

Teaching *Urban Water Problems*: Curriculum Design to Assessment

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abstract

Urban Water Problems is a 4-contact hours per week, senior level core course for the *Water Resources Management* majors and an elective course for the *Environmental Engineering* majors. This paper elaborates the evolution of the course in a five year period (2011-2015) in terms of curriculum design, teaching methodology and assessment tools.

In 2011, the learning outcomes of this course were set to focus on understanding the established urban water management, quantitative and qualitative analysis, scientific data collection and report writing. 4-hr/week classes were divided into lectures, term paper research, class room discussion on contemporary water issues, and paper and documentary review. Term paper, class lecture based write ups, documentary and article reviews and weekly class discussion on urban water topics were used to assess the student performance. While the students performed fairly, the assessment showed the need for improvements in curriculum, student participation and assessment methods.

In the following year, “Understanding emerging urban water issues” was added as another course outcome. Over the time, additional established topics and the emerging topics were incorporated into the curriculum. Student participation was increased with the weekly review assignments and the subsequent class discussion. In addition, the field trips or the guest lectures were included. The weights of the term paper and the class participation were reduced in the assessment, and three exams (two mid terms and one final) were introduced. The exam questions included the direct questions on the classroom lectures, and the open-ended questions on the reviewed documentaries and papers, individual term paper, weekly discussion topics and guest lectures. Technological tools such as Blackboard and Mondopad were used to make the student learning process easier than the traditional learning did. Five year class data showed the improvement in the curriculum and the elevation of the student knowledge in the subject.

introduction

Criterion 3, the Student Outcomes a through k for accrediting engineering programs for the 2015-2016 cycle by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (EAC-ABET) provides the basic guidelines for developing the curriculum for any strong engineering program¹. Following these guidelines, the curriculum of a successful environmental engineering program should comprise courses that a. disseminate the basic science and/or management knowledge. b. introduce established technologies and/or management practices, c. train the students with hands on exercises, d. guide in designing or in

applying protocols, e. provide industrial experiences through internships and/or undergraduate research experiences, f. focus on gathering data and research g. enhance the communication skills through report writing and presentations, h. teach professionalism and ethical conduct, and i. make the students understand and follow emerging issues, their solutions and novel technologies.

Hence, during the development of a new course for an environmental engineering program, the course developer should set the course outcomes to fit the one or more outcomes of the EAC-ABET Student Outcomes and fitting assessment tools. The instructor should also be aware that the course development is an ever-evolving process with the feedbacks from the earlier assessments and the adaptability and accommodation for the new topics, novel teaching approaches and technologies. In the literature, few pedagogical studies are found addressing the issues of developing core or elective environmental engineering courses. Kolari et al presented an approach on including a research study project in a course, *Water and Soil Analysis*.² Bowen et al developed the group design project with hands on exercises, engineering analysis and computer programming for a freshmen civil and environmental engineering course.³ Ramanitharan elaborated a teaching methodology called *Connect2U* for a general educational (science) course, *Introduction to Water Resources Management*.⁴ Bielefeldt's paper provided the insight of developing an capstone design course for an environmental engineering program.⁵

In this background, this paper presents the evolution of an upper level elective course for the Environmental Engineering Program, *Urban Water Problems* that is also taught as a core course in the Water Resources Management program in a five year period (2011-2015) in terms of curriculum design, teaching methodology and assessment tools.

course: urban water problems

Urban Water Problems is a 4-contact hours per week, senior level core course for the *Water Resources Management* majors and an elective course for the *Environmental Engineering* majors. This course was developed with the intention to identify and address the water related issues pertinent to the urban environment. While it includes the quantitative and qualitative estimation problems, they are minimal as the objective of this course is introducing the urban water issues to the students. The course catalog description of the course is as follows:

Urban Water Problems (II;4) - Examination of water problems faced by urban America and solutions to those problems. Urban Hydrology, water treatment, the supply of quality drinking water, storm management, flood protection, water for recreational fishing, economic development and infrastructure of dams and river control structures. The economic, physical and political aspects of transportation systems are emphasized.

This course aims to address the program outcomes related to a. the dissemination of the basic science and/or management knowledge. b. data collection and research c. enhancement of the communication skills through report writing and presentations, and, d. understanding the emerging issues, their solutions and novel technologies.

learning outcomes, teaching methodology and assessment tools

Table 1 shows the learning outcomes for this course for the 2011 Fall semester. 4 hours/week classes were divided into classroom lectures, term paper research, class room discussion on contemporary water issues and paper and documentary review. In the classroom lectures, the instructor taught established urban water topics including the basics of water demand, drinking water treatment, wastewater treatment, water distribution, storm water, urban waterbodies, and urban water pollution due to transportation. Given the nature of the course with the chosen topics no text book was used, but the students were expected to summarize the classroom lectures the instructor provided. The additional course materials were provided by the instructor in the form of PowerPoint presentations and as the materials available in the public domain. In the beginning of the semester students chose individual term paper topics with after discussing with the instructor. The term paper report and presentation guidelines were given to the students with the syllabus. Students also did weekly summary of ten urban water related issues found in the media I the preceding week, and discussed in the classroom. In addition, every week the students were assigned with video documentaries and journal papers on urban water issues to review. The student performance, as it shown in Table 1 was assessed with class lecture based write ups, documentary and article reviews, weekly class discussion on urban water topics and class attendance. Table 2 provides how the points for the final grade was broken down.

Table 1. Learning outcomes for the course in 2011 Fall

No	Learning Outcome	Assessment tools
1	Gain the basic understanding of Urban Water Management	Write ups on Lecture Topics, Documentary Reviews
2	Perform quantitative & qualitative analyses in Urban Water Issues	Term paper report, Field trip reports
3	Understand the emerging Urban Water Issues	Weekly Class Discussion, Term paper
4	Develop abilities of scientific data gathering & report writing	Field Trip Report and Write ups on Lecture Topics

Table 2. Evaluation scheme in 2011 Fall

Evaluation Method	Type	Percent in the final grade
Write ups on class lecture topics & field trips	Individual	20
Documentary critical reviews	Individual	20
Class discussion on emerging topics	Individual	10
Final report on the chosen topic	Individual	40
Class presentation of the final report	Individual	10
Total		100

While the student performance was assessed with the above scheme, the success of student outcomes was assessed with the weighted average of the student performances for each assignment. As it is shown in Table 3, the performance scale for a student's any assignment was categorized into one of the four groups based on the point percent the student got and a respective performance point was assigned accordingly. Once the individual performance points

were computed, they were aligned with the respective student outcomes (such as in Table 1) to get the weighted average performance point (AVG) for individual outcomes. This individual outcome was used to assess the student outcome levels and the respective recommendations as it is shown in Table 4.

Table 3. Performance scale for any assessment tool used

Performance scale	Assignment percent	Performance Point
Excellent (E)	$E \geq 90\%$	5
Satisfactory (S)	$75\% \leq S < 90\%$	3
Developing (D)	$60\% \leq D < 75\%$	2
Unsatisfactory (U)	$U < 60\%$	0

Table 4. Outcome attainment levels based on the weighted average performance of the class

AVG (5 points max)	Equivalent Percentage	Recommendations
$AVG \geq 3.50$	$AVG \geq 70\%$	Met, no action
$3.00 \leq AVG < 3.50$	$60 \leq AVG < 70\%$	Mostly met, check conditions
$2.50 \leq AVG < 3.00$	$50 \leq AVG < 60\%$	Partially met, check conditions, analyze for correction
$AVG < 2.50$	$AVG < 50\%$	Not met, analyze and take action

The course outcome attainment levels for the corresponding the recommendations were used to take follow up actions on the curriculum, assessment tools and teaching methods. (As an example, Appendix-A shows the summary of the assessment of student learning outcomes and the follow up actions for Urban Water Problems between the assessment semester 2014 Fall and the follow-up year 2015 Fall.)

In 2011, although the students performed fairly according to their grades, the student outcome assessment showed the need for the review of the curriculum with the additional topics, the enhancement in student engagement in the class and the improvement in the assessment methods.

Based on these course outcome findings, in the following year (2012), to expand the student knowledge beyond the established urban water topics and to know emerging problems, “Understanding emerging urban water issues” was added as another course outcome. Over the next four years, additional established topics pertinent to urban water such as Total Maximum Daily Loads(TMDLs), storm water management, and Environmental Impact Statement (EIS), and the emerging issues related topics such as climate change-urban water nexus, water security and safety, GIS applications and the introduction to hydrological and hydraulic models and software that are use in urban water management were incorporated into the curriculum.

These topics were identified by the instructor from professional journals, expert columns, conference announcements, news media, successful and unsuccessful research grant proposals and the fitting topics that the students brought up. The class hours previously used for the term paper research and the documentary reviews were used for teaching these topics.

Student participation was increased with the weekly assignments on the summary of ten urban water issues discussed in the media in the previous week and the subsequent class discussion. In addition, the field trips or the guest lectures were included. Classroom discussion and guest lectures were helpful in selecting term paper topics and emerging urban water issues that could be included for the next year class.

‘The write up on the classroom lecture’ component was removed as an assessment tool as it was found repetitive once the course was well established with diverse topics. Table 5 presents the updated learning outcomes and the respective assessment tools for 2015 Fall class. The weights of the term paper and its presentation and the class participation were reduced in the assessment, and three exams (two mid terms and one final) were introduced. Table 6 shows the proposed student performance evaluation scheme for 2015 Fall. Although a mini project on urban water models and GIS applications were planned due to the difficulties encountered in data preparation, it was not implemented in Fall 2015 semester. Hence, the points allocated for the mini project was provided to the final examination.

Table 5. Learning outcomes for the course in 2015 Fall

Learning Outcome	Assessment Tools
Gain the basic understanding of Urban Water Management	Documentary Reviews, Exams
Perform Quantitative & Qualitative analyses in Urban Water Issues	Term paper report, Exams
Understand the causes, processes, consequences and solutions of the emerging Urban Water Issues	Articles and Weekly Class Discussion, Term paper, Exams
Apply the abilities of critically review the scientific materials	Documentary and paper reviews, term paper
Develop abilities of scientific data gathering & report writing	Weekly current issues, and Final Term paper writing and presentation

Table 6. Proposed student performance evaluation scheme in 2015 Fall

Evaluation Method	Type	Percent in the final grade
Mid Term Exams + Final Exam	Individual	15+15+ 15
Documentary & paper critical reviews	Individual	20
Mini Project: Urban Water Model & GIS	Individual	7
Class discussion on emerging topics	Individual	5
Final report on the chosen topic	Individual	15
Class presentation of the final report	Individual	3
Participation and Attendance	Individual	5
Total		100

The exam questions included the direct questions on the classroom lectures, and the open-ended questions on the reviewed documentaries and papers, individual term paper, weekly discussion topics and guest lectures. Student opinions and suggestions on the course from their class

participation activities were used to modify the teaching methodology and to add new topics in the course.

Table 7 shows the titles of the student term papers in the five year period 2011-2015. It can be seen that while the first three year topics are mostly contained on the established topics, the last two year topics are on the diverse emerging topics from impact of hydraulic fracturing on water resources to water-energy nexus to Flint water crisis. The changes in the term paper topics were done mainly due to two reasons. 1. Some of the established topics in the initial years were adopted by the instructor in the class room lectures. The examples are water for recreation, urban flooding and waster for urban agriculture. 2. Emerging urban water problems-especially the ones that are pertinent to the students’ communities- were identified so that the students can research and see how to address those problems with their knowledge and experience. These topics were found to give a faster learning curve. The topics included Hydraulic fracturing, Urban water justice, Flint water issue and water issues in the urban areas that affect minorities.

The semester end classroom presentations on term papers served dual purposes; enhancing the student communication skills and disseminating one student’s term paper research findings to the other students. Most of the student assignments were saved as the electronic formats too so that they could be used in the future for teaching purpose and for assessment documentation purpose. In contrast to the initial years in which the students were expected to submit the term paper only at the end of the semester, in the latter part of the study period, students were expected to provide the topic on or before the first mid term grade period, and the tentative abstract of the paper around the second mid term grade period. And, the points were provided to reflect these progress in the mid terms. This helped the students to steadily work on the term paper throughout the semester in stead of rushing at the end of the semester to work on the term paper.

Table 7. Term paper titles in the period of 2011-2015

Term paper topics (2011-2013)	Term paper topics (2014-2015)
Strategic analysis of water issues reported by the media within the month of July 2011, Water related hazards in USA, What lies beneath: Water and swimming pools, Urban flooding, From wastewater to drinking water, Urban agriculture, Overcoming world water crisis, Pond contamination,	Hydraulic fracturing, Hydraulic fracturing in West Virginia & Carrol County, Ohio, Water issues in urban areas that affect minorities, Water pricing, Urban water justice, Water scarcity, Water security and safety in urban areas, The water-energy nexus, Rainwater harvesting: Saving it for a rainy day, Flint water issue (not completed by the student)

A student’s knowledge about the urban water issues was expanded with the emerging issues as each student did on a contemporary issue that was not discussed in the class, and then presented to the rest of the class. In addition, the students were able to connect these problems so that they involved in the term paper with a sincere interest.

In the initial years, the class was taught with the use of whiteboard and projector. Web based tool Blackboard was minimally used. However, in the latter part of the study period, teaching approach was improved with the technological tools. Projectors and whiteboards were given up

for more advanced tools. In addition to Blackboard, Mondopad was mainly used as the tool. Blackboard and Mondopad were used to make the student learning process easier than the traditional learning did. Mondopad was used as the board to teach and the daily notes was saved as a pdf and sent to the instructor's email. This notes were either shared with the students through the USB drive or Blackboard. Mondopad was also used for Microsoft applications needed for teaching such as PowerPoint, Excel and MSWord and to access the webpages and Youtube demonstration videos. Blackboard helped to archive classroom notes, PowerPoint presentations and assignments and in this way enhanced the online interaction between the instructor and the students and continuous learning. In addition, in 2015 semester, Skype on the Mondopad was used for a live guest lecture.

discussion

Five year class data showed the improvement in the curriculum, the student learning in the subject and the achievement of the most of the course outcomes. However, there are still space for improving the curriculum and the assessment tools with increased participation of the students. It was noticed that while four of the five student outcomes were met, the first outcome was only partially met. The cause for this result was found in the low number of assignment submissions by few students. In a small class with 2-8 students, even one student's total abysmal performance or few students' mediocre performances or missing assignments could significantly impact the assessment. However, when those students performed well in the examinations and term paper, they would still pass. To encourage the higher rate of assignment submission which in turn will make the first outcome fully met. in the future, minimum number of assignment submission will be made mandatory.

Mini project on urban water models and GIS applications in urban water problems will be implemented. This will also help to improve the students' understanding on solving urban water problems, and in turn will help to attain all the outcomes met.

acknowledgement

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references

1. ABET. 2014. Criteria for accrediting engineering programs: effective for reviews during the 2015-2016 accreditation cycle. <http://www.abet.org/wp-content/uploads/2015/05/E001-15-16-EAC-Criteria-03-10-15.pdf> Accessed on 26th January 2016.
2. Samuli Kolari, Eeva-liisa Viskari and Carina Savander-ranne. 2005. Improving Student Learning in an Environmental Engineering Program with a Research Study Project. Int. J. Engng Ed. Vol. 21, No. 4, pp. 702-711, 2005

3. James D. Bowen, Peter Thomas Tkacik and Kimberly Warren. 2011. Combining Hands-On Design, Engineering Analysis, and Computer Programming in a Freshman Civil and Environmental Engineering Course. *Proceedings of the 118th American Society for Engineering Education*. Vancouver, BC, Canada. ASEE. 26-29 June 2011. 12p.
4. Ramanitharan Kandiah. 2015. Connect2U Approach to Teaching Introduction to Water Resources Management as a General Education Course. *Proceedings of the 122nd American Society for Engineering Education*. Seattle, WA. ASEE. 14-17 June 2015.
5. Angela R. Bielefeldt. 2012. Competitions for Environmental Engineering Capstone Design Projects: Student Preferences and Learning Outcomes. *Proceedings of the 119th American Society for Engineering Education*. San Antonio, TX. ASEE. 10-13 June 2012.

appendix-a

Assessment of student learning outcomes and the follow up actions for *Urban Water Problems*

Instructor: _____ Course: Urban Water Problems

Initial Assessment Semester: Fall 2014 Class enrollment: 4

Follow-up Assessment Semester: Fall 2015 Class enrollment: 7

Course Learning Outcome	Assessment Tools	Assessment Results/Findings	Analysis and Planned Use of Results	Change in Student Learning Outcomes Following Instructor's Use of Results/Findings
1. Gain the basic understanding of Urban Water Management	Write ups on Lecture Topics, Documentary Reviews, Exams	By average, the class had 2.25 out of 4.0 scale in the grading. Homework and assignments got 1.5 in the 5 scale, which means that the requirements have not met.	A small class with one student not submitting any assignment can significantly affect the assessment. future assessments should point out such situations. Submission of the homework & assignments were low in numbers. Students were encouraged to submit the homework on time. Write up on lecture notes	By average, the class had 3.0 out of 4.0 scale in the grading. Homework and assignments got less than 2.21 in the 5 scale, which means the requirements have not met. However, this was due to one student's no submission of any homework. Excluding this particular student will make the AVG equal to 2.57/4, which means that

			topics seem to be repetitive. Hence, it was removed.	requirements were partially met.
2. Perform Quantitative & Qualitative analyses in Urban Water Issues	Term paper report, Exams	The term paper assignment got 2 in the 5 scale, which means the requirements have not met	Quantitative assignment found low in number. New topics (culvert design and TR-55) were included. One student did not submit any assignment.	Term paper assignment got 3.57 in the 5 scale, which shows all the requirements met.
3. Understand the causes, processes, consequences and solutions of the emerging Urban Water Issues	Weekly Class Discussion, Term paper, Exams	The term paper Assignment got 2 in the 5 scale, which means the requirements have not met	One student did not submit any assignment. Ten Articles/ week summary should be more tuned and focused	Term paper assignment got 3.57 in the 5 scale, which shows all the requirements met.
4. Apply the abilities of critically review the scientific materials	Documentary and paper reviews, term paper	Critical review performances was done good with the students who submitted.	New assignments were added. And class room discussion was increased with classroom short multimedia presentations and discussion.	Critical review performance improved from the previous cycle.
5. Develop abilities of scientific data gathering & report writing	Weekly current issues, Write ups on Lecture Topics and Final Term paper writing	The term paper assignment got 2 in the 5 scale, which means the requirements have not met. Similar scale value 2 found for presentation too.	One student did not submit any assignment. The importance of the term paper component was stressed more.	Term paper assignment got 3.57/5 scale, which shows all the requirements met. and, the presentation got 4.29/5 scale. These values included the data of the student who did not submit the assignments.