort or team project.
(3.92) Use effective skills for promoting discussion and contribution from all team members.
(3.90) Demonstrate the ability to work with people of diverse cultural and personal styles.
(3.75) Encourage full participation of all team members.
(3.56) Recognize the multidisciplinary aspect of project teams.
(3.54) Understand the roles that individuals play in teams.
(3.35) Cultivate a personal style that is non-judgmental.
(3.04) Use different team facilitating techniques for different kinds of teams.
(2.98) Describe when a team is appropriate and when it is not.
(2.90) Employ tools for team self-assessment.

Goal Cluster 7: Measurement Skills

(4.60) Choose appropriate instruments for solving problems.
(4.10) Explain the basic premises of scientific method as it applies to both social and physical sciences.
(4.08) Design and critique simple experiments for collecting scientifically valid data.
(3.92) Apply appropriate statistical inference tools in data analysis.
(3.88) Choose an appropriate sampling method to get a representative sample.
(3.83) Explain why there is no such thing as a perfect measurement and how to correctly report error and uncertainty.
(3.77) Identify designs of experiments that may lead to biased research findings.
(3.77) Explain the limitations of an instrument or measurement in terms of accuracy, precision, and reliability.
(3.77) Apply appropriate statistical inference tools in data analysis.
(3.65) Explain why calibration of instruments is critical to good science and engineering.

(3.54) Maintain laboratory notebooks that meet professional scientific standards and the general legal requirements for laboratory notebooks in the workplace.
(3.27) Demonstrate competence in using a wide range of instruments.
(3.23) Read and interpret a "specification sheet" for an actual scientific instrument.
(3.23) Describe the principles involved in the operation of a variety of indicators and sensors used in scientific research.
(3.12) Explain how data or signals are converted from a variety of sources into a form suitable for further analysis.
(2.92) Be able to calibrate a variety of instruments.

Goal Cluster 8: Professional Development
(3.94) Demonstrate positive attitudes toward learning.
(3.73) Explain or defend one's own opinion on current issues.
(3.63) Describe the necessity for taking personal responsibility for sustained, self-directed learning throughout one's life.
(3.27) Interact with a student or faculty member from another culture or country.

Goal Cluster 9: Ethics
(3.79) Conduct moral reasoning for a complex ethical problem and arrive at a decision that is consistent with a professional code of ethics.
(3.71) Discuss how ethical positions are translated into social decisions and institutions.
(3.67) Explain the professional options that are available to someone who is asked to do something unethical on the job or who observes unethical practices in the workplace.
(3.62) Apply key ethical principles and standards of conduct to simple, concrete scenarios in which there is little ambiguity.
(3.54) Conduct moral reasoning with respect to an ethical problem and arrive at a decision that is consistent with a set of ethical principles.
(3.50) Explain the key ethical concepts common to most professions and work settings, including confidentiality, conflict of interest, corporate social responsibility, fairness/justice, impartiality/objectivity, openness/full disclosure, and trusted agent.
(3.50) Correctly interpret organizational and/or professional codes of ethics.
(3.46) Understand the scope and responsibilities of "fair use" of copyrighted material.
(3.35) Explain the professional requirements for protecting data that is proprietary, "business confidential," trade secret, and so forth.
(3.27) Identify research scenarios that involve a conflict of interest and explain why.
(3.12) Explain what the current laws are with respect to "informed consent" and the use of human subjects in research.
(2.85) Identify several ethical theories used in public and private discourse.
(2.83) Explain the professional requirements for protecting "personally identifiable information" that is data and records that may be linked to a real person.
(2.69) Explain what the current laws are with respect to the ethical treatment of animal subjects.

Goal Cluster 10: Management Skills
(3.71) Identify the technical limitations and economic and social constraints bounding a problem solution and clearly state criteria for judging the outcome ultimately achieved.
(3.69) Evaluate information available about a problem in the context of its underlying technical aspects and non-technical issues (ethical, political, and economic).
(3.50) Explain the chain of reasoning that results in one's own opinion.
(3.50) Describe how the tools and information learned in an ISAT concentration would be helpful in resolving current social problems.
(3.25) Identify and discuss various stages of the design process of components, systems and institutions as it is professionally practiced in technical, managerial and societal contexts.
(3.04) Define and give an example of technology assessment.

Goal Cluster 11: Social Systems & Institutions

(3.58) Recognize existing economic, social, and political institutions through which problem solutions will be implemented.
(3.50) Analyze the difference in science and technology issues from the perspective of developed and developing countries, including technological choices and appropriate technology.
(3.48) Identify at least three decisions pending in the political arena which have scientific or technological aspects.
(3.44) Discuss the impacts of several technologies on a society.
(3.38) For a given scenario, identify the costs and benefits of economic growth as it relates to issues of sustainability and equity.
(3.37) Describe how public interest is expressed through democratic processes, policy making, regulation, taxation and budgeting.
(3.31) Describe several "market forces" that technological firms feel such as the relationship of supply, demand and prices, the pressure to differentiate their product from others, the pressure to avoid liability costs, the role of stakeholders, etc.
(3.27) Correctly locate the country or world region in which recent major events have occurred.
(3.23) Recognize deficiencies in participation, equity, disclosure, consent, and oversight provisions in existing institutions, such as firms, government agencies, non-profit organizations, etc.
(3.13) Analyze news coverage of scientific or technological events in terms of intellectual theories and methods.
(3.13) Understand how to achieve social goals such as participation, equity, disclosure, consent, and oversight through the design of institutions.
(3.12) Give an example of a global/planetary physical problem and how the international community organizes to deal with it.
(3.08) Identify organizations in the news as private or public sector.
(3.08) Understand the unique technological problems facing underdeveloped countries.
(3.08) Describe how societies create and support technological change through patents and copyright systems, science and technology policies/spending, and innovation incentives.
(3.04) Specify at least one other country's perspective on an issue and discuss how it differs from that of the United States.
(3.02) Identify and discuss the major institutions of the International Community, especially agencies relevant to development and application of science and technology, such as the UN System, World Bank, and Non-Governmental and Private Voluntary Organizations.
(3.02) Identify social actors as private or public sector and explain their interests.
(2.98) Describe the relationship between competition and labor/civil rights issues, such as workplace safety rules, collective bargaining and right to work, and technological unemployment.
(2.77) Recognize and describe several unique aspects of social science.
(2.73) Identify the polity or polities [decision-making units] in which the individual student has membership (whether or not he or she participates).
(2.73) Know at least one political position of your (the student's) representatives in Congress.
(2.69) Define and discuss terms and issues related to the United States' [public and private] interests in multilateral and bilateral relations, east-west and north-south dialog, and harmonization of policies.
(2.65) Identify and discuss the function of major institutions involved in free trade.
(2.54) Compare the scientific capacities of the United States to those of other nations.
(2.46) Give examples of major characteristics of the international system including anarchy, nation-state sovereignty, and asymmetry.
(2.42) Compare technological systems in two different countries.
(2.17) Recognize arguments of technological determinism and social constructivism.

APPENDIX C: FACULTY MODIFIED PROGRAM GOALS AND OBJECTIVES

Goal A: ISAT graduates apply and integrate fundamental principles of mathematics, physical science, biological science, and technological principles.

Objectives:

1. Illustrate the unifying principles of science, such as the conservation of energy, and their universal applicability across all disciplines.
2. Discuss the fundamental probabilistic nature of the physical universe and many of the real systems and problems encountered in science, engineering and business.
3. Describe the concept of equilibrium in science and technology, including the dichotomies between stable and unstable equilibria in the context of static and dynamic component and system behavior.
4. Apply the concept of rate of change and cumulative effects to situations arising from various fields of study, and relate it to calculus.
5. Explain the fundamental principles of life on Earth, including the genetic code, the cell, and the metabolic cycles of living things as they absorb matter and energy, organize their internal structure, eliminate waste, and reproduce.
6. Describe the organization of the biosphere, hierarchies of life, the effects of living on the Earth, and the history of life on Earth.
7. State the fundamental principles governing our environment on Earth including geological forces, such as weather and climate; ecological principles of succession, evolution and biogeochemical cycles; and pollution.

Goal B: ISAT graduates can design experiments; select measurement methods; and collect, analyze and interpret data appropriately.

Objectives:

1. Choose an appropriate sampling method to get a representative sample.
2. Explain why there is no such thing as a perfect measurement and how to correctly report error and uncertainty.
3. Maintain laboratory notebooks that meet professional scientific standards and the general legal requirements for laboratory notebooks in the workplace.
4. Select, understand, and use appropriate instruments for solving problems.
5. Explain why calibration of instruments is critical to good science and engineering.
6. Identify designs of experiments that may lead to biased research findings.
7. Design and critique simple experiments for collecting scientifically valid data.
8. Demonstrate competence in using a wide range of instruments.
9. Describe the principles involved in the operation of a variety of indicators and sensors used in scientific research.
10. Report and analyze data in a neutral and impartial manner. This includes recognizing "sins of omission": the deliberate exclusion of data that contradicts a main hypothesis or analytical purpose.
11. Apply appropriate statistical inference tools in data analysis.
12. Explain the basic premises of scientific method as it applies to both social and physical sciences.

Goal C: ISAT graduates are familiar with research design principles and apply them in actual research projects.

Objectives:

1. Understand the scope and responsibilities of "fair use" of copyrighted material.
2. Explain the professional requirements for protecting "personally identifiable information;" that is, data and records that may be linked to a real person.
3. Explain what the current laws are with respect to the ethical treatment of animal subjects.
4. Explain what the current laws are with respect to "informed consent" and the use of human subjects in research.
5. Identify practices that constitute fraudulent data collection and reporting and/or the falsification of data.
6. Explain the basic procedures for "chain of custody" of research and evidence samples.
7. Identify research scenarios that involve research misconduct and explain why.
8. Construct and implement an effectively designed information search strategy by using advanced searching techniques and refining the strategy as needed.
9. Identify factors that add bias to popular accounts of scientific or technological issues.
10. Effectively gather information relevant to a problem or its possible solution from a variety of archival and electronic sources and clearly state what is known and what is yet to be determined.
11. Recognize the integrated and interdisciplinary nature of the ISAT curriculum and be familiar with appropriate research tools and information sources in a variety of academic disciplines.

Goal D: ISAT graduates work effectively as part of a multidisciplinary team.

Objectives:

1. Organize tasks, plan work schedules, promote responsibility, define product and interim deliverables and establish effective expectations and sanctions to facilitate the work of the team.
2. Display effective interpersonal communication skills in teams or group processes by eliciting/recognizing member contributions, synthesizing opinions, mediating conflicts, and reaching group consensus.
3. Employ tools for team self-assessment.
4. Understand the roles that individuals play in teams.
5. Describe when a team is appropriate and when it is not.
6. Use different team facilitating techniques for different kinds of teams.
7. Demonstrate the ability to work with people of diverse cultural and personal styles.
8. Recognize the multidisciplinary aspect of project teams.
9. Cultivate a personal style that is non-judgmental.

Goal E: ISAT graduates can identify, formulate, analyze, and solve technological problems and understand their societal implications.

Objectives:

1. From a list of possible solutions, select the alternative that best meets the goals and objectives and satisfies all constraints and criteria stated in the definition of the problem.
2. Clearly define and articulate a research problem or question.
3. Develop alternative problem solutions using a variety of methods and tools such as problem decomposition, simulations, analogies, deductive reasoning, calculus, or computation, and through the application of scientific principles.
4. Evaluate problems and solutions with respect to the technical, social, and economic factors impacting them.
5. Evaluate problem solution alternatives against goals, objectives, constraints and criteria of the problem. Determine how well the proposed solutions solve the problem. Assess the feasibility and political acceptability of each alternative.
6. Identify a problem's essential elements, interactions and transformations, and distill the key goals to be achieved.
7. Use logic, expert systems, mathematics, and verbal reasoning to support a solution or hypothesis through a chain of reasoning from premises to conclusions.
8. Select appropriate information retrieval tools.
9. Choose the source or sources appropriate for answering a research question.
10. Recognize the variety of information sources available.
11. Critically evaluate all information sources for reliability, validity, accuracy, authenticity, timeliness, and bias.

Goal F: ISAT graduates know the theoretical foundations of ethics, and use this knowledge to reason typical ethical problems.

Objectives:

1. Explain the professional options that are available to someone who is asked to do something unethical on the job or who observes unethical practices in the workplace.
2. Conduct moral reasoning for a complex ethical problem and arrive at a decision.
3. Identify research scenarios that involve a conflict of interest and explain why.
4. Correctly interpret organizational and/or professional codes of ethics.
5. Explain the key ethical concepts common to most professions and work settings, including confidentiality, conflict of interest, corporate social responsibility, fairness/justice, impartiality/objectivity, openness/full disclosure, and trusted agent.
6. Apply ethical principles to issues in science and technology.

Goal G: ISAT graduates communicate effectively on social, scientific, and technical matters.

Objectives:

1. Prepare and deliver oral presentations at a technical level appropriate to the audience.
2. Compose a variety of professional documents including memos, meeting minutes, letters, simple proposals, press releases, and executive summaries.
3. Write effective titles, captions, labels in order to communicate data and analyses.
4. Conceptualize, write, and revise technical reports and research papers suitable for the intended audience.

5. Tailor written and oral communications appropriately by recognizing and accommodating audience diversity in areas such as education, socioeconomic level and culture.
6. Clearly and effectively communicate a problem and its proposed solution in the form of oral presentations and written professional reports that document the problem, the solution process, the proposed solution and the expected outcome.
7. Write a clear, concise and complete problem statement identifying needs, stakeholders, interest groups, objectives and target specifications, preferably in quantitative measurable terms.
8. Explain the chain of reasoning that results in one's own position

Goal H: ISAT graduates can analyze science and technology issues informed by broader global, political, economic, and social contexts.

Objectives:

1. For a given scenario, identify the costs and benefits of economic growth as it relates to issues of sustainability and equity.
2. Identify social actors as private or public sector and explain their interests.
3. Identify at least three decisions pending in the political arena which have scientific or technological aspects.
4. Describe the relationship between competition and labor/civil rights issues, such as workplace safety rules, collective bargaining and right to work, and technological unemployment.
5. Design institutional processes to achieve such goals as participation, equity, disclosure, consent, and oversight.
6. Describe how public interest is expressed through democratic processes, policy making, regulation, taxation and budgeting.
7. Describe how societies create and support technological change through patents and copyright systems, science and technology policies/spending, and innovation incentives.
8. Give an example of a global/planetary physical problem and how the international community organizes to deal with it.
9. Describe several "market forces" that technological firms feel such as the relationship of supply, demand and prices, the pressure to differentiate their product from others, the pressure to avoid liability costs, the role of stakeholders, etc.
10. Discuss the impacts of several technologies on a society.
11. Recognize existing economic, global, social, and political institutions through which problem solutions will be implemented.
12. Analyze the difference in science and technology issues from the perspective of developed and developing countries, including technological choices and appropriate technology.
13. Discuss how ethical positions are translated into social decisions and institutions.
14. Give examples of major characteristics of the international system including anarchy, nation-state sovereignty, and asymmetry (political and economic).
15. Critically evaluate news coverage of scientific or technological events.
16. For a specific project, be able to conduct basic "engineering economy" analysis.
17. Be able to characterize economic markets in terms of their competitive structures and supply and demand dynamics.

Goal I: ISAT graduates are autonomous, self-directed learners who recognize the need for lifelong learning.

Objectives:

1. Demonstrate positive attitudes toward learning.
2. Describe the necessity for taking personal responsibility for sustained, self-directed learning throughout one's life.

Goal J: ISAT graduates use the computer as an effective problem solving tool.

Objectives:

1. Model and simulate processes and systems on computers as a means of generating data and understanding phenomena.
2. Use computers to enter and retrieve data, and acquire measurements directly from instruments.
3. Use standard software tools to test and evaluate hypotheses.
4. Use computers to manage projects through planning, tracking, and communication with peers and instructors.
5. Use computers for exploratory data analysis, graphing data, producing descriptive statistics, and exploring relationships between variables.
6. Select and utilize appropriate data visualization tools to understand data and communicate analyses effectively.