AC 2009-930: DEVELOPMENT OF A THREE-COURSE SEQUENCE IN WATER RESOURCES FOR ENVIRONMENTAL AND CIVIL ENGINEERING

Simeon Komisar, Florida Gulf Coast University

Diane Bondehagen, Florida Gulf Coast University

Tanya Kunberger, Florida Gulf Coast University

Robert O'Neill, Florida Gulf Coast University

Development of a Three Course Sequence in Water Resources for Environmental and Civil Engineering

Simeon Komisar, Diane Bondehagen, Tanya Kunberger and Robert O'Neill, Department of Environmental and Civil Engineering, Florida Gulf Coast University, Ft. Myers, FL 33965

Abstract:

In designing the curricula for the new Environmental and Civil Engineering programs at Florida Gulf Coast University, priority was given to sustainable water resources, fitting with the vision and mission of our University and School of Engineering. We were forced to rethink the delivery of this body of knowledge in light of universal constraints on teaching resources, available credits within our template, and the need to deliver design experiences throughout. Typically, this body of knowledge is addressed in a two required-course sequence, with two additional courses delivered as technical electives, if at all, at the undergraduate level, or is delayed until the MS degree.

Using both CE and ENVE faculty, singly and in teams, we teach fluid mechanics, hydraulics, hydrology, and water resources in an interactive lab-lecture format, providing ever increasing exposure to design with uncertainty, cost, and environmental constraints. Students utilize laboratory test and measurement equipment as well as field exercises and are trained in the use of modern software to evaluate and design water resource systems and infrastructure. The final course in the sequence is taught as a design studio, with students functioning on interdisciplinary teams, with real world design projects. We have followed a cohort of students through this sequence and have documented learning outcomes using direct measures of competence including exams, lab reports, design projects, presentations, and outside evaluations, and indirect measures including surveys of student perception of learning.

Introduction:

Students graduating with degrees in both Environmental and Civil Engineering at FGCU are expected to be competent in Water Resources Engineering. This focus for both programs reflects the current physical, ecological and economic climate of Southwest Florida which has experienced dramatic growth over the last decade along with prolonged drought conditions and increased frequency and intensity of precipitation events. This nexus of increased population and water demand, shrinking water supply, and increasingly inadequate water routing and retention infrastructure has made it imperative to graduate engineers and future community leaders well educated in this domain.

Teaching water resources engineering to a level of competence appropriate to these challenges then becomes a difficult task in light of universal constraints on teaching resources, available credits within our template (128 semester based credits at FGCU), and the need to deliver design experiences throughout. A two required course sequence of (1) Fluid Mechanics and (2)

Hydraulics or Hydrology and Hydraulics are often the required courses in a CE curriculum, as shown in Table 1, below, showing an analysis of 20 well established programs in Civil Engineering at publicly supported Universities, yet some programs require only one course in the general fluids area and very few require a lab.

Level and Title of Required Course	# of Schools (out of 20)
1st Course titled "Fluid Mechanics" (or some variant)	20
2nd Course titled "Hydraulics" (or some variant)	4
2nd Course titled "Hydrology" (or some variant)	1
2nd Course titled "Hydraulics and Hydrology" or "Water Resources …" (with similar combined content according to catalog descriptions)	9
NO 2nd Course specified	6
Hydraulics Lab or other Lab course (1 credit) specified	2
Schools: U.Ka., UIUC, UMich., OSU, UIowa, UF, UMinn., UVm, VT, GT, UC-D, UCLA, UT, UWisc., NCSU, ASU, CP-SLO, SUNY-Bu., UWa. **Department Web sites examined 3/01/2009 through 3/19/2009**	

Typically, additional courses at the undergraduate level are delivered as technical electives (often surface and/or groundwater hydrology and water resources design). For most undergraduates in CE not focused on Water Resources, then, this means minimal preparation in water resource issues or a delay in acquiring this knowledge until graduate school or continuing education credits or work experience fills in the gap. For a state like Florida where these issues are critical and impact all structural, geotechnical, construction and transportation projects, this gap may ill prepare our graduates for professional practice.

To address this issue, we created a sequence of three courses. Unlike the majority of CE programs queried in Table 1, we required our students to have basic theory, hands-on experience and significant design experience. The first course in Fluid Mechanics incorporated numerous hands on experiences, delivered in studio format, to the traditional lecture based instruction in fluids. These experiences were no different than those often found in a fluids or hydraulics lab except that the integration of the experience was controlled by the instructors. These experiences included measurements of viscosity, pressure, forces on a submerged gate, fluid streamlines, and static and dynamic head used to verify Bernoulli's Equation.

The second course in the sequence and the key to this approach is a combined Hydrology and Hydraulics class that stresses hands on learning but does not attempt to crowd significant design experience into the same three credit class. Using a similar format to that described above, we delivered this class in the same combined lecture – lab format, but now with added emphasis on the use of computer based tools. We still integrated hands on experimentation but also made use of mathematical and statistical techniques for determining flow and pressure distributions in networks and the likelihood of occurrence and the magnitude of both routine and extreme events. Students were able to predict and then measure velocity of flow, head loss in pipes, sluice gate and weir flow in hands-on labs. Concepts like the Unit Hydrograph, Loss Methods, and Watershed / Runoff / and Routing Models (HEC_RAS) were developed. Design projects in this second course were focused and well defined. Students were given flow specifications and asked to size and design a culvert, for example.

The third class in the sequence tied all this together. Short review sessions at the beginning of the course served to remind students of key principles, and some additional concepts (like safe yield and multiple use of reservoirs) were presented but this class was focused on application of the material to real world problem solving and design projects. Five projects were completed in the course and included (1) a cost optimization comparison of design alternatives for a supply pipeline; (2) pipe size and storage tank placement in the water distribution system for a new subdivision to minimize pumping and chlorine dosing; (3) forensic analyses of a malfunctioning water treatment plant based on Hydraulic Grade line determination through the major and minor losses of the plant; (4) watershed model development using historic USGS rainfall and stream flow data to calibrate and verify system response, which was then applied to model and predict the impacts of development; and (5) creation of stormwater pond system for an actual site here in Southwest Florida. This last project brought in a local P.E. to present the data, drawings, constraints and regulatory issues as well as the client concerns.

For each class in the sequence we developed specific learning outcomes and an assessment method, including a rubric, to address attainment of our class objectives. For example, some of the key learning outcomes for the Hydrology and Hydraulics course are shown below:

Students taking this class will be able to:

1. explain the hydrologic cycle and be able to evaluate the rainfall- runoff process utilizing infiltration techniques and unit hydrograph concepts
2. explain flood frequency analysis and utilize probability concepts and frequency distributions to evaluate hydrologic data
3. analyze open channel structures
4. design a culvert for a specified flow
5. compute normal depth and design an open channel using uniform flow concepts
6. evaluate the occurrence of critical depth and design channel transitions
7. model the rainfall-runoff process for a watershed using the HEC-1 Flood Hydrograph software

8. apply hydrologic routing methods to evaluate the movement of a flood hydrograph through a channel or reservoir

An example of the rubric and analysis is shown below:

		Assessment Tool	
Learning Outcome	**Rubric:**	**Results for Homework 5**	**Results for Exam 1, question 1**
apply hydrologic routing methods to evaluate the movement of a flood hydrograph through a channel or reservoir	40 % of the students score 85% or above	68%	**52 %**
	75% score 70 or above	90%	**76 %**
	90% score 65% or above	100%	**91 %**

Discussion and Future Efforts:

Most undergraduate programs in both CE and EnvE are credit constrained. The ABET requirement for depth in technical content is commonly interpreted as a sequence of at least two courses in four sub-disciplines in CE. In EnvE this depth requirement is expressed as a need for coverage of water, waste, air and soil along with Environmental and Ecological Health. In addition to other requirements for Engineering Education the ability to find enough credits within an often mandated credit limit for the BS degree has lead to a de-emphasis of some course content. Thus choices must be made by individual programs on how to package and deliver a relevant curriculum and for defining exactly what a relevant curriculum entails.

This is especially apparent in Water Resources, which we have identified as ciritical to our mission in South West Florida. Fluid mechanic fundamentals routinely take an entire semester of instruction. Many programs, as shown in Table 1, combine Hydrology and Hydraulics or go even further, combining Hydrology, Hydraulics and Design in a single course in Water Resources Engineering.

Our experience has suggested that a three course 9 credit sequence may provide enough time and repetition to effectively create CEs and EnvEs who are truly competent in Water Resource issues. The use of a three course sequence in Water Resources for both Civil and Environmental Engineering was created to present material in different ways, creating general approaches and then relating them to specific examples, with repetition an important idea. Concepts grasped incompletely (for example, the relationship between rainfall and runoff) the first one or two times they were presented, were completely understood when used in the real world modeling and site development/ stormwater pond designs in Course Three in the sequence. In addition, different teaching styles were used. With Fluid Mechanics, the well defined problem and problem set along with exams and lab reports, was emphasized. The Hands – on parts of that course were important. In the Hydrology and Hydraulics class, more of a reliance on mathematical and modeling tools was employed. And in the Water Resources Design class, students learned to visualize and create virtual representations of real world systems, interact with "clients," and employ judgment on the importance of societal, political and economic constraints along with engineering solutions.

This three course approach facilitated real competence. Our students were able to identify, describe and solve simple problems as well as to begin to identify complex problems with multiple constraints, select and apply appropriate tools to attack these problems, evaluate the solutions they obtained and analyze those solutions in light of uncertainty.

Given the newness of our program, we do not yet have assessment data from our Alumni who will be able to report on that level of competence in their professional practice. We intend to collect that information in an ongoing process to assess and evaluate the investment of our time and effort.