Challenges of Developing a New Academic Minor for Junior Faculty: A Case Study of Developing a New Marine Construction Minor without a Civil Engineering Major Program

Dr. Farzam S. Maleki P.E., Massachusetts Maritime Academy

Dr. Farzam S. Maleki is an associate professor of engineering in Massachusetts Maritime Academy. He is a professional engineer and has a Ph.D. in civil engineering - hydraulic engineering from Clemson University.

Gail M Stephens P.E., Massachusetts Maritime Academy

Gail M. Stephens, PE, is an Associate Professor, and the Energy Systems Engineering Program Coordinator in the Engineering Department at the Massachusetts Maritime Academy (MMA). Gail holds a Bachelor of Science degree in Naval Architecture from the United States Naval Academy and a Master of Science in Mechanical Engineering from the Pennsylvania State University. Prior to joining the MMA, Gail served as a Civil Engineer Corps officer of the United States Navy for almost 10 years, worked in private industry, and co-founded two companies one in product development and the other in the service industry.

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Farzam S. Maleki, PhD, PE Assistant Professor, Massachusetts Maritime Academy and
Gail M. Stephens, PE, Associate Professor, Massachusetts Maritime Academy
101 Academy Blvd, Buzzards Bay, MA 02532

Abstract

Successful engineers work in a collaborative nature across a multitude of engineering disciplines. While specialization exists in post-graduate education, it is vital to expose the undergraduate student to a broad spectrum of engineering disciplines with which he/she may be exposed in their chosen career. Furthermore, in order to train the engineers of tomorrow, it is imperative for educators to introduce new teaching methodologies and demonstrate collaboration wherever possible; at the respective university and with industry partners.

One way to achieve the desired outcome is to create an academic minor. An academic minor can be used by the university for a number of purposes: (1) expose undergraduates to a related or growing field (2) gauge academic interest for development of a new academic major, (3) grow the university undergraduate student population by offering another major, (4) provide support for local or national industry needs, (5) provide essential experience to undergraduates in preparation for the entry into the work environment (enhance their academic credentials or add to their resume), and (6) provide faculty opportunities of professional development or conduct research in an area of interest to them.

At the Massachusetts Maritime Academy (MMA) students are trained and educated to work in a marine environment and they learn how to work on job sites through a number of required cooperative education placements. Currently, MMA offers three engineering majors, i.e. Marine Engineering, Facilities Engineering and Energy System Engineering along with three academic minors, i.e. Energy Management, Facilities Operations, and Marine Construction (MC). The newly developed minor, MC, is a civil/construction related minor degree with focus on both nearshore and offshore construction. The minor was first proposed in 2016 and began offering courses to the initial enrollment of 3 students in year 2017.

Like any other new major/minor, the main challenge is to attract students to consider this new minor and have sufficient enrollment for each class to be able to run. Consequently, student retention is another important factor.

Periodic educational plan review, support from administration, and alumni involvement are all found to be essential in the success of a minor. The first few years of starting the minor can be considered as the most important time frame in the development and promotion of a minor and requires extra planning, resources, and effort. This paper intends to share the experience of the authors in creating a new minor in a non-related major and can be used as a guideline for junior faculty members, especially in smaller institutions with fewer resources, who are interested in learning more about the challenges of developing a new minor.

Introduction

With the fast pace of advancement in technology, the need for interdisciplinary education and proper training in higher education seems compulsory. One approach is to involve students in a different but relevant area to their own primary academic major, which can be accomplished through an academic minor. By taking extra courses, electives, and completing industry internships, students can learn a secondary discipline in another area of interest while mastering their own major. The academic minor can be beneficial in different ways. If relevant, it can support the major and help the students to broaden their knowledge in a specific concentration area. It can also be a benefit for job hunting. Distinct academic minors can provide potential employers with a better understanding of a student's skill sets.

Although offering an academic minor may be appealing from a student's perspective, it is quite a challenging process for the administration and educators who must start the minor degree from scratch, especially in the case where the proposed minor is not supported by an academic major. In planning an academic minor there are several questions that need to be answered:

- Can we fit extra courses into students' educational planning?
- Does the school have required infrastructure and resources to offer the minor?
- How much and what kind of institutional support is required?
- Will other instructors in the department and academic advisors help promote the minor by encouraging their students and advisees to plan for and enroll in the minor?
- How can the instructor influence current students to spread the opportunity through word-of-mouth to other students?
- What role can other constituencies, such as private consulting firms, industry partners (construction companies), and local/state/federal agencies with representation on the department advisory board, play in developing, promoting, and supporting the proposed minor.

In this paper, we discuss the challenges of initiating a new minor at MMA where a corresponding academic major is not offered, followed by some lessons learned and recommendations to overcome the challenges.

Academic Minor Initiation

In order to initiate a civil/construction related academic minor at the MMA, some preliminary studies were conducted to justify the suitability and feasibility of the minor. During department faculty meetings the proposed minor degree, Marine Construction (MC) minor, was announced and an unofficial vote was taken to determine the faculty's opinion. Once the proposed minor was approved within the department, an official "academic minor proposal" was submitted to the University's "Curriculum Committee" and "All University Committee" for consideration and approval.

A critical step in the developing the academic minor is establishing the Program Educational Objectives (PEOs) and the course outcomes. While the MC minor is not in itself an accredited degree, the authors referred to ABET criteria for accrediting engineering degrees [1] in developing the program educational objectives and the student learning outcomes. The approved program educational objective for the marine construction minor states, "the MC minor will prepare engineering students for careers or advanced studies in the fields of marine construction or construction project management as they relate to large and complex construction projects in the marine environment." Each course has stated learning objectives which, when completed, will satisfy the PEOs.

The level of skill sets obtained by the students upon graduating from the proposed minor were discussed and modified during several department advisory board meetings. In separate meetings between the minor coordinator, department chair, dean of undergraduate education, and registrar, the number of required courses were evaluated and approved to ensure the curriculum's strength and student's educational competency. The approved number of required credits to fulfill the minor (i.e. 18 credits) was chosen carefully to neither overburden nor add an extra semester to the student's academic tenure. Typically students are required to complete 128 credits plus required cooperative education placements and experiential learning opportunities, which vary by major. Through proper academic planning, facilitated by a student's academic advisor, additional minor courses will not require an extra semester of study.

To ensure professional credibility and provide a solid foundation for initiating the program, the primary instructor of the minor, who developed the minor and course offerings and who currently serves as the minor coordinator, has a PhD in the Civil engineering and is a licensed professional engineer (PE) with several years of consulting and construction experience. To enhance the pool of faculty supporting the minor, the newest faculty hired, also holds a PE in civil engineering with extensive design and consulting experience in the marine environment.

Much of the cost of initiating the minor was funded by the general administration of the institution and its programs. From the administration's perspective, elements that should be considered in the cost of initiating a new minor include:

- Hiring new faculty to support program.
- Assignment of classroom and laboratory space to support the minor. Will additional space be needed or can the existing spaces be scheduled to accommodate the new class offerings
- Flexibility of teaching assignments allowing faculty to conduct classes with very low enrollment, especially in the first few program years.
- Financial support for laboratory equipment, supplies, and transportation for field trips

In our case, most of the initial costs were absorbed by creative scheduling of classroom space, strategic faculty hiring, and supplementary (adjunct) teaching contracts for new courses with small enrollments. The remainder of the program initiation costs were covered through collaboration with supporting industry and institutions. For example, the cost of scientific diving elective course, EN-7152, was covered by a supportive industry partner along with Woods Hole Oceanographic Institution.

Key to the success of instituting a new minor degree program is to have a student body with enough engineering curiosity and an academic foundation to enroll in the program. It does not matter how great a program one develops if not enough students enroll. Additionally, if one of the reasons to develop the program is to gauge interest in a new major in order to grow the institution, the developers must look at the demographics of the institution to determine the eligible pool of candidates.

In this case study, the total undergraduate enrollment at MMA is currently 1709 with just over ten percent (10%) reported as ethnically diverse (non-white or Caucasian) and 14% women. Over 40% of the student population is enrolled in one of the three engineering degrees. While the freshmen may demonstrate an interest in the minor and may be targeted for future marketing efforts, they are not eligible to begin the MC minor. Likewise, the seniors are too close to graduation to begin the minor. Therefore, only the second and third year students (sophomores and juniors) are candidates for the program. As stated previously, the best time for a student to enroll in the MC minor is sophomore year. Of the current junior class (graduating in year 2020), there are 60 engineering students who have a GPA above 2.5, making them eligible to enroll in an academic minor. Of those 60, 22 have enrolled in a minor degree, 10 of them are in the MC minor (16.7%) [2].

Academic Learning Outcomes, Course Sequence and Educational Resources

As with any academic major, it is of paramount importance for learning outcomes for the minor to be clearly identified. Additionally each course offered within the minor should detail the

specific learning objectives and skills the student should acquire as a result of their participation in the course. For the MC minor the learning outcomes include:

1. An ability to apply engineering principles to solve unique challenges in the marine construction environment.
2. An understanding of the components of and the relationship between construction methods, materials, and equipment used in marine construction projects.
3. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the ecological, environmental and geotechnical impacts of engineering solutions in the marine environment, and consider global, economic, environmental, and societal contexts.[1]

From the educational planning standpoint, sophomore year is the best time for a student to develop a comprehensive plan to complete the minor. It is always recommended for students to declare the minor early so they can plan for the required courses. The MC minor requires 18 credits of which nine (9) credits are obtained from three (3) core courses (En-7247, EN-7257, and EN-7262). These core courses are provided in Table 1:

Table 1: Required Core Courses

Course name	Course ID	Credits	Pre-requisite course	Corequisite course	Course Offering
Construction Methods and Management	EN-7247	3	EN-2101(engineering statics) or EN-2211 (mechanics)		Spring and Fall
Marine Construction I	EN-7257	3		EN-7247	Spring
Marine Construction II	EN-7262	3	EN-7257	EN-3201 (fluid dynamics) or EN-4111 (fluid mechanics) and EN-7257	Fall

In addition to these core courses (9 credits), students are required to take another 9 credits to fulfill the minor degree requirements. In order to provide more flexibility in educational planning, students can choose plan A, i.e. take three 3-credit elective courses (total of 9 credits of elective courses) OR plan B, i.e. take one 6-credit co-op plus one 3-credit elective course. A credit hour for cooperative education (co-op) is defined as “a minimum of 40 contact hours, with one hour of coursework” [3] for each cooperative education workday. Cooperative placements are offered in the winter and summer during breaks in the academic semesters. For the six

academic credits received, the student is required to complete a minimum of 240 hours of co-op experience for the winter term or 280 for the summer term, which equates to a minimum of six full work weeks or 30 eight hour days and submit a comprehensive written report. The MC minor Cooperative Program (co-op) is intended to be both a technical and interpersonal educational experience; where a student is exposed to diverse facilities, equipment, machinery, people, and geographical locations.

The co-op evaluation is based on student's formal project report and the employer's evaluation survey. The minor co-op employer evaluates the students' performance based on the following criteria:

1- Evaluation of Student Performance Expectations

- Specialized Knowledge
  - Basic knowledge and understanding of the theoretical aspects
  - Basic knowledge & understanding of the technical aspects
- Broad and Integrative Learning
  - Ability to explore concepts and questions that bridge different areas of learning
  - Ability to write effectively
  - Ability to communicate effectively
  - Ability to critically and creatively comprehend and evaluate new information and ideas
  - Ability to use quantitative reasoning skills, applying basic concepts of mathematics and science
  - Capacity for lifelong learning, including ability to utilize technology
- Applied and Collaborative Learning
  - Ability to work and achieve goals as a member of a team
  - Capacity for leadership, including the ability to make rational decisions while complying with a set of standards
  - Ability to perform and behave in a professional manner acceptable for career goals
- Civic and Global Learning
  - Capacity for ethical reasoning, including the ability to make decisions and act in a socially responsible manner
  - Ability to integrate knowledge and skills in civic and global contexts
  - Capacity for empathy, including an appreciation for diversity and inclusion
  - Capacity for civic action, including the ability to engage in service that benefits the public good

Elective courses should be selected from the list of courses relevant to minor Program Education Objectives (PEOs), Table 2, or other courses authorized by minor coordinator.

Table 2: Suggested Elective Courses

Course Number	Course Name
EN-3102	System Dynamics & Vibrations (ME & FE majors)
EN-4121	Electrical Power Distribution (ME majors)
EN-7141	Advanced CAD
EN-7142	Diesel Engines (FE & ESE majors)
EN-7151	Commercial Turbines (ME & ESE majors)
EN-7241	As-built CAD
HU-6073	Technical Writing (ME and ESE majors)
MS-2244	Introduction to GIS
SM-3121	Physical Geology
EN-7152	Scientific Diving

For academic planning purposes, students are encouraged to take the EN 7247 in their sophomore year, either in the fall or spring. Tables 3A and 3B show the proposed academic plans for the MC minor, plan A and plan B, respectively.

Table 3A Suggested Academic Plan for Marine Construction Minor - Plan A
(best option if student enrolls in the minor during their sophomore year)

Academic Year	Academic Action Plan for MC minor	Course Planning Fall	Course Planning Spring
1st Year	Informational sessions, guest speaker, class meeting, academic advisor meeting		
2nd Year	Minor declaration	EN-7247 Const.Meth.&Mgmt	En-7257 MC I
3rd Year		EN-7262 MC II	1st Elective - Table 2
4th Year		2nd Elective -Table 2	3rd Elective -Table 2

Note: each of the engineering programs includes a “free elective” in the fall and spring semester of the 4th year, therefore, no additional credit hours are needed in year 4. Years two and three (sophomore and junior), would require the addition of one course to the student’s academic major in each semester.

Table 3B Suggested Academic Plan for Marine Construction Minor - Plan B
(Best option if student does not enroll in the minor until junior year)

Academic Year	Academic Action Plan for MC minor	Course Planning Fall	Course Planning Spring
1st Year	Informational sessions, guest speaker, class meeting, academic advisor meeting		
2nd Year	Minor declaration		
3rd Year	Plan for MC minor Co-op (summer or winter)	EN-7247 Construction Methods&Mgmt	En-7257 Marine Construction I
4th Year		EN-7262 MC II	Elective course -Table 2

Regarding "free elective" course taking, by choosing plan B, the student would need to add an extra course in each of the semesters of their sophomore year.

This plan of action was accepted based on an annual review after the initial proposal. The initial course work proposal included four core courses, (1) Construction Methods and Material, (2) Construction Project Management, (3) Marine Construction I, and (4) Marine Construction II. This made it difficult for students to fit the minor in their educational plan and required a greater time commitment. The first year review showed that by combining "Construction Methods and Material" and "Construction Project Management," into one course of "Construction Methods and Management," (i.e. MC minor degree credit requirements were reduced from 21 to 18 credits) the program would be more appealing to students while upholding the educational objective.

Another challenge in creating this minor was the lack of a dedicated textbook and teaching resources. Because of this, the course material was prepared from a series of technical engineering handbooks, industry handouts, American Society of Civil Engineers (ASCE) standards, and available media resources. In the cases where the topics were heavily technical and outside the typical undergraduate level of education, the material was adjusted to the requisite level of student understanding.

The last and one of the most difficult challenges to overcome was that of creating meaningful laboratory experiments, e.g. soil mechanics and concrete technology, on a campus without a civil engineering degree program. The pedagogy employed by the school is centered around a "learn-do-learn" philosophy and without hands-on learning, the students miss a major component to their education. In order to make sure that a student enrolled in the MC minor gains all required education, the preparatory topics, which would normally be part of a civil engineering degree, have been incorporated into relevant courses. For example, for geotechnical related topics, two complete 75-minute class times have been allocated for introductory topics such as soil

classification, sieve analysis, different compaction tests, and soil load bearing capacity concepts. These introductory sessions include lectures and recorded videos which illustrate the topic within a laboratory setting and demonstrate the practical aspects within the marine construction industry.

Two Strategies

Two strategies found to be beneficial in making the concept more tangible are (1) inviting expert guest speakers or lecturers and (2) using field trips, whenever possible to show actual marine construction projects. As documented by Randy Laist [4], inviting guest speakers to the classroom can be an effective learning strategy which provides students with other perspectives, adds variety to class routine, and provides students with first hand stories. It is noteworthy to address some of the disadvantages of guest speaker/lecturer in terms of educational effectiveness. An invited lecturer can be unfamiliar with the student's level, he/she may present materials already covered in the classroom, or encounter time management issues. These issues can be addressed by better preparation and communications between guest speaker and host professor. As an alternative approach, team-teaching in some topics with other faculty members has also been found to be effective by increasing students' engagement ([5], [6], [7])

Field trips may be designed to serve as an effective educational activity. Specifically in a technical course, it can provide a real life experience for students to see their course material in action. Field trips can also help students to learn about practical skills and creates an invaluable environment to foster social skills [8]. Field trips can be considered as consolidating learning activity whereby the course material is reinforced by exploring subject-specific knowledge. It can also serve to foster group leadership and communication skills [9].

Fortunately, at a waterfront campus, there are typically a number of marine construction projects within an hour of the campus. The challenge then becomes finding the time when all students, faculty, and hosts at the facility to be visited are available. Valuable lessons can be learned by students if they are able to visit near or onshore projects such as pier construction, pile driving, dredging, and erosion mitigation. Offshore projects are more difficult to visit and require creative solutions to emulate. Not many schools have an opportunity to visit offshore marine construction projects such as a wind farm or an oil rig. A particular challenge arose during the discussion of underwater installation. Without a dedicated lab space, it was difficult to demonstrate the practical aspects of underwater construction techniques and keep the students engaged in active learning. One solution to temper the situation was the introduction of a scientific diving course. This is an area which will need more attention, creativity, and refinement.

An important aspect of any program is continued assessment and improvement. Student outcome assessments are based on class field trip reports: one of which is accomplished as a group and

one of which is conducted individually and co-op employer evaluations. Midterm and final exams are used to quantify and evaluate student progress and learning objectives attained. The MC minor program is assessed via an annual review by the Engineering Department Chair, program coordinator, involved faculty, and other stakeholders (industry partners, etc.) As the first group of students are scheduled to graduate in June 2019, a survey of employers and stakeholders will be used to assist in evaluating the program to date and recommending changes and future improvements.

Administration Support

Like any other initiative, creating a new minor degree program requires significant support from the school's administration. Furthermore, it is critical that the support is comprehensive and continues throughout the establishment and implementation of the minor degree. The institutional support includes concept and curriculum approvals, financial support for both students and faculty, classroom and laboratory spaces, registrar and scheduling support, admissions support, marketing and promotional materials. The MMA's administration, has demonstrated a commitment to the program throughout the process of creating the MC minor degree allowing for course improvements and enhancements, articulation agreements with nearby institutions and memoranda of understanding with industry partners.

This support has been crucial to the initial success of the marine construction minor and should be continued until the program is well established. Since MMA does not have a civil engineering major, the support from the administration was considerable and included input from many departments including athletics (pool access), registrar, admissions, engineering faculty, campus facilities, and IT to name a few. Additionally, the administration had to remain flexible with both the faculty and students by allowing students to participate in off campus activities. Traditionally, major degree programs complete the majority of their work on campus. Lastly, the administration had to be willing to accept advice from industry experts in order to ensure a viable program that is desirable to the end user.

Role of Other Constituencies

Construction contracting companies and consulting firms can play a significant role in supporting the academic minor and are great resources to maintain a high quality program. As the end user of the MMA's products, they can influence the student's educational path by reviewing the course material and providing feedback. During department and advisory board meetings with the minor degree curriculum coordinator, up-to-date industry challenges and high demand industry areas can be discussed and incorporated into the minor degree course materials. Other aspects of the student's program that could provide benefit to both the student and the other constituency, are internships and cooperative education placements. Construction companies can support the program by recruiting students for their required cooperative

educational courses and feed their pipeline of future engineers. Additionally, construction companies can provide input on the co-op requirements and feedback to the school based on their areas of expertise. Industry partners may also enhance the program by helping with financial support to students through covering the cost of the course and scholarships to encourage students to enroll in the minor degree program.

Conclusion

Initiating a new academic minor degree is a worthwhile endeavor and provides additional learning opportunities not only for the student but for the faculty involved. Inherent in the process is the professional development of the faculty and staff who work to initiate, support, and administer the new minor degree program. The students gain a valuable skill set that can set them apart from their peers when applying for jobs while the faculty increase their professional development in their area of interest. In many cases, junior faculty at smaller institutions do not have required resources to learn about the process. This paper is intended as a blueprint for junior faculty in developing an academic minor.

The challenge of initiating a minor degree in a marine construction at MMA that does not have a civil engineering major presented a unique set of issues which are summarized below.

Summary of issues

1. There is a limit to the number of additional credits that a student can reasonably incorporate into their academic program to achieve a minor degree without extending their entire college career.
2. MMA does not have an undergraduate major in civil engineering to help support development of the minor.
3. The courses for the other engineering degrees (marine engineering, facilities engineering and energy systems engineering) do not directly relate to the marine construction minor degree which requires creativity in developing example problems and projects which provide real life opportunities to explore the industry
4. There are a limited number of students eligible to enroll in the minor degree which makes its growth difficult.

Recommendations

1. Gather support from faculty members within the department and industry partners.
2. Be persistent in requests for institutional support
3. Be creative in finding solutions to topics that cannot be directly demonstrated in the classroom or laboratory environment
4. Market early to prospective students and keep at it. Demonstrate the viability of job placement in the industry after graduation.
5. Consider offering test courses at no charge to judge interest and allow for modifications

6. Allow courses to run when initial student enrollment is low in order to grow the course through word-of-mouth.
7. Be realistic in setting time frames for completion

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