Design of Public Health Engineering Course Using Multimedia Resources for Dual Mode Delivery

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***Abstract**: Educating students who aspire to be engineers and technologists in the field of Public Health Engineering is a challenge as it encompasses a diverse technical content demanding an interdisciplinary knowledge encompassing chemistry and microbiology. Students find it hard to visualize the processes that occur within the treatment systems for successfully designing the components. This difficulty is even more complicated especially when the courses are offered at distance mode where students have to rely solely on the course materials to gain in-depth understanding. This paper presents successful design and development of multimedia resources such as animations for Public Health Engineering course which is perceived to be challenging by civil and environmental engineering undergraduates. The preliminary evaluation of the revitalized course indicates that the overall performance of the students increased by 12.1% in 2009 compared to 2008 as a result of enhancement.*

Keywords: *Multimedia resources; Animations; Public Health Engineering*

Introduction

The University of Southern Queensland (USQ) is internationally recognized for its dual mode delivery of programs both via on-campus and external modes. At USQ, about 80% of the students enrol on external while 20% in on-campus mode. Traditionally, on-campus students attend face-to-face lectures and take advantage of instructor interaction while the external students rely solely on the study package for guidance. The study package usually consists of a study guide, a text book and selected readings. Study guide directs the students to refer materials in the text book and selected readings, provides solutions to the tutorial problems and includes extra materials not covered in both selected readings and text book. These are heavy - text based printed materials that are sometimes monotonous for the distant students to read through to grasp the key-concepts. Furthermore, previous research suggest that reliance on the more traditional text-based instructional materials supplied by many institutions may inadvertently disadvantage a significant proportion of their students as it does not take into account the diverse learning needs of the students (Sankey and St Hill, 2008). In recent years, advances in instructional technologies via online learning management system have enabled interactive learning to be a reality. With the incorporation of new instructional design strategies into the materials, it is possible to engage students to achieve the desired learning outcome (Ragan, 1999). Not only instructional method becomes important but also the assessment and measurement strategies have to be creative in the distance education setting.

Many engineering related courses require students to visualize the processes occurring within a system for them to understand the key concepts presented in those courses. Furthermore, many students nowadays are visual learners and therefore little inclined to read through and comprehend printed materials and text-based on-line courses. The multimedia resources allow a better visualization of simulation of physical processes as well as models with complex geometry, while enabling students to obtain better understanding through the verbal and visual explanations (Noronha et al (2009) and Mayer (2003)).

Noronha et al (2009) enhanced the Structural Engineering education by the incorporation of multimedia tools. They concluded that these multimedia tools were not only powerful in improving teaching and learning of engineering subjects but also in representing an important source of motivation to engage students. Dharmappa et al (2009) successfully developed a multimedia package

dealing with several pollution control processes in Environmental Engineering not only to enhance the visualization aspects but also to explain the dynamics of the processes that usually occur over longer periods of time that cannot be easily integrated into normal teaching environments.

While many academics developed multimedia tools to facilitate the teaching and learning during face-to-face delivery in engineering courses, almost none report the development and delivery of multimedia tools including animations to enhance online learning. The importance of multimedia tools would further be realized especially when the courses are offered in external mode or at distance where students have to rely solely on the course materials to gain in-depth understanding of key concepts. According to a survey conducted, while the students learning via distant mode value the flexibility of printed media, they would like to see more multimedia enhancement as a higher priority (McDougall et al, 2001).

This paper therefore, aims to present the successful design and development of multimedia resources for Public Health Engineering which is normally perceived to be a challenging course by civil and environmental engineering undergraduates. It further discusses the preliminary evaluation of the revitalized course by comparing the overall performance of the students.

Why was multimedia enhancement needed for Public Health Engineering Course?

Public Health Engineering is a core course for those final year undergraduate and post-graduate students majoring in Environmental and Civil Engineering in the Faculty of Engineering and Surveying at the USQ. About 95% of the student cohorts enrolled in the course is from Civil Engineering major, while the rest makes up the Environmental Engineering major. *Public Health Engineering* is designed to introduce the modules on water supply and distribution system, conventional and advanced water treatment processes, wastewater treatment, sludge and solid waste treatment and disposal methods.

The pre-requisite for this course is Hydraulics 1, which assists students in understanding the hydraulic aspects of the design concepts presented in the modules. As water with its associated quality issues demands an interdisciplinary knowledge encompassing chemistry and microbiology, students need to grasp the required concepts in these areas to apply them in water and wastewater treatment to meet the course objectives and to successfully design water and wastewater treatment components. The majority of civil students have the basic hydraulics knowledge required to design the components, however, as they lack chemistry or microbiological background needed for understanding the water and wastewater treatment processes, they show their disinterest.

In order to motivate and inspire the students, they are taken to a water treatment and advanced wastewater treatment plant located nearby. The water treatment plant treats dam water using conventional coagulation/flocculation and sand filtration processes. The advanced wastewater treatment plant employs physical means such as screening, biological means such as anaerobic, anoxic and aerobic processes for nutrient removal along with chemical means such as disinfection. During these field visits, the students are first given an introduction on the treatment processes both by lectures and by using automated computer configurations and then taken around different processes within the plants. These field trips provide first-hand knowledge regarding the processes from the practicing engineers, apart from an academic. However, all they can see in these plants are different tanks or reactors having full of water/wastewater flowing from one tank to another. Little knowledge they gain visually by looking at the reactors as far as design features of the tanks are concerned (they can only see this if they visit the plants when the reactors are empty). Furthermore, the detail bio-chemical reactions going on within the processes in each of these reactors are not apparent or clear for the students.

In order to stimulate the students' interest and engagement, a new and innovative approach is required to facilitate the students' learning of these concepts that are perceived to be challenging by Civil Engineering students. The approach requires the use of contextualized case-studies, visual presentations without being overwhelmed by textual overload with summative assignments and on-line formative quizzes to promote progressive learning and to reinstate the key-concepts.

Integration of Contextualized case-studies

Since the course includes modules spanning from water, wastewater and solid waste treatment, there is no single text book that has the necessary contents in required depth catering for the specific learning objectives. Furthermore, the exiting US based text books do not conform to Australian guidelines and design requirements. Furthermore, they contain case-studies that are not contextualized to Australian circumstances. The course had been delivered through a study book for external students in previous years, the contents covered conventional treatment extensively, however lacked information on recent advancements in the field. Therefore, the course needed revitalization incorporating new modules on advanced water treatment to keep abreast with current technological developments including topical Australian case-studies, with updated modules citing recent guidelines and up-to-date knowledge in the field of study.

In order to update the study materials with current technological development, the information on processes such as membrane technology, distillation, ion exchange, electrodialysis for water treatment, and membrane bio-reactors for wastewater treatment. This was supported by the following topical case studies.

- Sydney's desalination project was used to demonstrate how sea water as a drought proof source can be exploited to produce potable water using the above technologies.
- Toowoomba water futures project was presented as a case-study for possible water reclamation innovation where wastewater can be reclaimed to potable standards.
- Singapore's NEWater Plant project was used to demonstrate how a membrane bio-reactor can be utilised to treat waste water, a predetermined quantity of source water, to potable standards.
- The Pimpama integrated water management system at the Gold Coast was used to demonstrate how a community is tackling water issues. This includes examples of how a household could be connected for different water usage utilising appropriate quality of water, such as rainwater tank connected to laundry and bathroom, recycled wastewater connected to toilets and outdoor gardening, and treated drinking water connected to kitchen and to replenish the rainwater tank.

When the students are exposed to the real-world case-studies such as the above, they would understand the relevancy of them and would engage more in learning the underpinning technologies. These case studies inspire students to find alternative water resources outside of those traditionally regarded as suitable, and to invent technologies to upgrade the water quality to suit various community water requirements.

Multimedia enhancement

Animations as multimedia enhancement

Realizing the fact that the majority of the students nowadays are visual learners, animations were developed to explain the key-concepts. The animations were chosen because they could stimulate the reactions that occur within a treatment plant or process which cannot be seen simply from a video-clip or a photo image.

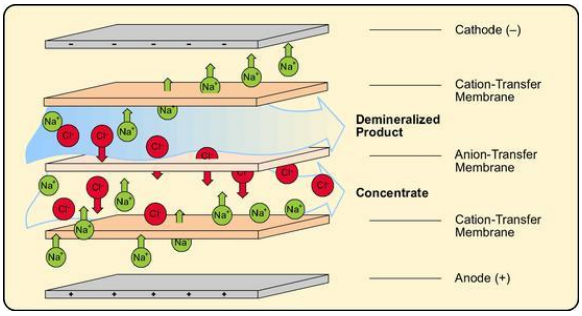

Figure 1 Electrodialysis - Amended from Source: <http://www.cbnga.com/electrodialysis.jpg>

Adobe Flash software was used to create the animations. Each animation was designed with visual prompts and clear movements so that students can easily follow and understand the processes. The navigation embedded in the animations enables students to repeat and reinforce those parts of the processes that are unfamiliar to them. Certain animations on disinfection, filtration and secondary wastewater treatment plant were supplemented with textual explanations. These visuals aids will imprint this foundation knowledge on students' minds and give them a clear basis on which to build further knowledge. Some of the more difficult processes in advanced water treatment such as distillation, electrodialysis, ion exchange and reverse osmosis were enhanced by audio accompaniment to reinforce the information presented in the animations. This presents an alternative learning method for those students who benefit by audiovisual learning methods. Figure 1 is an example that describes the basis on which the animation on electrodialysis is built. A transcript of the audio is provided for those students who choose or need to read the material to further their understanding. The audio presentation provides the students with the opportunity to concentrate on the animation while listening to the audio explanation, rather than having to read and comprehend at the same time. Similar presentations were developed to explain other processes, such as reverse osmosis, coagulation and flocculation, sedimentation, advanced wastewater treatment, etc.

The animations developed mainly follow transmission theory of teaching and learning in which the knowledge or concepts of water and wastewater treatment plants are transmitted to the students via audio and textual accompaniment. Where applicable, these explanations were supported by real life examples to generate students' interest. In order to explain osmosis the following example is used. "Have you ever wondered why drinking salty water can be fatal? It is just as easy to die from thirst in the sea as it is in the desert. Osmosis is why drinking salty water is not recommended. When one drinks salty water, osmotic pressure begins drawing water out of one's body to try to dilute the salt in the stomach until dehydration occurs and person dies." In order to explain distillation processes, we use the following real life example with animation. "In this distillation process, we are mimicking the hydrological cycle that occurs in nature. The heat that radiates from the sun evaporates the sea water, and the pure water vapor rises and accumulates as clouds. When the moving clouds come in contact with the cooler mountains, condensation occurs. This concentrates the vapor to form water droplets which fall to earth as rainfall". These explanations enable the students to compare and connect the information with the prior knowledge they possess. This is based on cognitive instructional design whereby animations are used to emphasize the importance of applying knowledge to the relevant situations. Since most of the USQ students are adult learners, they can benefit greatly by being able to use different cognitive learning styles.

Illustrations as multimedia enhancement

Several graphical illustrations were designed and included throughout the book to visually explain the required concepts, since a *picture is worth a thousand words*. These graphics have been interspersed throughout all the modules, to support the text, to communicate clear objectives for student learning and to stimulate curiosity and independent learning. Figure 2 is an example of such designed illustration which depicts the unplanned indirect potable use. This occurs when a water supply is abstracted for potable purposes from a natural source (surface or groundwater) that is fed in part by the discharge/disposal of treated or non-treated wastewater effluent. The subsequent potable use of the wastewater was not an intentional part of the effluent disposal plan and therefore, the wastewater discharged is not treated to a much higher degree as it is with the planned indirect potable reuse. The illustration was useful to explain this type of indirect potable reuse that occurs whenever an upstream water user discharges wastewater into a water source that serves as a water supply for a downstream user. This explanation is then followed by how such unplanned indirect potable reuse occurs along major river systems in Australia and worldwide. Further, another illustration on planned indirect potable reuse that employs advanced treatment system with multiple barrier approach is used subsequently to explain to the students the advantages of such systems that can boost the water supply without compromising the quality.

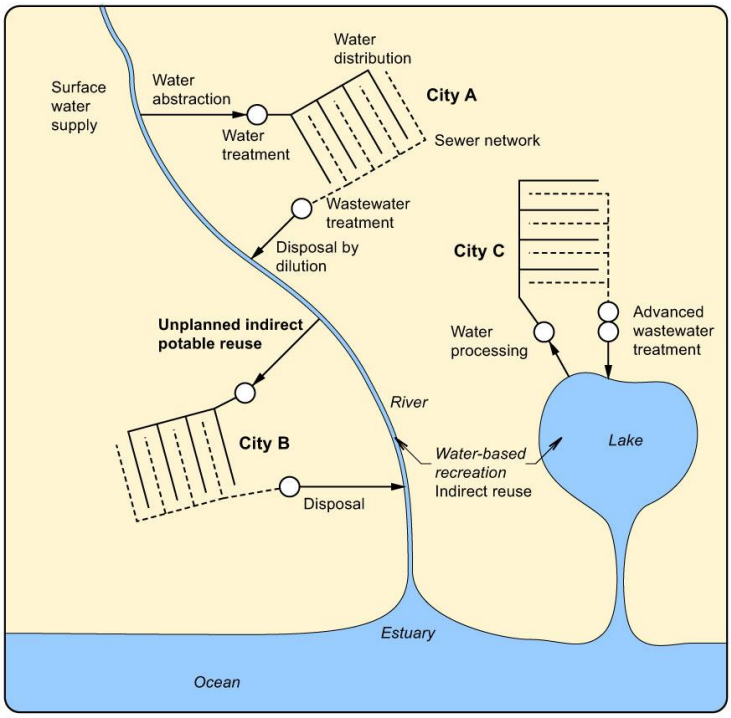

Figure 2 Water recycling (Unplanned indirect potable reuse)

Video-clip as multimedia enhancement

One of the modules in Public health engineering was on the design of sewer system that conveys the domestic wastewater to a central facility for treatment. In this module, an interesting case-study on 1992 sewer explosion in Guadalajara, Mexico was included to explain to the students how different underground services need to be properly designed and constructed to prevent such disasters in future. This case-study was taken as a video-clip telecast by National geographic channel on "Seconds from disaster" episodes. Numerous gasoline explosions occurred over four hours that destroyed 8 kilometres of streets in Guadalajara. Residents complained about gas-smell coming from their sewers and water pipes. It was later found out that gas was leaking out of gas-pipes into sewers. New water pipes, made of zinc-coated ion, were built close to existing steel gasoline pipeline. The electrolytic reaction that occurred between the two eventually caused the metal to corrode, creating the hole in the gasoline pipeline from where gas leaked into the ground and finally into the main sewer pipe. The sewer pipe was built into a U-shape so that the city could expand their underground railway system. Usually, sewers are built in a slope so that gravity helps move waste along. In order to get the U-shape to work, an inverted siphon was placed so that fluids could be pushed against gravity. The design was flawed, however. While liquids were successfully pumped through, gases were not, and gasoline fumes would build up, which eventually caused the pipes to burst (Wikipedia, 2010). This case-study educates the students about the important design flaw that eventually caused a disaster.

The revitalized course materials were then delivered using "Integrated Content Environment", which is an ideal tool to present such colourful multi-media resources, which can be flexibly accessed through Web or CD-Rom, with user-friendly navigation paths.

Assessment

Industrially relevant assignment as summative assessment

The assessment scheme had two assignments and an exam at the end of the year. These assignments are industrially relevant in nature which requires students to use higher order cognitive skills and competencies to solve problems and situations. The assignment 1 requires the students to design a water supply scheme and suggest effective immediate and long term measures to satisfy present demands and that at the end of the design period for a given population. The assignment 2 requires

the students to design "a sewer network" for a simulated subdivision which would cater for various users such as domestic houses, parks and schools. These assignments intend to create an understanding of overall design of such complete systems following the guidelines set up by the local councils and assess the students' capabilities in meeting these specific objectives set in the course specification. They also prepare the students work ready to tackle similar design issues upon graduation.

Quizzes as formative assessment

While the assignments gauged deeper understanding of two modules in design of water supply scheme and sewer network, they do not give the students the opportunity to understand the qualitative nature of the materials that are presented in the modules related to chemistry and microbiology. Several self assessment online quizzes were developed specifically to motivate the students to learn these unfamiliar materials and other theoretical concepts presented in the course. These quizzes were developed using multiple choice questions, numerical and true/false options available in the USQ Moodle environment to facilitate progressive learning. The facility of calculated question type available in Moodle was also explored in order to individualize the questions. In this type, variable parameter sets are used in place of numbers in the question. The system then generates a set of random numbers to be used for the variables in the question. A formula is provided for the correct answer based on these variables. Therefore, no two students can get the same question. Example of such question is given below. In this question, the values would change every time the students refresh the quiz page.

Question 1: Saturated water has 10 mg DO/L. Before secondary treatment, 3 mg O_2/L was measured in a water sample that had been saturated with oxygen and left at 20 ^oC for 5 days. After secondary treatment, 9 mg O_2/L was measured in the water after saturation with oxygen and 5 days at 20^oC. BOD removal efficiency (in percentage) in the secondary treatment is

Answer:

Submit

In a class of 68 students, average attempt/quiz has been 85.

Student performance

Overall student performance was compared for the years 2008 and 2009 in Public Health Engineering course. The grades HD, A, B, C and F are awarded with cut-off marks being 85%, 75%, 65% and 50% respectively. FNS and FNC indicate that the students failed to sit the exam and failed to contribute respectively. According to Figure 3, about 67.3 % and 79.4 % students achieved a higher than C grade in 2008 and 2009 respectively, which shows an increase of about 12.1 %.

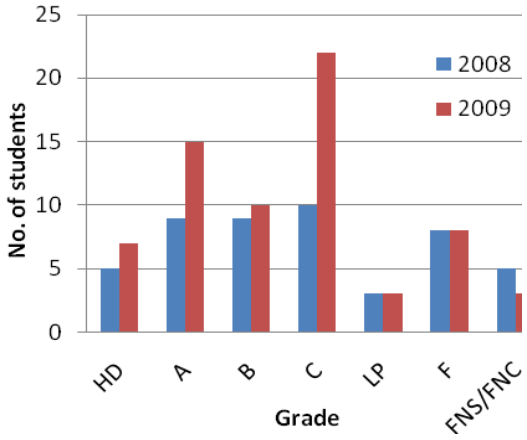

Figure 3 Exam performance

The percentage of students who failed also reduced from 16.3% in 2008 to 11.7% in 2009 respectively. The performance in any year can be variable depending on the student cohort enrolled in a course during a particular year, questions posed and etc, but we conclude that the increase in performance in this year is certainly noticeable. The course in Public health engineering underwent revitalization as not only new animations were introduced, but also several topical case studies were introduced in addition to the introduction of several illustrations and online quizzes to enhance the outcome. Therefore, it is understood that the increase in overall performance is due to increase in student engagement or interest as a result of multimedia enhancement.

Some feedback from students:

"While going through the course material .... in ENV 4203 (Public Health Eng.) I had found out that some of the animations produced there, really sounded to be very interesting and did clearly explain the processes....which were only known to us previously through words and pictures. The animations have certainly put some life to the bookish words. ... a word of appreciation for giving us a better way to understand the real processes in form of animation." - feedback from a student

"Animations of key concepts were very useful"- Another student

"Quizzes were useful" – Another student

The feedback for the questions such as "Animations were useful to learn the treatment processes"; "Animations were well structured and presented" and "Audio accompaniments for animations were useful" received the scores of 4.4, 4.1 and 3.90 in a 5 scale with a response rate of 20%. Animations and colorful illustrations in the course material have increased student engagement and interest in the subject. They enabled them to create mental models and visualized pictures regarding the processes, which increased their learning outcomes. Distant students who solely rely on the study materials and those learners, who learn from visual means, benefit greatly from the developed multimedia resources. The effectiveness of such inclusion of multimedia enhancement will be thoroughly evaluated in future.

Conclusions

Distant education can be greatly enhanced by the inclusion of multimedia resources that can greatly enhance the learning outcomes of the students. Public Health Engineering, a final year course that is normally perceived as difficult by Civil Engineering students was revitalized including several multimedia resources along with contextualized case-studies to increase student engagement and to retain long-term memory. The animations were chosen because they could stimulate the reactions that occur within a treatment plant or process which cannot be seen simply from a video-clip or a photo image and to transmit knowledge on chemical and microbiological reactions that have been occurring within the processes. The industrially relevant assignments and online quizzes were further used to refine the concepts and to foster independent learning. Consequently, the student engagement has certainly increased in these subjects with appreciable increase in exam performance. Multimedia enhancement is an ongoing process that will improve the learning outcomes of those distant learners who solely rely on the study materials for learning.

Acknowledgment

I would like to acknowledge the Faculty of Engineering and Surveying at USQ for providing the resources to develop these course materials. I would also like to acknowledge Mrs Neralie Macdonald (Materials Development Officer, USQ) for her contribution in script writing, Miss Zoe Lynch (Multimedia e-Learning Developer, USQ) and Anthony Skinner (graphics) for their contributions in developing the animations and illustrations in the Public Health Engineering Course and Jason Myatt (Senior Audio Producer, USQ) for providing narration and audio editing for the animations.

References

Dharmappa, H., Corderoy, R. and Hagare, P. (2009), "Supporting learning in environmental engineering: interactive water treatment processes" Available from http://www.ascilite.org.au/conferences/melbourne01/pdf/papers/dharmappah.pdf., [Accessed on 24th Feb 2010].

Felder , R., M. and Silverman, K., L. (1988), "Learning and teaching styles in Engineering Education" , *Engineering Education*, 78 (7), 674-681.

Mayer, R., E. (2003), "The promise of multimedia learning: Using the same instructional design methods across different media", *Learning and Instruction*, 13, 125-139.

McDougall, K., Apan, A., Wolski, I. and Young, F. (2001), "Distance, multimedia and web delivery in surveying and GIS courses at the University of Southern Queensland", *Proceedings of 42nd Australian Surveyors Congress, 25-28 September 2001*, Brisbane, Available from citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.129.9145, [Accessed on 6th Oct 2010]

Noronha,M., Bittencourt, T.,N., Proenca, S., P., and Guello, G., A. (2009), "Multimedia-based environment in structural engineering education" ,Available from http://www.lmc.ep.usp.br/pesquisas/TecEdu/artigos/icece00.pdf, [Accessed on 24th Feb 2010]

Ragan, L.C. (1999), "Good teaching is good teaching: An emerging set of guiding principles and practices for the design and development of distance education", Cause and effect Journal, 22 (1), Available from http://net.educause.edu/ir/library/html/cem/cem99/cem9915.html , [Accessed on 24th Feb 2010]

Sankey, M. and St Hill, R. (2008), "Ethical considerations in providing distance education in the light of massification", *Proceedings of 5th International Lifelong Learning Conference: Reflecting on Successes and Framing Futures, 16-19 June 2008, Yeppoon, Queensland*, 342-347.

Yung, I., H. , "Effects of animated pedagogical agent with instructional strategies in multimedia learning", *Journal of educational multimedia and hypermedia*, 18, 4, 2009, 453-466.

Wikipedia, 2010, " 1992 explosions in Guadalajara" http://en.wikipedia.org/wiki/1992_explosions_in_Guadalajara, [Accessed on 24th Feb 2010]

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