Situating a Senior Project Course in a University QEP Research-Based Instructional Framework

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Abstract

The process of reaffirming accreditation at the University of Houston has identified research-based instruction as a critical component of the campus learning environment for the foreseeable future. This assertion is consistent with broader trends in higher education that tout the benefits of this approach especially with regard to enhancing undergraduate instruction. This paper briefly explains the Quality Enhancement Plan (QEP) at the University of Houston-College of Technology (UH-COT) and elaborates on the steps that have been taken UH-COT and provides some examples of the current and future implementation of this plan.

Introduction

The role of undergraduate research as an instructional tool can be traced to the landmark Boyer Commission Report, Reinventing Undergraduate Education: A Blueprint for America's Research Universities [1]. A follow up report confirmed that some of the report's recommendations had begun to filter into the undergraduate curricula [2]. However, a later survey revealed that many institutions still faced challenges implementing research-based educational strategies in their undergraduate programs [3].

Wendy Katkin [3] describes four key learning components of the Boyer undergraduate research model. These are: written and oral communication skills, inquiry-based learning, collaborative learning and teaching, and capstone courses/senior projects [3]. Working in concert, these components serve as the foundation for an effective undergraduate research program. The instructional emphasis of this model is on the involvement of students in the development of their own knowledge through a hands-on experience. Indeed, Edward Crawley, et al. [4] suggest all students can benefit from an education set in the context product, process and system development and gain an appreciation for the potential value of scientific discovery on everyday life. The challenge is how to implement and sustain this learning process in the long term.

The University of Houston's focus on undergraduate research evolved from a collaborative effort to develop a Quality Enhancement Plan (QEP). The QEP is a major component of the reaffirmation process for the Southern Association of Colleges and

Schools (SACS), a regional accreditation agency [5]. In September 2006, a QEP committee representing a cross-section of university stakeholders began meeting to brainstorm and discuss ideas that could potentially enhance student learning. After five months of investigative work, including gathering feedback from the wider university community, the QEP committee recommended an undergraduate research focus to the University of Houston (UH) SACS Leadership Team [6].

Once the university SACS team accepted the recommendation of the QEP committee in January 2007, the leadership began the process of delineating the framework for undergraduate research at UH. The first step was to develop a common definition of research that would resonate with the entire UH community.

> Research is a diligent and systematic inquiry or investigation into a subject in order to discover facts or principles, and increase the sum of knowledge, enhance design, or enrich artistic ability [6].

Fundamentally, the objective of the undergraduate research initiative or Discovery-Based Learning Initiative was to incorporate and/or emphasize research activities and skills in the undergraduate curriculum. Figure 1 presents the specific goals delineated by the report [6].

- Undergraduate research should be a signature program from UH, one that makes the university more attractive to potential students with records of strong academic achievement.
- Undergraduate students at UH will participate in some level of research activity by the time they receive their bachelor's degrees.
- By the time they graduate, UH students will have a fundamental understanding of research and its importance to society.
- The number of students participating in research experiences who are selected for presentation will grow.
- Undergraduate student retention will improve.
- The six-year graduation rate of first-time in college students and the four-year graduation rate of transfers beginning with 60 or more credit hours will improve.
- External funding for undergraduate research will grow.

Figure 1: QEP Goals for Undergraduate Research

In order to assess university progress toward the general undergraduate research goals, the QEP also identified several student learning goals. These include:

- Students will be able to formulate a research question or problem.

- Students will be able to identify basic principles and knowledge related to their research question or problem.
- Students will be able to develop a research plan to address or resolve a specific question or problem.
- Students will be able to collect and interpret data and information in an attempt to resolve the question or problem.
- Students will demonstrate awareness of the responsible conduct of research.
- Students will be able to articulate their research findings through written, performance and/or oral presentations.

Many of these goals have been a critical part of the undergraduate learning experience across a variety of disciplines. However, the intent of the QEP was to develop a systemic plan for making research activity and skill-building a core element of undergraduate education at the University of Houston. In addition to providing a common university framework for enhancing student learning, the undergraduate research initiative has also served to highlight instructional practices throughout the campus that have been incorporating elements of research-based education.

An Example

One of the most prominent examples of research-oriented education practice is exemplified by the Senior Project course in the Computer Engineering Technology (CET) program. The Senior Project course (ELET 4308/ELET 4108) was originally taught under the title of *Microcomputer Interfacing* and consisted of a three hour lecture and one hour lab. The course covered topics such as Op-Amps, ADC/DAC, interfacing, signal conditioning, microprocessor I/O, bus structure, and some machine language. The course was more hardware intensive with a very limited software component present.

In addition, there existed a severe time constraint in the execution of the course. For example, the lab component consisted of several small experiments during the first half of the semester while the second half was devoted to a term project. Students formed teams of two and proposed their idea to the lab instructor and course instructor for approval. Students then had to purchase their own parts and most often worked outside of the lab (due to a limited lab space availability) to construct their prototypes. However, course and lab instructors had very little interaction in this format and part-time faculty often taught the laboratory component. This environment was certainly not conducive to a meaningful team project experience.

Seeking to revise the curricular structure of CET, the instructor for ELET 4308 identified that most of the Senior Project course topics were covered earlier in the degree plan. Deficiencies observed in the senior project course were also traced back to the fundamental courses and gave rise to the CLABS (read as C- LABS) Project [7, 8, 9] in summer 2004. The CLABS Project was made possible with a change in administration of the college and department, hiring a new generation of energetic faculty and strong desire

for change at all levels. The rationale behind the CLABS Project is reported in several publications [10, 11, 12, 13, 14, 15, 16].

After a thorough review and revision, the new Senior Project course (ELET 4308/ELET 4208) was offered in updated form in fall 2004. A key feature of the new course was that the project component would now be a semester long activity reflecting a comprehensive capstone experience. An assessment of the course components reveals that the curriculum and instruction also incorporated most of the general research-based learning activities later described by the University Quality Enhancement Plan. Figure 2 provides a map of course learning activities against the student learning goals proposed by the UH QEP.

		ELET Course Components				
		Final Project	**Project Proposal**	**Progress Reports**	**Workshops**	**Guest Speakers**
UH QEP Student Learning Goals	Formulate a research question or problem	✓	✓			
	Identify basic principles and knowledge related to their research question or problem	✓	✓		✓	
	Collect and interpret data and information in an attempt to resolve the question or problem	✓	✓	✓		
	Demonstrate awareness of the responsible conduct of research	✓	✓	✓		✓
	Articulate research findings through written, performance, and/or oral presentations	✓	✓	✓		

Figure 2: QEP Learning Goals vs. ELET 4308 Course Activities

Additionally, assessment and evaluation play a key role in the Senior Project course. Each learning activity is accompanied by a rubric-based performance assessment usually taking into account multiple perspectives including the instructor, graduate assistants, industry representatives (during the final project presentation), members of the department's Industry Advisory Board, faculty and university guests. In addition to performance assessments, student surveys are also implemented to gauge perceptions of course effectiveness. Two surveys are conducted during the first session. The first survey is a self-assessment of the student knowledge and information about their work schedule (most students work part time and few work full time). A similar survey is conducted at the end of the semester and the results are then compared. The purpose of this survey is to

assess student's knowledge and workload and provide guidance if an overloaded schedule is identified [17, 18, 19, 20].

Results from these assessments are used to make pedagogical and curricular decisions regarding the direction of the course. The assessment tools themselves are consistently evaluated for their effectiveness and relevance to the instructional process.

The Relationship of Undergraduate Research to the Senior Project Course

It is clear that the University of Houston's adoption of undergraduate research-based learning as the QEP topic dovetails well with the Senior Project Course. In addition to hands-on research skills, the course infuses the curriculum with opportunities for students to participate in oral and written communication exercises (e.g. proposal and final project presentations) that are consistent with Boyer Commission Recommendations for improvement [1]. Students in the upper level classes are also being asked to review freshman, sophomore, and junior course projects and presentations. The act of evaluating other's work within a technical context and reporting their qualitative evaluations back to the instructor further enhances critical thinking skills at the highest level of Bloom's taxonomy [21].

Senior Project students also have the chance to engage in paid, industry-sponsored professional activities. In order to enhance their problem solving experience, industry personnel are increasingly presenting senior level students with opportunities to tackle real world problems that require timely solutions.

In the short term, the goals of the program include:

- Building on previous successes.
- Monitoring student progress in the senior project pipeline by examining outcomes from redesigned freshman, sophomore, and junior level courses.
- Monitoring and improving the assessment instruments.
- Encouraging additional faculty to take part in student mentoring.
- Encouraging continued student participation in department sponsored tournaments such as Botball, and First LEGO© League.
- Engage students in volunteer work in venues such as Children's Museum of Houston, and Young Audiences of Houston.
- Dissemination of information collected from the instructional process.

Each of these activities further enhances the undergraduate experience by reinforcing a process of continuous improvement. Many of the short-term goals have been implemented in the past three years. Long-term goals for the Senior Project Course present many challenges. However, some efforts along these lines are currently underway.

Long-term goals include:

- Increasing industry participation in mentoring and sponsoring student projects
- Facilitating joint projects with other departments within ET
- Facilitating joint projects with other schools at UH
- Participation in regional and national competitions
- Conference presentations by students
- More patentable projects
- More journal publications
- Increase student sense of community responsibilities

As stated previously, outcomes related to some of these goals are already starting to materialize. Several students have successfully applied for provisional patents and published papers based on their projects [22, 23, 24, 25, 26]. However, the goal of the program is to make this type of success a commonplace occurrence.

Conclusion

The adoption of undergraduate research as a top priority for the University of Houston serves as a validation of the work taking place in the Senior Project Course. Indeed, the renewed focus should facilitate adoption of this approach in a variety of courses that would benefit from the model. As the University continues to build capacity for undergraduate research, the Senior Project Course will be positioned as a leading example of the instructional effectiveness of this strategy.

References

[1] Boyer Commission on Educating Undergraduates in the Research University, S. S. Kenny (chair), Reinventing Undergraduate Education: A Blueprint for America's Research Universities, State University of New York–Stony Brook, 1998.

[2] Kenny, S. S., E. Thomas, W. Katkin, M. Lemming, P. Smith, M. Glaser, and W. Gross, "Reinventing Undergraduate Education: Three Years After the Boyer Report," State University of New York–Stony Brook, 2001.

[3] Katkin, W. "The Boyer Commission Report and Its Impact on Undergraduate Research," *New Directions for Teaching and Learning*, No. 93, pp. 19-38, 2003.

[4] E. Crawley, J. Malmqvist, S. Ostlund, and D. Broder, *Rethinking Engineering Education: The CDIO Approach* , Berlin:Springer, 2007.

[5] Southern Association of Colleges and Schools, http://www.sacs.org/

[6] *Discovery-Based Learning: Transforming the Undergraduate Experience through Research*, available from: http://www.uh.edu/~qepsite/QEP_Report.html, 2008.

[7] Attarzadeh, Farrokh, "Innovations in Laboratory Development for Computer Engineering Technology Programs," *Proc. of The9th Annual IJME-INTERTECH*

International Conference, Session ENT, October 19-21, 2006, Keen University, Union, NJ.

[8] Attarzadeh, Farrokh, Gurkan, Deniz and Benhaddou Driss, "Innovative Improvements to Engineering Technology Laboratory Education to Engage, Retain and Challenge Students of the 21st Century," *Proc. of the 2006 ASEE Gulf-Southwest Annual Conference*, Southern University and A&M College, Baton Rouge, LA.

[9] Gurkan, Deniz, Attarzadeh, Farrokh, Benhaddou, Driss, Gallardo, Victor, and Chacón, Sergio, "Learning-Centered Laboratory Instruction for Engineering Technology," *Proc. of the 2006 ASEE Gulf-Southwest Annual Conference*, Southern University and A&M College, Baton Rouge, LA.

[10] Farrokh Attarzadeh, "Novel Approach to Digital Laboratory Experimentations," *Proceedings of the 2007 ASEE Gulf-Southwest Annual Conference,* UTPA, March 28-30, South Padre Island, TX.

[11] Farrokh Attarzadeh, Enrique Barbieri, "Training Requirements for the Graduate Assistants in the Capstone Course," *Proceedings of the 2007 ASEE Gulf-Southwest Annual Conference,* UTPA, March 28-30, South Padre Island, TX.

[12] Farrokh Attarzadeh, Victor J. Gallardo, Enrique Barbieri, "Toward Best Laboratory Management Practices," *Proceedings of the 2007 ASEE Gulf-Southwest Annual Conference,* UTPA, March 28-30, South Padre Island, TX.

[13] Farrokh Attarzadeh, Victor J. Gallardo, Deniz Gurkan, Enrique Barbieri, "Teaching and Graduate Assistants Training," *Proceedings of the 2007 ASEE Gulf-Southwest Annual Conference,* UTPA, March 28-30, South Padre Island, TX.

[14] Susan Miertschin, Driss Benhaddou, Cheryl Willis, Farrokh Attarzadeh, "Using Interactive Concept Maps to Enhance Learning and Thinking Skills," *Proceedings of the 2007 ASEE Gulf-Southwest Annual Conference,* UTPA, March 28-30, South Padre Island, TX.

[15] Attarzadeh, Farrokh, "Empowering Students to Become Highly Skilled Professionals for the 21st Century Industries," *Proc. of The 9th Annual IJME-INTERTECH International Conference, Session EN, October 19-21, 2006,* Keen University, Union, NJ.

[16] Attarzadeh, Farrokh, "Innovations in Laboratory Development for Computer Engineering Technology Programs," *IJME, special issue, 2007,* Volume 7, Number 2, Spring 2007, http://www.ijme.us/issues/spring2007/sl2007paper1attrasheh.pdf

[17] Farrokh Attarzadeh, Miguel A. Ramos, Enrique Barbieri, "Assessing the Assessments in a Senior Computer Engineering Technology Capstone Course," Proceedings of the 2008 ASEE Gulf-Southwest Annual Conference, The University of New Mexico – Albuquerque, March 26-28.

[18] Farrokh Attarzadeh, Enrique Barbieri, Miguel A. Ramos, Mayuri Mahajan, Vishal Naik, Aditya Gupta, "How the Capstone Class Students Perceive Their Knowledge Base?" Proceedings of the 2008 ASEE Gulf-Southwest Annual Conference, The University of New Mexico – Albuquerque, March 26-28.

[19] Farrokh Attarzadeh, Enrique Barbieri, Ankur Shukla, Prafulla Kesari, "The Role of the Teaching Assistants in a Senior Level Computer Engineering Technology Capstone Class," Proceedings of the 2008 ASEE Gulf-Southwest Annual Conference, The University of New Mexico – Albuquerque, March 26-28.

[20] Farrokh Attarzadeh, Enrique Barbieri, Miguel A. Ramos, "The Evolution of a Senior Capstone Course in the Context of a Research-Based University Quality Enhancement Plan," Proceedings of the 2008 ASEE Gulf-Southwest Annual Conference, The University of New Mexico – Albuquerque, March 26-28.

[21] Benjamin S. Bloom, "Taxonomy of educational objectives: The classification of educational goals: Handbook I, cognitive domain," New York; Toronto: Longmans, Green, 1956.

[22] Matthew Moreno, Amador Salazar, Rafael Gijon, Farrokh Attarzadeh, Mayuri Mahajan, Aditya Gupta, Prafulla Kesari, "Active Vehicle Water Level Monitoring System," Proceedings of the 2008 ASEE Gulf-Southwest Annual Conference, The University of New Mexico – Albuquerque, March 26-28. Abstract submitted. *Note: students will present and compete in best papers and best posters.*

[23] Juan Hernandez, Michael Alegre, Dragan Siljegovic, Robie Calong, Farrokh Attarzadeh, Ankur Shukla, Vishal Naik," Network Controlled Data Acquisition Drone," Proceedings of the 2008 ASEE Gulf-Southwest Annual Conference, The University of New Mexico – Albuquerque, March 26-28. Abstract submitted. *Note: students will present and compete in best papers and best posters.*

[23] Lee Howard, Brian Sturhan, Brian Meixell, Juan Montelongo, Manmeet B. Patil, Farrokh Attarzadeh, "Endless Coffee Pot," Technology Interface, Volume 8 No.1, Fall 2007, http://technologyinterface.nmsu.edu/Fall07/

[24] Alisha Garrett, Chris Vanderbles, Ricardo Moreno, Farrokh, "STAN – The Smart Trash Can," Technology Interface, Volume 7, No. 1, Fall 2006. http://technologyinterface.nmsu.edu/Fall06/

[25] Boodram, P., Brown, T. R., McNeilly, R. A., Mohammed, M., Mahesh, R., and Attarzadeh, F., "High Temperature Automobile Protection System," *ASEE-CoED Journal, VOL. XVI, No. 4, pp. 68-75, October-December 2006 issue.*

Biography

FARROKH ATTARZADEH earned his PhD in Electrical Engineering from the University of Houston in 1983. He is an associate professor in the Engineering Technology Department, College of Technology at the University of Houston. He teaches software programming, operating systems, digital logic, and is in charge of the senior project course in the Computer Engineering Technology Program. He has developed a concept referred to as EMFA (Electromechanical Folk Art) as a vehicle to attract young students to the STEM fields. He is the Associated Editor for student papers at *the Technology Interface* (http://engr.nmsu.edu/~etti/), Manuscript Editor for the *International Journal of Modern Engineering* (IJME, http://www.ijme.us/), Conference Associate Chair for the *IAJC-IJME International Conference* (http://www.ijme.us/IJME_Conference_2008/index.htm), and Chair,

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WILLIAM FITZGIBBON, III earned both his BA and PhD degrees from Vanderbilt University in 1968 and 1972 respectively. He is currently serving as Dean of the College of Technology of University of Houston and holds professorial rank in both the Department of Mathematics and the Department of Engineering Technology of the University of Houston. Previously he served as Chair of the Department of the Mathematics, co-Head of the Department of Computer Science and President of the University of Houston Faculty Senate. Over the course of his career he has held faculty positions at the University of California, San Diego and the University of Bordeaux I and the University of Bordeaux II as well as a research position at Argonne National Laboratory in Illinois. His academic discipline is applied mathematics with specialization in mathematical biology (mathematical models in epidemiology and ecology), reactive flow, nonlinear partial differential equations and integro-differential equations. He has well over 130 research articles plus numerous articles, reviews, and reports and has lectured extensively in North America, Europe and Asia.

ENRIQUE BARBIERI received his Ph.D. in Electrical Engineering from The Ohio State University in 1988. He joined Tulane University where he was on the faculty of the Electrical Engineering Department (1988-96) and was a tenured Associate Professor and Chair of the Electrical Engineering & Computer Science Department (1996-98). In 2002 he joined the University of Houston as Professor & Chair of the Department of Engineering Technology. His research interests are in control systems and applications to electromechanical systems. He is a member of IEEE and ASEE and Chairs the Executive Council of the Texas Manufacturing Assistance Center.

MIGUEL A. RAMOS earned his Ph.D. in Educational Research, Measurement and Evaluation from Boston College in 2004. He is the Director of Assessment and Accreditation Services for the College of Technology at the University of Houston. Dr. Ramos has worked as Program Evaluator for Boston Connects, a school-community-university partnership designed to address non-academic barriers to school success via a web of coordinated health and social service resources in ten public elementary schools. He has also worked as a federal education researcher for the Southwest Educational Development Laboratory evaluating the effectiveness of reform models developed to improve student academic performance by enhancing systemic coordination of academic resources. In addition, Dr. Ramos has served as a consultant in a variety of contexts investigating a range of issues including program effectiveness, organizational communication, assessment and public policy, and research methodology.