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Development of a Limited Undergraduate and Graduate Space Studies Curricula

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Abstract

Embry-Riddle Aeronautical University (ERAU) began developing a non-technical space studies curricula by introducing an undergraduate minor in 1990. Careful planning of the curriculum and favorable student interest in the space subjects assisted in the success of the nine-course program. The success of the minor has allowed the University to study the creation of broader undergraduate and graduate degree programs in space studies subjects.

Developing a graduate program is more difficult than undergraduate programs because of the necessary ties to a strong undergraduate curriculum and because of the need for supporting courses and experienced faculty members. The structure and delivery of the graduate space studies curriculum at ERAU was developed within an already-existing program, the Masters of Aeronautical Science. Details of the needs study and both graduate and undergraduate curriculum are presented as examples of a limited and successful space curriculum development.

Introduction

Setting a course for building a space-oriented curriculum may be as simple as following examples from other colleges or universities. However, a standard formula to create the curricula, or adapt specific courses to the faculty strengths or the student needs, may not be possible because of the unique character of a school, the complexities of budgeting and planning, or the occasional academic inflexibility encountered within both large and small institutions.

The smaller college or university has both advantages and disadvantages in curriculum development when compared to larger schools. The smaller school must be aware of the need for curriculum changes to accommodate changing enrollments and post-graduate employment trends if funding is limited primarily to student tuition. However, recent severe state budget deficits prove to be more restrictive on the public institutions than on some private counterparts. Moreover, the traditions of instruction and administration within a large institution can be difficult to overcome when making additions or adjustments to degree programs. Especially today, the success of a new program often needs to be demonstrated before acceptance - making program innovation difficult.

The School

Embry-Riddle Aeronautical University is a private institution with two campus centers and extended education sites located throughout the world. The Daytona Beach, Florida and Prescott, Arizona residential campuses have approximately 6,800 students enrolled with an additional 13,000 part-time (6,000 full-time equivalent) students enrolled throughout the 116 Extended Campus sites. Together, the two residential campuses produce more than seven percent of the aerospace engineering graduates in the U.S. each year.

The Degree Programs

A number of degree programs are available at the University covering a variety of disciplines associated within aerospace and aviation fields. The degrees offered include Associate, Bachelor's and Master's level programs. The engineering programs include Aerospace Engineering, Electrical Engineering, Engineering Technology and Engineering Physics. Flight-oriented degree programs at the Bachelors level include Aviation Technology, Aeronautical Science and Professional Aeronautics. Fourteen other Bachelors and Associate degree programs include Aviation Computer Science, Aviation Business Administration and Aerospace Studies. Fifteen minors are also available to the undergraduate student, most of which are also oriented towards aerospace and aviation subjects.

The Aeronautical Science Department at the Daytona Beach campus provides the greatest potential support for the undergraduate space curriculum since it has the largest enrollment at a single campus. These students show a strong interest in flight-related courses, especially space operations classes. The aerospace engineering and engineering physics also include several space-oriented courses, although these students have a more rigorous diet of mathematics and physics, hence fewer elective courses available. The distribution of students and their interests played a significant role in determining the level of coursework and mathematical preparation for the Space Studies minor. A more challenging course curriculum would more likely have reflected faculty preference than the interests of the majority of the approximately 1200 students who were surveyed when determining the curriculum feasibility.

Masters Degree programs are available in Aerospace Engineering, Aeronautical Science, Technical Management, Software Engineering and Business Administration in Aviation. The total number of Masters students at all campuses is approximately 3,500 and widely scattered geographically. This wide campus separation has led to extended classroom delivery through video classroom and electronic mail distance education methods.

The Faculty

As in most college and university campuses, the faculty at ERAU plays a vital role in establishing and maintaining the curricula through democratic debate and administrative agreements. Because most curriculum changes or additions require extensive preparation time, resources must be available to the faculty for developing these courses and programs. If release time or support funds are not available for course development, the burden of curriculum advancement is placed on interested faculty members and their donated time.

One of the primary elements in development of these courses has been, and continues to be, the involvement of active, ambitious faculty members who are dedicated to not only teaching and research, but course development and following the courses through a sometimes torturous approval process. Additional support for developing a specialized curriculum from the university administration is improved by the participation of the faculty

in related research and, of course, outside funding. At ERAU, a number of faculty at the two main campuses are actively involved in research in the near-Earth space environment, astronomy, atmospheric physics and closely related fields, making the development and approval of space-related curriculum easier.

Curriculum Initiation

An initial survey of the students at the Daytona Beach campus indicated enthusiastic interest in and support for space-related courses requiring lower to mid-level math skills. A development committee was empaneled to study a possible space curriculum for the University using faculty members to represent each department. The recommendations were reviewed by the academic officers and sent through the curriculum approval process for debate. Concerns for the costs of and the actual need for the new curriculum, as well as course content, extended the approval process by approximately two years but with positive contribution.

The decision to implement the Space Studies minor within the Aeronautical Science Department was based on a greater course content flexibility in the degree program, a greater number of students with interests in this subject area, and the number of students on the Daytona Beach campus. This program choice has obvious restrictions on the level of scientific detail, although the variety of subjects offered in this program is greater than it would be in the Engineering Physics or Aerospace Engineering Degree programs.

Masters Specialization

The development of the Masters specialization in Space Studies at ERAU followed soon after the implementation of the minor program. The faculty responsible for proposing and instructing the graduate and undergraduate programs were the same as those contributing time and effort to develop the Masters curriculum. Although the subject areas in the Masters courses were similar to those in the minor, the development, approval and implementation were not.

The primary difference in the development of the Masters specialization compared to the minor was in the evaluation of the students and defining the University needs. Since the Masters level courses are available at a number of ERAU campuses and the potential students are widely scattered, the survey study for the program was limited to the undergraduate Space Studies students. The limitations of using a limited sample are obvious. However, it was assumed that the majority of the students entering the graduate program would have taken courses in the undergraduate Space Studies, or have enrolled in the Space Studies minor. A beginning enrollment for the Masters was estimated at ten from the survey response, based on a conservative interpretation of the results, with an estimated continued enrolment of twenty within two years.

Delivery methods for the ERAU Masters programs are more versatile than those of the undergraduate courses due to the use of distance education/video presentation methods by the Continuing Education and the Independent Study divisions at the University. This allows for the simple expansion of student enrollment in the Masters specialization in Space Studies as the remote ERAU education sites begin to offer the program.

The Courses

Undergraduate

Several departments at the Daytona Beach campus share in the space subjects offerings, with several courses in spacecraft design, planetary and atmospheric physics and astrophysics. These courses are not available to the majority of students because of the mathematical prerequisites.

The initial offering of Space Studies courses was approved as a minor approximately one year after the first courses were taught as experimental courses. The minor was made available to anyone with an interest in the subject, and who satisfied the prerequisites.

The minor is intended to assist the student in employment positions with managerial - not technical - potential in the aerospace industry. Although the non-technical curriculum may impose limitations on the student's ability to understand detailed concepts in spacecraft design and the space environment, the function of the minor is to extend the degree to fields outside of the student's major course of study and not necessarily to prepare them completely for their career goals.

The courses in the Space Studies minor which are offered on the Daytona Beach campus are listed below with the class level of course numbers approximately corresponding to; 100 - freshman, 200 - sophomore, 300 - junior and 400 - senior.

1. SP 110 Introduction to Space Flight

Description: A survey of the major aspects of space flight. Topics covered include the history of space flight, Space Shuttle operations and present and future commercial, industrial and military applications in space.

2. SP 200 Planetary and Space Exploration

Description: This is a survey course of the U.S. and international space programs. The student will be introduced to the Earth and its space environment, to methods of scientific exploration and to spacecraft and payload criteria.

3. SP 210 Space Transportation System (STS)

Description: The U.S. Space Shuttle is reviewed in flight profiles, guidance and navigation control, proximity operations and brief hypersonic orbiter aerodynamics. Included are manned space flight operations, supporting systems, the Space Shuttle missions and future STS operations.

4. SP 215 Space Station Systems and Operations

Description: This course is designed to provide a brief study of the Space Station flight operations, its supporting elements and planned component systems. This will include commercial applications, logistical support, maintenance and servicing design concepts. The subjects are covered at the introductory physics level.

5. SP 220 Life Support Systems

Description: The requirements and design criteria for life support systems in space and on other planets are outlined through a human physiology, spacecraft limitations and requirements, the space environment and a review of past and present life support design.

6. SP 300 Satellite and Spacecraft Systems

Description: Orbital satellites and spacecraft are discussed according to their application, design and environment. The power systems, shielding and communications systems are reviewed along with the missions, space environment and limitations.

7. SP 400 Introduction to Space Navigation

Description: This is an introductory course to space navigation. A review of basic mechanics and astronomy includes Kepler's laws and Newtonian motion, time definitions, physical characteristics of the solar system and the Earth/Moon system. Emphasis is on navigational techniques and space navigation methods in the Earth's upper atmosphere and to the nearby planets.

8. SP 425 Selected Topics in Space and Aerospace

Description: Problems which relate to the engineering, implementation or technology related to space flight or the aerospace industry are selected by the instructor. These courses provide the student with experience in simple numerical and analytical problem solving in several applications.

In addition to these courses, a sophomore level mathematics course, Space Math, MA 125 is available to the student interested in these areas, which offers many of the simpler math tools to the students.

Other, more rigorous space-oriented courses are offered in other departments with much different prerequisites and expectations for the student. These are listed below.

9. ES 409 Space Mechanics

Description: The mathematics and physics of the two-body problem. Orbits, satellite launch, orbit transfer, interception and rendezvous, and celestial astronomy. Geodynamics; gyroscopic instruments; precession and nutation; inertial navigation. This course is based heavily on vector dynamics, differential equations and spatial geometry, as well as computer programming skills, which are used in writing computer program solutions of selected two-body problems. Prerequisites include advanced calculus, mechanics and scientific programming.

10. EP 410 Space Physics

Description: Origin, evolution and structure of neutral and ionized terrestrial atmosphere. Effects of the Sun's electromagnetic radiation on ozone shield. Photo ionization and thermal structure of the neutral atmosphere as well as the ionosphere and magnetosphere. Solar disturbances and their effects on satellite orbit decay and on long distance communication. Studies of composition, thermodynamics and physical processes of the near-earth space environment, rocket and satellite monitoring and remote sensing. Numerical and instrument design projects are included. Prerequisites are advanced calculus and second semester physics.

11. PS 401 Astrophysics

Description: A study of the basic physical processes operating in the astronomical environment; stellar structure and evolution, the interstellar medium, galaxies and cosmology. Astrophysical concepts are emphasized, thus underlining the common features operating within many astronomical systems. Prerequisites include modern physics and advanced calculus.

Graduate

1. MAS 511 Earth Observation and Remote Sensing

Description: U.S. and international solar system exploration programs are reviewed and related to the current and proposed Earth-research projects. Examination of these research programs will be structured towards defining problems related to planetary observation, environmental changes on Earth, and resource exploration. Formatted research data from Earth-resource satellites and EOS sources will be used for demonstrating specific research techniques, exploration methods, and several of the economic and social elements of Earth exploration.

2. MAS 512 Space Mission and Launch Operations

Description: Launch control, mission operations and the facilities for manned and unmanned missions at U.S. and foreign sites are outlined. Satellite and spacecraft launch facility system discussion covers safety, meteorology, communications and tracking, navigation and control systems. Mission control operations and systems will include spacecraft project descriptions and control site operations. Computer-based simulation instruction provides mission- and site-specific operation detail.

3. MAS 513 Space Habitation and Life Support Systems

Description: This course addresses the problems related to space-flight induced changes in the major body systems which need to be solved in this decade to develop countermeasures for maintaining the health of crewmembers on long duration space operations. Physiological

elements of zero gravity environment, radiation hazards and protection measures are explored, along with physical and chemical closed-loop life support systems for long duration space missions. More elaborate life support systems for larger manned missions and space colonies are outlined for further student development.

4. MAS 601 Applications in Space: Commerce, Defense and Exploration

Description: The scientific, military and commercial interests in international and domestic space programs are examined throughout the history of space flight. The needs of commercial space endeavors and methods of expanding space technology into manufacturing are contrasted to the importance of scientific exploration and the requirements of military space operations. The justification, development and costs of scientific exploration programs, defense-related projects and commercial endeavors are used to study the evolution of space missions and the development of future programs.

The Costs

A major concern in implementing any new curriculum is the costs; the greatest of which is the faculty salaries and overhead. The eight Space Studies minor courses listed above would require one full-time faculty member to teach, assuming that an instructor could be found with the experience. To ease the teaching load and reduce the dependence on the limited faculty, it is expected that one more full-time faculty member will be added within the next few years.

Course development costs can be significant, especially when considering the course materials and texts. Had this program required outside development, support from the administration would have been questionable. Similar development cost concerns for the graduate specialization were encountered but were less a factor because of the history of the faculty members donating development time for the courses and the success of the minor.

The cost for additional facilities for instruction were minimal but involved some expansion of the main campus library's resources and the purchase of a number of microcomputers with CD-ROM capability and video disk player systems. Computer facilities, graphics packages and compilers used for elementary problem solving in the courses were already on the campus and available for classroom use.

The Future

The Space Studies programs at ERAU have begun to extend the curriculum and commitment of the University in the direction space operations and education. A full undergraduate or graduate degree is not yet feasible at the University but the foundation for developing both is in place.

In order to involve more students in the Space Studies curriculum, as well as other space-related courses, we have begun a series of spacecraft design, fabrication and flight projects. The projects will integrate funding research, engineering design and in management courses and, of course, the Space Studies curriculum. Cooperative education agreements are also being developed with NASA and several industry partners for these projects as well as other campus programs.