OVERVIEW OF THE BS PROGRAM IN INTEGRATED SCIENCE AND TECHNOLOGY (BS ISAT)

Prepared for review by the STEM/HHS Executive Advisory Council (EAC), Fall 2012

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Charge to the Reviewers

The BS ISAT program seeks feedback from the STEM/HHS Executive Advisory Council about our program's educational mission and goals. In particular, we are seeking input on the relevance of the attributes that we hope our graduates attain within a few years of leaving our program (called program educational objectives) and the skills that we strive to impart to graduates of our program (student learning outcomes). We appreciate the importance of an external perspective, and we hope that the input we receive will help us examine and improve our program and the curriculum that we offer.

Program Educational Objectives (PEOs) are described in Section 4 of this report. These are capabilities which should be demonstrated by each graduate within the first few years after completing the program and specify that ISAT Graduates

- Broadly apply concepts in science, technology, and business;
- Perform comfortably in multi-disciplinary teams;
- Communicate effectively with others;
- Demonstrate sensitivity to political, social, and ethical contexts;
- Use the computer effectively as a problem-solving tool; and
- Solve problems skillfully.

Student Learning Objectives (SLOs) are described in Section 5 of this report. They are program-specific objectives that closely correspond to the ABET "a-k" outcomes which the students must demonstrate *at* graduation and specify that the ISAT Graduates

- Apply and integrate concepts in mathematics, physical science, biological science, earth science, and technology;
- Apply sound experimental methodology;
- Are familiar with the professional requirements for the acquisition and use of information and data;
- Work effectively in multidisciplinary teams;
- Identify, formulate, analyze, and solve technological problems and understand their societal implications;
- Identify and apply the principles of ethics applied to professional careers in science and technology;
- Communicate effectively on social, scientific, and technical matters;
- Analyze science and technology within broader global, political, economic and social contexts;
- Are autonomous, self-directed learners who recognize the need for lifelong learning;
- Use the computer as an effective problem solving tool; and
- Are integrated problem solvers who look out from the perspective of a problem and then assemble the tools and knowledge needed to solve it.

Executive Summary

The BS ISAT program seeks feedback from the STEM/HHS Executive Advisory Council about our program's educational mission and goals. The following document has been prepared to facilitate this review by describing the program's strategic intent, goals, and success factors and explain how the curriculum and learning objectives support them. In Section 1, the BS Program in Integrated Science and Technology (ISAT) is described in terms of its mission, the relationship of that mission to the department and university-level mission statements, and the stakeholders who are invested in the program carrying out its mission. Section 2 explains the fundamental philosophy of the program in the context of its historical development. An overview of how strategy and objectives are aligned is presented in Section 3, along with a description of how the program approaches continuous improvement and ensures that feedback received from its stakeholders is integrated into improvement efforts. In Section 4, the strategic Program Educational Objectives (PEOs) are outlined, representing the desired characteristics of students a few years after graduation, followed by the Student Learning Objectives (SLOs) in Section 5 that establish skills and capabilities that the students should present upon graduation. Section 6 provides more detail about the curriculum and, finally, outcomes in terms of employment and graduate school placement are described in Section 7.

1. Program Mission and Stakeholders

The cross-cutting mission of the BS ISAT program is to

> *…prepare students to excel in a complex, technological world by empowering, inspiring, and motivating them to become critical thinkers and lifelong learners able to provide multi-disciplinary solutions to scientific and technological challenges with sensitivity to social, ethical, and global considerations*.

Situated within the Department of Integrated Science and Technology that administers the program, BS ISAT also strongly supports the overarching mission of its department, which is "*to empower 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."* Both statements of purpose are seamlessly aligned with the university-wide mission of JMU, which establishes the institution as "*a community committed to preparing students to be educated and enlightened citizens who lead productive and meaningful lives*."

The program carries out its mission by gathering and responding to the needs of eight (8) stakeholder groups, through educational and other activities in support of the BS ISAT community. The stakeholders are: the current students, faculty and staff who serve the program, future employers of BS ISAT graduates, program alumni, JMU administration, professional societies, and accreditation bodies.

Table 1 below provides 1) a summary of internal and external stakeholder groups; 2) the primary sources of information from which their needs, perspectives, and opinions are gathered; and 3) their concerns with respect to the status and evolution of the BS ISAT program. The collection of these stakeholder groups or constituencies are regularly re-examined as part of annual program planning to ensure that all relevant parties are represented by BS ISAT strategy and objectives.

Table 1: Primary Stakeholder Groups of the B.S. Degree Program in ISAT

Stakeholder Group	Information Sources	Primary Concerns
Current Students	Student assessment, focus groups/exit interviews, surveys, IHS^	Meeting one's individual goals, establishing and maintaining the value of the degree
Faculty/Staff	Committees, faculty meetings, retreats, annual evaluations	ISAT stature, effective teaching, resource adequacy, and fair allocation of workload
Future Employers	Employer surveys and interviews, EAC+, outreach with local and regional businesses	Availability and skill sets of graduates
ISAT Alumni	Interviews, alumni surveys, informal communications	Program stature and long-term value of ISAT degree
University Administration	Direct reporting, program reviews, and assessment	Program strength and influence on College and JMU reputation
Professional Societies	Direct faculty and student participation in ~100 different organizations such as IEEE, ASME, SME, and VA Bio	Professional development and continuing education of faculty, students, and alumni
Accreditation Bodies	Regular formal program reviews and evaluations	Periodic audit to certify that ISAT meets accreditation criteria, its own educational objectives, and outcomes

^ ISAT Honor Society (IHS) is a student-run organization in ISAT which provides feedback to the Department and facilitates intellectual interaction among students and between faculty and students.

+ The STEM/HHS (formerly CISAT) Executive Advisory Council (EAC) is primarily populated by key ISAT constituents.

* Technology Alumni Group for JMU

2. Program Background

A distinctive trait of the ISAT Program is its interdisciplinary nature, which permeates the program and its culture. Traditional disciplinary expertise, though valued, is secondary to the ability to work across disciplinary boundaries and to synthesize work from a variety of academic and real-world fields. One of the many ways in which this principle manifested itself is in the organization of the curriculum around problem areas, rather than disciplines.

Just as real-world practitioners most often view themselves more as part of an industry than as a disciplinary specialist, expertise in the ISAT Program is defined more by association with one of the strategic sectors than with a particular disciplinary background. The six strategic sector areas (Figure 1) reflect what are widely viewed as some of the most important problem areas in society to which science and technology are expected to make a large contribution.

Figure 1: Strategic sector areas in the ISAT curriculum

Applied Biotechnology	***Telecommunications***	***Energy***
Engineering & Manufacturing	***Information & Knowledge Management***	***Environment***

The pedagogical foundations of this program are firmly rooted in the multi-faceted notion of scholarship advanced by Boyer (1990). Most significantly, ISAT was intended to advance the scholarship of integration: taking knowledge from various disparate disciplines and exploring the interstices between the scholarship of discovery in multiple fields. Indeed, it might be said that pursuing the scholarship of integration was a motivating factor in the creation of the ISAT Program, which is reflected in its name and organization. Additionally, the scholarship of application was critical to ISAT, since the Program focused on tackling real-world problems. Although the motivation to address the application of knowledge stemmed from the desire to graduate pragmatic problem-solvers, the sentiment also extends to the faculty, as hands-on experience and experience in practical scholarship of application were a virtual requirement for new faculty at the Program's outset. (Roberds, 2005) Finally, the scholarship of teaching also informed the Program's creation. Given JMU's roots as a teacher's college and its long tradition of focusing on undergraduate education, it was natural that a new program trying to re-envision STEM education would encourage its faculty to engage actively in the scholarship of teaching.

As a result, the BS ISAT community is committed to providing its students with a practical focus, a hands-on approach, multi-disciplinary exposure and experience, a focus on computing and communication, and a background in and understanding of the social context of effectively solving socio-technical problems.

Practical Focus**:** The ISAT Program is designed to have a curriculum-wide focus on real-world problems and practical solutions. In practice, this manifests itself in several ways. First, instructors place less emphasis on derivations of scientific and mathematical principles and more on their application. Importantly, this also includes a heavy focus on technology; indeed, one might argue that the program would be better named Integrated Technology and Sciences (including social sciences). Second, a disproportionate amount of time is devoted to subjects with important and current real-world applications. Third, theoretical concepts are taught in the context of problems and applications, rather than being taught as abstractions that are only later applied to practical problems. Students are strongly encouraged to seek out and participate in summer internships and, by the start of their senior year, about half of ISAT students have had at least one internship experience.

***Hands-on Approach*:** Given the practical focus of ISAT, a hands-on approach to education is almost required. Labs – be they environmental, computer, or biotechnology labs – are very accessible to undergraduates. Indeed, students get the opportunity to use scientific instruments and equipment from the time they start their ISAT courses. Upper-level students have extensive time with a range of equipment in their areas of focus, and some upper-division courses have a strong lab or project component. The curriculum has always included a mandatory course in instrumentation and measurement, although it has proved extremely challenging to teach given the breadth of the equipment used in the range of fields represented in the Program.

***Multi-disciplinary*:** From the outset, ISAT was intended to cut across traditional disciplinary boundaries. Because real-world problems seldom fall neatly into disciplinary categories, taking a multi- or inter-disciplinary approach was essential. Disciplinary knowledge is obviously still taught, but not in the context of the discipline and not for the purpose of advancing knowledge within the discipline. Content areas are divided primarily by real-world problem areas, which are inherently multi-disciplinary. Many faculty members bring professional experience or other expertise in working across disciplinary boundaries, and virtually all have interdisciplinary inclinations.

***Computing and Communication*:** During the 1990s, the centrality of computing to numerous STEM fields was abundantly clear. Any broad-based technical program like ISAT would need to produce graduates who were adept at using computers in a variety of ways. In ISAT, the focus was not so much on programming and coding, but on how computers could be versatile problem-solving tools. At the same time, there was increasing awareness of the importance of good communication skills for engineering and other STEM students. Outside of academia, career success often depends far more on the ability of technical graduates to communicate effectively, particularly with non-technical people, than on their technical prowess. Thus, integrating instruction in both oral and written communication into the curriculum became an important characteristic of ISAT, and many technical programs have followed in emphasizing communication skills.

***Social Context*:** A distinctive feature of the ISAT Program is the strong emphasis that it places on the social, political, economic, and cultural aspects of science and technology. Undoubtedly this stems from the Program's focus on real-world problems, which are never purely technical. A strong social context thread runs through the entire curriculum, although only two of the courses required for all ISAT students are solely dedicated to it. Given the breadth of the notion of "social context," the topics covered vary substantially: from ethics to business considerations and economics to political structures and more. Importantly, for ISAT, social context is neither traditional STS (science, technology and society) nor is it simply applied ethics nor is it strictly science and technology policy. Its broad definition includes all of the above concerns, while also factoring in ideas of social justice, internationalism and cultural concerns, and policy as a tool for problem solving. These courses are not outsourced to faculty in other departments; regular, full-time ISAT faculty members teach social context courses and participate fully in the Program.

3. Continuous Improvement of the BSISAT Program

To support the realization of its mission, and satisfy the current and emerging needs of its internal and external stakeholder groups, continuous improvement of the BS ISAT Program is organized according to an annual cycle (Figure 2) that conforms to the ADLI (Approach-Deployment-Learning-Integration) evaluation criteria embedded within the Educational Criteria for Performance Excellence (BPEP, 2012):

***Approach*:** Various aspects of the BS ISAT Program are aligned with the program, department, and university mission statements through goals and measures that align strategic interests with operational concerns. These are as follows:

- **Program Educational Objectives (PEOs)** -- capabilities which should be demonstrated by each graduate within the first few years after completing the program
- **Habits of Mind for the ISAT Practitioner** -- an outline of how the PEOs can potentially be operationalized into *real-life practice* in the context of each course within the program, and secondarily, to assist faculty in developing and evolving courses that support the PEOs
- **Student Learning Objectives (SLOs)** -- program-specific objectives that closely correspond to the ABET “a-k” outcomes which the students must demonstrate *at* graduation (also called "Goals") Each of the SLOs has several sub-objectives that further define it (also called “objectives”.)
- **Course Outcomes** that are specified and assessed by individual faculty, designed to support SLOs as well as the goals of accreditation bodies, and evaluated at the course level

Individual faculty members are encouraged to apply the principles described with the Habits of Mind as they develop syllabi and evaluation rubrics to ensure strong alignment between the BS ISAT program strategy and how this strategy is operationalized through classroom activities.

***Deployment*:** The above approach is designed to be deployed both broadly (by all faculty and integrated with college and university-level concerns) and deeply (across all course offerings, regardless of focus or level). The faculty, in consultation with students, alumni, employers, and advisory committees, periodically review the PEOs (via annual reports and a major Program Review at least once every five to six years as required by JMU and accreditation bodies) to determine whether these continue to meet the needs of various constituencies of the Program. A typical review cycle begins with observations and recommendations made in the annual Assessment Committee Report prepared for the Program and formally submitted to the Department Head each May. The Report summarizes all assessment activities conducted during the academic year. A summary of key findings and recommendations is presented to the faculty in the following August retreat or in a later faculty meeting. Any issues or concerns raised in these Reports are considered by both the ISAT Leadership Team and the faculty-at-large to decide on how to proceed. Usually, the appropriate standing committee, academic team, or a special task force is charged with evaluating the issue more closely and developing a plan of action.

The Program continues to assess ISAT students and graduates to make certain that they meet the requirements specified in the PEOs, Program Outcomes, and Learning Objectives as they graduate or after graduation. A brief summary of the assessment instruments used for this purpose, their timing, and what they measure is provided here. The instruments measure many aspects of learning such as content knowledge, performance, and attitude/motivation. Both qualitative and quantitative data are collected using objective, self-reported, and peer/faculty evaluation of performance.

Learning: A distinctive feature of the continuous improvement of the BS ISAT Program is the emphasis that is placed on process improvement through learning about the process. That is, BS ISAT continually monitors each element of its approach and ensures that feedback from information sources that characterize stakeholder concerns is regularly considered in the context of the process to improve the approach itself.

As a recent example, in May 2012, program faculty adopted a revision of SLO Goal F and Goal H and their associated objectives. The Social Context academic team, after meeting several times and having several discussions on these Goals, felt that the suggested changes produce a more logically consistent and more measurable set of learning objectives. The changes to Goal F are minor tweaks to make these more logical and more measurable. The changes to Goal H are more extensive. They have been streamlined, taking out topics that were viewed as a grab-bag of examples, and instead seeking to keep the spirit of those goals intact in a more focused fashion. As an example, the old Learning Objective H-7 contained the terms "workplace safety, collective bargaining, and technological unemployment." To demand that these be in the learning objectives is to suggest that *all* BS ISAT students learn these in a meaningfully deep way. This is an issue of granularity. The revisions to Goal H make these objectives clearer, more measurable, and at a more appropriate level of resolution for program-wide learning objectives.

Integration: It is also important to the BS ISAT Program to align and harmonize its processes, plans, measures, and actions with its approach to ensuring that goals and objectives are met for all stakeholder groups. The leadership team within the department monitors, responds to, and evaluates the performance of all faculty and the alignment of individual goals with department goals through the annual Faculty Activity Report. This group collectively performs the same function to integrate departmental goals and objectives with those at the college and university level by participating in the annual Program Review process, and the accreditation review that occurs once every 5-6 years.

4. Program Educational Objectives

The BS ISAT Program has identified six (6) characteristics that should be demonstrated by each graduate within the first few years after completing the program. These **Program Educational Objectives (PEOs)** specify that the ISAT Graduate

1. Broadly applies concepts in science, technology, and business;
2. Performs comfortably in multi-disciplinary teams;
3. Communicates effectively with others;
4. Demonstrates sensitivity to political, social, and ethical contexts;
5. Uses the computer effectively as a problem-solving tool; and
6. Solves problems skillfully.

The BS ISAT Program PEOs echo the following major themes of the JMU mission statement:

> *Educated and enlightened* – Students who become critical thinkers and lifelong learners become educated and enlightened citizens.
>
> *Productive and meaningful* – Students who can arrive at multi-disciplinary solutions to scientific and technological problems while being sensitive to social, ethical, and global considerations are well prepared to lead productive and meaningful lives.

Furthermore, these PEOs are designed to support students as they pursue a professional career, graduate school, or both. The scientific, technological, and applied focus of the ISAT Program prepares students to enter professions or begin advanced study. It also provides the academic foundation for graduate work and an appreciation for the need to continue their education.

To ensure that a focus on the PEOs can be effectively integrated into SLOs and course outcomes, BS ISAT has developed **Habits of Mind for the ISAT Practitioner** as guidelines for behaviors to model and emphasize within the classroom. These guidelines provide a basis for aligning activities and course outcomes with the overall PEOs of the program.

Drivers for the Habits of Mind: ISAT practitioners are experts in the problem-centric approach. They begin by seeking to understand the problem from a variety of viewpoints. They select the appropriate specialties, methodologies, and tools to address the problem, working both within and across disciplines to draw in specialized expertise, as needed. They are comfortable working alongside specialists from the traditional sciences (though in a role distinct from them), and they serve as an intellectual bridge between natural scientists, social scientists, and other stakeholders. Particularly in problems that emerge from interactions between technology, people, and social processes, the lateral rigor of ISAT practitioners can be helpful.

Description of the Habits of Mind: By using a problem-centric approach, ISAT practitioners

- Analyze problems and develop solutions that account for the systems from which they emerge. They typically extend the problem boundary to include the relevant actors or forces involved, including those associated with both the natural world and those associated with social or cultural institutions or norms
- Adopt a long-term perspective on the problem by seeking to understand the history of its evolution and how it might unfold in the future, given the dynamic forces in play
- Know when and where to seek outside expertise from those who have a greater depth of knowledge in the disciplinary tools needed to tackle important parts of the problem.
- Identify and engage relevant and diverse perspectives (for example, stakeholders, analytical viewpoints)
- Identify correspondingly diverse tools from multiple disciplines that are needed to address the problem
- Explicitly address the political context and dynamics that are relevant to the problem, recognizing that even the definition of the problem can vary from one stakeholder group to the next. For example, the ISAT practitioners want to know
    - ✓ who is paying for, supporting, and/or subsidizing the problem solving effort; and
    - ✓ how those parties might be working to shape the definition of the problem and the tools that are used
- Employ good scientific methodologies to understand and solve problems. They are literate in the sciences and in technology. They are able to use social and natural scientific methodologies to build knowledge about the problem and its possible solutions. They are comfortable working with a variety of data and form judgments and conclusions based on sound analyses, while recognizing the uncertainty and limits of their conclusions. ISAT practitioners are
    - ✓ familiar with the major conceptual schemes (the theories) that form the foundations of the sciences, how they were arrived at, and why they are widely accepted
    - ✓ cognizant of the norms and methods of science and key scientific terms and concepts
    - ✓ able to distinguish between observation and inference
    - ✓ skilled with hypothesis formulation and testing
    - ✓ skilled in qualitative and quantitative modeling methods to understand system behavior and to evaluate potential actions to influence future behavior
    - ✓ able to identify the appropriate scale(s) at which a problem can effectively be addressed (local, regional, global)
- Employ a variety of problem-solving methods and match them to situations in which they are most relevant and effective.
- Assess possible solutions for their technological, economic, cultural, social, and political merit. This assessment implies paying attention to the political, geographical, historical

and cultural dimensions of the problem. For example, the ISAT practitioner wants to know

- ✓ how technological dimensions of a problem interact with other dimensions
- ✓ which private and public interests are seeking to shape solutions and which interests are being excluded, such as the views of workers, residents, and neighbors
- ✓ how to incorporate democratic, fairness, and equity perspectives when formulating solutions
- ✓ the international implications of the problem and proposed solutions
- ✓ how to account for the complex interactions among these actors and forces in the solutions proposed, and
- ✓ the broader impacts of solutions on the systems of which they are a part

- Evaluate solutions both before and after implementation to assess their system-wide impacts
- Are self-reflective about their analysis, careful to articulate their own mental models and assumptions about the problem, and to subject those models to scrutiny

The BS ISAT Program thus provides students with a broad foundation in science and technology, together with problem-solving, teamwork, and communication skills that prepare them to be effective contributors in an increasingly multi-disciplinary work environment and in a multicultural and diverse society.

5. Student Learning Objectives

In contrast to the Program Educational Objectives (PEOs), **Student Learning Objectives (SLOs)** have been established to identify and assess the skills, capabilities, and knowledge that each student should be able to demonstrate *immediately upon completion* of the BS ISAT Program. The SLOs are organized by BS ISAT as *goals* and *supporting objectives*.

ISAT's goals and objectives reflect a program that is intentionally broad based in the sciences, focused on problem solving and use of technology, and which integrates social issues into the analysis of modern issues and processes. There are 11 primary goals with 78 specific objectives. Goals A - J (and their Objectives) were adopted by the faculty in September 2004 following a year-long process to revise the original program goals. Goal K was adopted on May 9, 2008 after an Integration task force spent 18 months defining "integration" in the ISAT context and drafting the goal and its nine objectives. The complete list of SLO goals and objectives appears in the Appendix.

Revisions of the Goals and Objectives that compose the SLOs are drafted by a designated committee or task force and then presented to the faculty for comments and a vote. These groups are open to input from all members of the BS ISAT faculty, and the goal revision groups are encouraged to actively seek this input throughout their deliberation and review process.

6. BSISAT Curriculum

ISAT was designed with a unique curricular structure, which, despite some changes, has remained conceptually consistent since the inception of the program in 1994. Unlike many multi-disciplinary programs, virtually all of the courses are taught within the program, rather than utilizing existing courses from other programs on campus. This makes sense in light of the great differences between ISAT and traditional disciplinary programs in approaching STEM education in terms of course structure, pedagogy, and even content (to some extent). The courses in the curriculum, plus the learning environment we create, constitute the undergraduate educational experience that produces the desired program outcomes. In the ISAT Program we have three types of courses.

- **Foundation Courses** – These courses are taken by all students during their first and second years in the program.
- **Sector Courses** – Every student is required to take two courses and sometimes a lab course in *three* of the six ISAT Sectors: Applied Biotechnology, Energy, Engineering and Manufacturing, Environment, Information and Knowledge Management, and Telecommunications. These courses are usually taken in the junior year.
- **Concentration Courses** – Every student concentrates in at least one and sometimes two or three of the sectors. These courses are usually taken in the senior year. ISAT 491, 492 and 493 together constitute the senior capstone experience.

The overall structure of the ISAT Program thus resembles an upside-down pyramid (Figure 2) that starts with a range of fundamental building blocks before narrowing to different problem areas and ending with more focused study in one area. Thus, students begin with broad **Foundations** during the first two years, narrowing to three strategic **Sector** areas during the third year, and focusing on one **Concentration** area during the fourth year. In addition, every student is required to complete a capstone project – either solely or as part of a team – that addresses a real-world problem on some level, although the scope and specificity of the projects vary enormously.

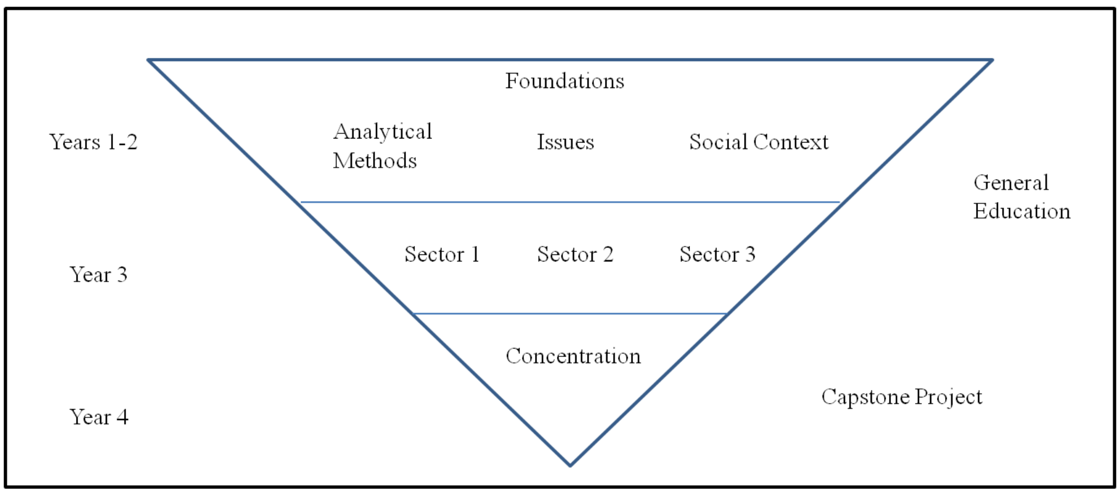

Figure 2: Conceptual diagram of the ISAT curriculum. Note the increasing focus as the student progresses through the curriculum.

The curricular structure is designed to give students broad exposure to a number of different problem areas and tool sets related to science and technology, while also providing an opportunity to delve deeper into areas of particular interest. Students thus have the chance to experience many different fields, which often leads to an evolution in individual students' interests while they are in the program. ISAT is thus ideally suited to the student who at age 18 or 19 doesn't know exactly what field in science/ technology he or she most wants to explore. The Foundations courses (see Figure 2) fall into three different areas: Analytical Methods, Issues, and Social Context. Five Analytical Methods courses cover core concepts in math and science, including calculus, physics, computing, and statistics as well as a course in Instrumentation and Measurement. The four Issues courses teach concepts in a broad range of disciplines including chemistry, biology, physics, engineering, and ecology, in the context of problems in the areas of Environment, Engineering and Manufacturing, Applied Biotechnology, and Energy. The two Social Context courses explore the ways in which social, political, cultural, and economic forces shape the evolution and implementation of technology and the practice of science as well as introducing students to policy as a tool for solving social problems (often hand-in-hand with more technical solutions).

Upon completing most of their Foundations courses, ISAT students select three of the six strategic Sectors (Figure 1) to focus on. Each Sector is a 7-credit sequence (two 3-credit courses and a 1-credit lab) and covers important technical, scientific, and socio-economic concerns in that area. Different sectors have different mixes of technical and social scientific content, but all of the sectors include some social context and most have a lab component. The sector courses let students further explore the areas that interested them most in the Foundations courses, while retaining a fair amount of breadth. Although students sometimes struggle to find a third sector that suits their tastes, the requirement to have three different sectors has always been viewed as a core value, because it requires students to achieve a depth of knowledge beyond the entry level in multiple fields.

	Area	**Credits**
Years 1-2	General Education (across campus)	31
	Foundations (includes 11 credits of Gen Ed Cluster 3)	
	Issues in Science and Technology	14
	Social Context	6
	Analytical Methods	17
Year 3	Strategic Sectors	20-21
Year 4	Concentration	12
	Capstone Project	6
Years 3-4	Electives	14-15
	Total	*120-121*

Table 2: The ISAT curriculum (with credit hours) at a glance

During the final year, students focus their studies more narrowly in one (or sometimes more) areas in the Concentration courses. Each Concentration includes four courses, although the amount of choice and the range of courses offered in each area varies substantially. Concentrations give ISAT students the chance to acquire a depth of knowledge in an area of interest to them, which many students feel helps them to market themselves as having an area of relative expertise. Students must concentrate in an area that they took sector-level courses in. They are free to double concentrate. ISAT students also have the option to create their own concentration in what is called a tailored concentration; this only requires the approval of an advisor and the Program Director. This tailored concentration option allows students almost unlimited choice in shaping their focus during their final year.

In addition to the concentration courses, every student must complete a capstone project, either individually or as part of a team. These capstone projects address any real-world issue that builds on some subset of the tools and concepts learned during the student's ISAT career; given the breadth of the Program, there is a very wide range of capstone project topics. Some projects resemble a more traditional scientific research project, particularly in the biotechnology area. More commonly, a project will involve addressing a problem of interest to a local business, governmental entity, or community group. The scope of these projects – both in a topical and in a geographic sense – varies greatly. The number of individual and team projects is usually about the same. Students concentrating in different areas often team up to tackle a project that would be hard to address with a team consisting of students from only one area. For example, a recent project consisted of constructing an online calculator for wind energy, involving students and knowledge from the Energy and the Information and Knowledge Management areas. All capstone projects have both an oral and a written component. In addition to writing up the work in a formal report, every student must participate in a public presentation as part of the ISAT Senior Symposium.

7. Outcomes

In addition to the more general outcomes designated by the Program Educational Objectives (PEOs), BS ISAT also prepares students for professional careers, continuing their education in graduate school, or both. Alumni Surveys administered by the JMU Office of Institutional Research (OIR) in 2010 and 2011, indicated that nearly half of 50 respondents had secured jobs upon graduation and three fourths had secured jobs within 6 months of graduation. About half of the respondents had plans that included graduate school.

Of the respondents who had attended graduate school or were currently enrolled, fields of study ranged from education to business programs to civil, environmental, and mechanical engineering. Graduates participated in programs at both the Master's and Doctoral levels.

Many BS ISAT graduates choose typical career paths associated with this major. However, some graduates choose unrelated careers that utilize skills and experiences developed during their years in college. Keep in mind that some fields require graduate study or further training. The listing below offers examples of possible career paths and is not meant to be comprehensive.

- Alternative Energy Consultant
- Applications Developer
- Artificial Intelligence Technologist
- Biological Weapons Trainer
- Biotechnologist
- Business Security Consultant
- Communication Systems
- Computer Simulation Specialist
- Computer Software Developer
- Database Administrator
- Defense Program Analyst
- Energy Industry Analyst
- Energy-Efficiency Consultant
- Energy Engineer
- Environmental Consultant
- Environmental Protection Specialist
- Expert Systems Developer
- Forensic Scientist
- Global Forecast Analyst
- Graphic Arts Technologist
- Health System Analyst
- Information Technology Technician
- Laboratory Technician
- Manufacturing Engineer
- Manufacturing/ Production Manager
- Market Analyst
- Materials Scientist
- Medical Imaging Assistant
- Peace Corps Worker
- Patent Classifier
- Pollution Control Technologist
- Production Control Supervisor
- Project Controls Engineer
- Quality Assurance Technologist
- Quality Control Technician
- Quality Engineer
- Recycling Product Developer
- Renewable Energy Specialist
- Research Technician
- Scientific Sales and Marketing
- Security Specialist
- Software Development Specialist
- Stream Restoration Specialist
- Sustainability Specialist
- Systems Administrator
- Technical Consultant
- Technology Instruction Designer
- Technology Manager
- Telecommunication Technician
- Waste Management Specialist
- Web Developer

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Appendix: ISAT Student Learning Objectives (SLOs)/Program Goals and Objectives

Goal A. ISAT graduates apply and integrate concepts in mathematics, physical science, biological science, earth science, and technology

Objectives:

A-1. Illustrate and apply the principle of conservation of energy and its applicability across all natural sciences.

A-2. Discuss the fundamental probabilistic nature of (a) the physical universe and (b) many of the systems and problems encountered in science, engineering and business.

A-3. Describe the concept of equilibrium, including stable and unstable equilibrium, in the context of static and dynamic component and system behavior.

A-4. Apply the concept of rate of change and cumulative effects to real-life phenomena, and relate these concepts to calculus.

A-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.

A-6. Describe the organization of the biosphere, hierarchies of life, the effects of living on the Earth, and the history of life on Earth.

A-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 apply sound experimental methodology

Objectives:

B-1. Explain the basic premises of scientific method as it applies to both social and physical sciences.

B-2. Choose an appropriate sampling method to get a representative sample.

B-3. Explain the limitations of measurements and how to correctly report error and uncertainty.

B-4. Maintain laboratory notebooks that meet professional and legal standards

B-5. Select and understand appropriate instruments for solving problems, and demonstrate competence in their use.

B-6. Explain why calibration of instruments is critical to good science and engineering.

B-7. Identify designs of experiments that may lead to biased research findings.

B-8. Design and critique simple experiments for collecting scientifically valid data.

B-9. Report and analyze data in a neutral, comprehensive, and impartial manner.

B-10. Apply appropriate statistical inference tools in data analysis.

Goal C: ISAT graduates are familiar with the professional requirements for the acquisition and use of information and data

Objectives:

C-1. Describe the scope and responsibilities of "fair use" of copyrighted material.

C-2. Explain the professional requirements for protecting "personally identifiable information;" that is, data and records that may be linked to a real person.

C-3. Explain the professional and legal requirements for the use of animal and human subjects in research.

C-4. Explain the basic procedures for "chain of custody" of research and evidence samples.

C-5. Identify research scenarios that involve research misconduct such as fraudulent data collection and falsification of data.

Goal D: ISAT graduates work effectively in multidisciplinary teams

Objectives:

D-1. Organize tasks, plan work schedules, promote responsibility, define product and interim deliverables, and establish effective expectations and sanctions to facilitate the work of different kinds of teams.

D-2. Display effective interpersonal communication skills in teams or group processes by eliciting/recognizing member contributions, synthesizing opinions, mediating conflicts, and reaching group consensus.

D-3. Employ tools for assessment of the roles of individuals within a team and for the team as a whole.

D-4. Describe when a team is appropriate and when it is not.
D-5. Demonstrate the ability to work with people of different disciplines, from diverse cultures, and with varying personal styles.

Goal E. ISAT graduates can identify, formulate, analyze, and solve technological problems and understand their societal implications
Objectives:
E-1. Evaluate a question or problem with respect to the technical, social, and economic factors impacting it.
E-2. Clearly define and articulate a research problem or question.
E-3. Identify a problem's essential elements, interactions and transformations, and distill the key goals to be achieved.
E-4. Develop alternative problem solutions using a variety of methods and tools.
E-5. Evaluate problem solution alternatives against goals, objectives, constraints and criteria of the problem. Determine how well the proposed solutions solve the problem.
E-6. Evaluate the feasibility of alternative problem solutions with respect to the technical, social, and economic factors impacting them.
E-7. Use logic, expert systems, mathematics, and verbal reasoning to support a solution or hypothesis through a chain of reasoning from premises to conclusions.
E-8. For a specific project, be able to conduct basic economic feasibility analysis.

(Revised 2012) Goal F: ISAT graduates identify and apply the principles of ethics applied to professional careers in science and technology.
F-1. Recognize when a situation involves ethical issues or that a problem includes an ethical component.
F-2. Analyze the ethical dilemmas in existing and emerging technologies using fundamental ethical theories.
F-3. Conduct moral reasoning for a complex ethical problem and provide rationale for a moral agent's decisions.
F-4. Evaluate past ethical decisions.
F-5. Evaluate professional settings and research scenarios for conflict of interest, fairness, justice, disclosure, and social responsibility.
F-6. Explain when and how a profession's code of ethics may be useful and applicable.

Goal G. ISAT graduates communicate effectively on social, scientific, and technical matters
Objectives:
G-1. Prepare and deliver oral presentations at a technical level appropriate to the audience.
G-2. Compose a variety of professional documents including memos, meeting minutes, letters, simple proposals, press releases, and executive summaries.
G-3. Write effective titles, captions, labels in order to communicate data and analyses.
G-4. Conceptualize, write, and revise technical reports and research papers suitable for the intended audience.
G-5. Tailor written and oral communications appropriately by recognizing and accommodating audience diversity in areas such as education, socioeconomic, level and culture.
G-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.
G-7. Write a clear, concise, and complete problem statement identifying needs, stakeholders, interest groups, objectives and target specifications, preferably in measurable terms.

(Revised 2012) Goal H: **ISAT graduates analyze science and technology within broader global, political, economic and social contexts.**
H-1. Explain the role of social and political institutions in solving scientific and technological problems at the local, national, and international level.
H-2. Describe how social interests are expressed through democratic political processes.
H- 3. Analyze how the interests of private and public stakeholders affect outcomes of political and economic processes.

H-4. Suggest institutional designs or policy changes at the appropriate levels of organization to achieve public goals and express collective values.
H-5. Explain how market forces influence technology development and adoption.
H-6. Identify limitations of market forces to produce sustainable and socially optimal outcomes.
H-7. Describe how societies support technological change through intellectual property and science and technology policies.

Goal I: ISAT graduates are autonomous, self-directed learners who recognize the need for lifelong learning.
Objectives:
I-1. Demonstrate positive attitudes toward learning.
I-2. Describe the necessity for taking personal responsibility for sustained, self-directed learning throughout one's life.
I-3. Recognize the integrated and interdisciplinary nature of current issues in science and technology and be familiar with appropriate research tools and information sources in a variety of academic disciplines
I-4. 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.
I-5. Select appropriate information retrieval tools.
I-6. Critically evaluate all information sources for reliability, validity, accuracy, authenticity, timeliness, and bias.
I-7. Identify factors that add bias to popular accounts of scientific or technological issues.

Goal J: ISAT graduates use the computer as an effective problem solving tool
Objectives:
J-1. Model and simulate processes and systems on computers as a means of generating data and understanding phenomena.
J-2. Use computers to enter and retrieve data, as well as acquire measurements directly from instruments.
J-3. Use standard software tools to test and evaluate hypotheses.
J-4. Use computers to manage projects through planning, tracking, and communicating with peers and instructors.
J-5. Use computers for exploratory data analysis; plotting data, producing descriptive statistics, and exploring relationships among variables.
J-6. Select and utilize appropriate data visualization tools to understand data and communicate analyses effectively.

Goal K: ISAT Graduates are integrated problem solvers who look out from the perspective of a problem and then assemble the tools and knowledge needed to solve it. To this end, ISAT students:
K-1. Identify relevant disciplinary knowledge that can help to solve a problem
K-2. Describe the importance of contributions from the broad variety of stakeholders for a particular problem
K-3. Compare and contrast the description of a problem from multiple viewpoints
K-4. Use tools from more than one discipline to solve a problem.
K-5. Identify possible emergent behavior in systems, i.e. that a system may be more complex than the sum of its parts.
K-6. Address complexity, ambiguity, and emergent behavior in problem solving
K-7. Evaluate the consequences of choosing to address a problem at a particular scope
K-8. Choose an appropriate scope to address the problem given available resources
K-9. Demonstrate the ability to remain aware of short-term and long-term goals and micro and macro scales simultaneously, i.e. can see the forest AND the trees