MODEL ACTIVITIES FOR COORDINATING CORE ENGINEERING COURSES

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Abstract

The United States Coast Guard Academy (USCGA) is a small undergraduate institution of approximately 1000 cadets with eight majors. The four engineering majors require students to take basic engineering courses such as Statics, Mechanics of Materials, and Dynamics. These courses are offered in multiple sections in a given semester and serve as the gateway to a career in engineering. A coordination system is employed at the academy for each service basic engineering course in order to ensure uniformity in multiple sections. Importance is placed on uniformity, which has successfully been achieved through activities including frequent faculty communications using a variety of media, standardized exams and grading across all sections, in-class demonstrations, and feedback to assess coverage. A course coordinator, typically a faculty member who has taught the course before, is selected to champion this effort. It is the course coordinator's responsibility to ensure that the same material is presented and assigned in all sections. The duties of the course coordinator in consultation with other instructors includes the selection of a textbook, review of previous course materials, revision of course objectives, development and update the syllabus, assignment of homework, development of quizzes, preparation of handouts, coordination of exam development and grading, coordination of faculty resources for tutoring and review sessions, chair end of course review, and development of statistical assessment data. In this paper, the authors present the course coordination model used at the USCGA using the Mechanics of Materials course as an example. Activities that have been proven to ensure uniformity amongst multiple sections, effective communication between instructors, and teaching practices that enhance student learning are also discussed.

Introduction

Multiple sections of the same course are very common in most universities throughout the country. For the most part, these sections may not be coordinated with instructors who are free to select different textbooks, assignment and run the course how they see fit. This approach could result in uneven distribution of workload and resources as students always seek out the least demanding instructors. Furthermore, this could also lead to very different concepts and information learned by students that could result in confusion in follow on courses as to what students have learned or are accountable for. A study conducted by Strong and Moskal [1] suggests that there could be an impact of coordinated courses on students' progression into engineering courses. They compared the assigned grades and impact on student selection of engineering courses later on of coordinated and non-coordinated courses in mathematics and computer science. Strong and Moskal facilitated the coordination of a course by assigning an instructor to lead the coordination efforts ensuring uniformity across sections and organizing the collaborative efforts between the instructors.

Whalen et al [2] also presented some benefits of coordinating courses. They found that having professors assigned to cover multiple sessions of these core courses without coordination and guidance resulted in high turnover for students from engineering. While having a faculty-team approach (coordination) in teaching the core freshman engineering courses increased the freshman-to-sophomore retention rates in engineering. This team teaching consisted of three primary factors that contributed to its success. One aspect was the process of developing, using, and improving a shared curriculum by arranging for faculty to meet and exchange ideas on a regular basis. Another aspect was the core of committed and dedicated instructors whose primary job was to teach freshman. The third aspect was the coordination with first-year advisors and other team members to monitor and help each individual student as needed. The course coordinators maintained consistency, shared resources, avoided duplication of effort, and fostered motivation. They were responsible for conducting biweekly meetings and managed issues that arose concerning curriculum, teaching media, physical facilities, and scheduling.

Having identified the benefits of course coordination, USCGA has successfully used this approach for more than 10 years. The approach used at USCGA, while described here in a linear fashion, is cyclical in nature with constant feedback within the activities shown in Figure 1. Apart from the identified benefits, another contributing factor to using a course coordination approach is that a third of the faculty is rotating military personnel. Course coordination helps maintain a high level of academic consistency and performance as new rotating military faculty (RMF) develop their teaching skills. As has been shown from studies by Strong [1] and Whalen [2], student performance improves when the faculty is well prepared, has continuity in teaching, and is enthusiastic. The course coordinator acts as a resource to provide that stability across the different sections.

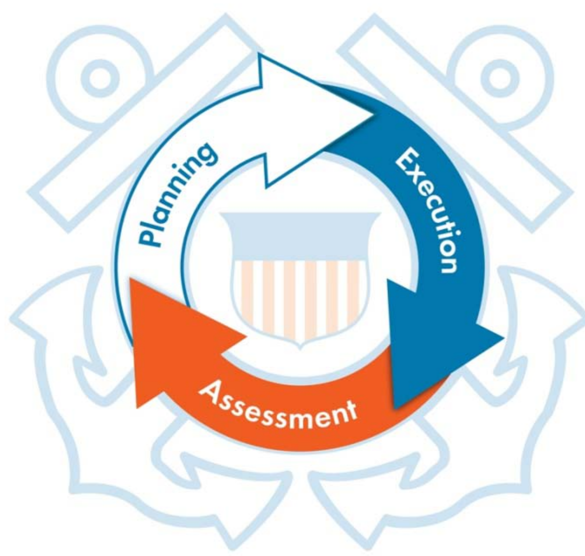

Figure 1: Course Coordination Cycle

Planning: Activities Prior to the First Day of Class

In preparation for the new semester, the course coordinator commences by reviewing the End Of Course Review (EOCR) and course objectives from the previous offering to identify those new ideas which worked well, and areas for improvement. As a part of the EOCR process, the multiple instructors of this course provide feedback for recommended content changes and the needs of subsequent courses. This is especially true for Mechanics of Materials, since it is a foundational course for the three mechanics based engineering majors at USCGA. Each discipline has several topics that they would prefer to be covered over others, resulting in discussions and feedback about the course. Armed with this information, the coordinator then reviews the textbook to ensure adequate coverage of these topics. The format of the current textbook is similar to that used in the Statics course taken the previous year. The coordinator in this case has to investigate if there is a new edition and determine when to transition to the new edition along with any supporting teaching aids. During the preparation for the new semester, the coordinator works with the lab technician in developing new in-class models to demonstrate some of the principles covered in the course. A schematic of the planning process is shown in Figure 2.

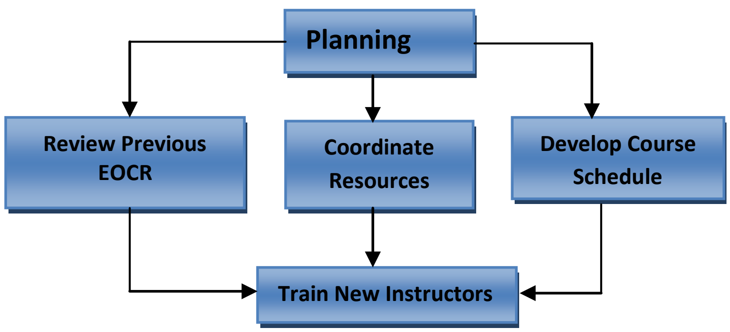

Figure 2: Planning Phase

The next step is to plan the course lectures, meetings, exam dates and lab schedules. This step is done to ensure the topics in the classroom and lab are coordinated to provide maximum topic reinforcement for students. Some planning requires coordination beyond the engineering department, for example, attempting to eliminate conflict in exam schedules of the science courses students take concurrently. Once the course topics and order of coverage are finalized, the coordinator modifies the existing list of lesson objectives based on feedback from the EOCR and develops homework and project assignments for the new semester. Some of the homework and project assignment developments are assigned to other instructors and reviewed by all course instructors before adoption in the course. A common practice is to plan a two hour block to run through all four of the labs included in this course. This exercise allows new instructors and lab technician opportunities to see the nuances of the testing lab procedures, and become knowledgeable on what has to happen behind the scenes to ensure the smooth running of the labs during the semester. Besides faculty resources, other assets coordinated include the assigned lab technician and campus-wide resources. The lab technician is essential n conducting the four formal labs in this course. The technician is responsible for preparing samples, setup equipment, and provides technical assistance for the end of semester open-ended project students must complete. This open-ended project involves the development and performance of an experiment to confirm one of the topics covered in the class. Finally, the course coordinator works with campus-wide resources, including the John and Erna Hewitt Writing and Reading Center and the Senior Instructional Support Specialist. These resources are used to provide training to cadets in writing the first major formal engineering lab report and manipulating data in Excel, so students can focus on the engineering concepts instead of the 'how to' of the assigned coursework.

The coordinator also mentors new instructors by spending time with them discussing the vision of the course, challenges of the students, and the common practice of the team and also provides new instructors with the required course materials including syllabus, detailed schedules for the course, lecture material, homework assignments, current and past quizzes and exams. If their schedule allows, new instructors are encouraged to sit in and observe classes by "seasoned" instructors in order to familiarize themselves with the materials. This gives the new instructors a framework that assists them in organizing and delivering the course in their own style.

Execution: Activities during the Semester

Once the semester commences, the course coordinator provide a steady stream of materials and information to instructors and students. These materials covers a wide range, including homework problems generated in house, example problems, innovative ways to present the material not included in the textbook, and information on scheduled tutoring times/locations. The coordinator is also responsible for posting homework solutions to the "Blackboard" website, along with additional exam preparation materials typically old exams or homework problems worked from previous years. Quizzes and homework formulations are developed by the team of instructors. As a part of this, the proposed materials are shared among the instructors for peer review and comment to ensure that the materials are ready for students well in advance. Another method of ensuing uniformity is the sharing of Bloom's Taxonomy oriented teaching objectives for each class amongst the faculty. These objectives are posted on a side board for each day by the course coordinator for use by students as a road map, and to reinforce the uniformity of classroom instruction. Individual faculty members have the freedom to develop their own materials for the classroom as long as the objectives are met. During the course of the semester innovative ideas are shared between instructors; some of which are incorporated into future lesson plans. Handouts for future use and other documentation for further development are placed in a central repository.

While USCGA prides itself in the high level of faculty-student interaction, and ready access to instructors for additional assistance, one observation was that struggling students oftentimes did not avail themselves of this resource. In the fall 2009 semester, it was proposed to use the first period (75 minute block) on Tuesday and Thursday for faculty and students to meet and discuss homework and answer questions regarding the materials covered that week. The small group interactions which grew from these meetings resulted in students teaching each other the materials with readily available faculty support. An additional benefit was that students gained study partners outside of the structured environment of these two periods, and allowed them to reach out for assistance after hours and on weekends. The course coordinator also arranged for evening or weekend review sessions hosted by faculty members at least 48 hours prior to exam dates. This structured times gave students additional opportunities to ask specific questions about topics covered on the exams, while encouraging them to begin studying prior to the night before the exams. This was designed to prevent the dreaded 'cram and dump' syndrome so common in students with multiple competing priorities, especially in this fast-paced course with wide-ranging topics and applications.

Another focus for the coordinator is the development of exam problems and 'proofing' of the exam. This process starts about two weeks prior to the exam, with a meeting of all the instructors and the heads of the three engineering majors. Topics are divided up among the instructors for individual development of an assigned exam problem to address one or more course objectives. No less than a week before the exam all proposed problems are collected and assembled into the first draft format. This draft exam is taken by all the instructors, and another meeting (sometimes via email) is held to discuss wording issues which may need clarification, overall length/difficulty of specific problems or the entire exam. When nuances between teaching styles are identified, say for example in relative emphasis of importance of units, this venue allows for calibration of the grading rubric and faculty interaction with students before the exams are issued to provide a standard expectation going into the exam. Once the exam is given, the faculty member who developed that problem is responsible to grade that problem, ensuring uniform grading across all sections. After grading all exams, the grades are input into a single spreadsheet for performance review across all the exam objectives and class sections. This process daylights the common areas of weakness for a section and the entire class, which generates conversation about student performance, stimulates discussion of standard ways to present the issues to students, and opportunities for additional instruction or supplemental materials to ensure student comprehension both in this and future semesters. This event also provides input data for the EOCR. A summary of semester activities is presented in Table 1.

Table 1: Summary of Semester Activities

Activity	Frequency	Benefit/Comments
Distribution of materials	As needed	Standardized materials so students from different sections are able to discuss/assist each other
Tutoring	Two scheduled 75 minutes sessions per week. One on one tutoring as requested.	Develops study groups outside this time. Scheduled time to complete homework/labs. Targeted small group/individual instruction.
Review for Exams	2 days before an exam.	Minimizes 'cram and dump' of material.
Exam Development & Proofing	2 Week prior to exam (3 exams & final).	Exam tests objectives. Fair/reasonable time. Consistent grading across sections.
Communications	Hourly/Daily/As needed.	Ensure consistency amongst faculty and students.
Formal Meetings	At least 4 times per semester.	Ensure consistency amongst faculty and programs.
Course Assessment	Each time course is presented.	Provides formal vehicle for course improvement. Supports Program Review.

Specific to the Mechanics of Materials course, in order to capture concerns as they arise, the department heads of the three engineering majors affected by this course (Civil Engineering (CE), Mechanical Engineering (ME), Naval Architecture & Marine Engineering (NA&ME)) are always invited to the exam preparation and resolution meetings in addition to the EOCR. This exchange allowed for multiple feedback opportunities from other courses being taken concurrently and academic advisor interactions with students.

As briefly discussed earlier, each exam is reviewed and proofed. Student performance on each question is also tracked to capture consistent student errors and identify topics or concepts that may need additional instructional coverage or development of new activities to improve students understanding. For example, assessment of student performance in 2008 showed only 44% of the students correctly applied Poisson's ratio to an exam problem. A review of the class instruction of this topic indicated it was inadequately addressed, so students did not fully assimilate the topic's importance. Remedial action was taken, and the issue was captured and discussed at the EOCR. As a result, new class examples and homework addressing the fundamentals of Poisson's ratio were developed, and faculty emphasized this concept during class and tutoring. These changes as a result of the assessment loop resulted in a significant improvement in students' performance with an average score of 68.9% on the 2009 exam problem covering Poisson's ratio.

A variety of communications methods are used between instructors and with students. Since the course coordinator has previously taught the course, and with the high turnover of RMF at USCGA, there is a standing invitation to other faculty to sit in and observe the course coordinator teach during the first period. If scheduling doesn't allow for this, another experienced faculty member is assigned to the second period and new instructors can observe them. Many times, this will generate impromptu conversations discussing teaching aids/methods used and developed. Course instructors formally meet at least four times a semester to discuss topics of concern. However, the most productive meetings have been found to be the impromptu ones which arise from a faculty located physically in close proximity to one another and having a respectful working relationship to quickly and openly address issues of concern before they fester. Communications with students takes multiple forms as well, including in-class oral and written communication, handouts, email, "Blackboard" website, and open office visits to any instructor teaching the course. Struggling students are especially encouraged to meet with instructors they have had in previous classes, or find they have a bond with.

Assessment

The assessment of the course includes selection of assignments for assessment, and the development and implementation of rubrics as appropriate. Assessment data is used in the EOCR process which occurs at the end of each semester the course is offered. The EOCR captures qualitative and quantitative data of the course activities including faculty input from small group discussions and impromptu meetings. Input from the other majors (CE, ME and NA&ME) for which the course is a prerequisite are received via communications with the head of each major as indicated above throughout the semester and during the EOCR process. Additionally, the EOCR is open to all interested faculty, which have at times included members of both the mathematics and engineering faculty. Student input is captured formally through mid-term and end of course surveys specific to the course objectives. It is also captured informally through faculty interactions and comments. Assessment of student learning through breakdown of the EOCR ultimately supplies information for the biennial self-study and regular

ABET Inc. accreditation visits to show how this course helps support the development of the Program Educational Outcomes.

Conclusion

The approach used at the United States Coast Guard Academy to coordinate multiple sections of basic engineering courses that has proven very effective was presented. This consists of three main phases: planning, execution, and assessment with regular feedback between the activities in each phase. Key components include a common class/lab/homework schedules, identical class topics and learning objectives, coordination of campus resources for all sections, common exams and grading, exam performance assessment, scheduled tutoring hours, open communications amongst teaching and senior faculty, and course assessment at many levels. The overall result is an environment in which students have clear expectations and responsibilities, resulting in a uniform level of comprehension as students move deeper into engineering mechanics topics within the three mechanics-based majors at USCGA. Faculty benefit from reduced individual administrative burdens, and sharing knowledge from those who have taught the course before to newly reported RMF's and civilian faculty.

References

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[2] Whalen, R., S.F. Freeman, B. K. Jaeger, and B. Maheswaran. "Teamwork is Academic: The Gateway Approach to Teaching Engineering Freshman." Proceedings of the American Society for Engineering Education Annual Conference, 2005.

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