TRANSFORMING AN ENGINEERING COURSE TO ENHANCE STUDENT LEARNING

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Abstract *¾ One of the key courses in the remote sensing and geographical information systems curriculum option at the University of Puerto Rico at Mayagüez, Pattern Recognition, was revised. The course revision was initiated by characterizing the learning profile of the student using Felder Learning Styles Model. The data indicated a predominance of sensorial, visual, active and sequential learners. The learning profile provided the framework for the design of course activities to match the learning style preferences of the student population. Course activities included ensemble a pattern recognition system to classified remotely sensed multispectral data, and a performance comparison of Bayesian, K-nearest neighbor and neural network classifiers. Case studies were designed to applied pattern recognition to solve problems in the science, engineering, agriculture and geology fields. The transformation of the teaching methodology included the development of soft skills such as teamwork, conflict resolution and written communication using cooperative learning. Assessment of student learning was documented using portfolio.*

INTRODUCTION

Advances in technology, globalization and the interdisciplinary nature of the workplace have influenced the academic environment. Barr and Tagg [2] proposed a transformation of the higher education process, a shift in the educational paradigm. In this proposal faculty become designers of learning environments rather than just lecturers. The new learning environments are cooperative, learner-centered and learner-controlled. It has been reported "too many graduates go out into the workforce ill-prepared to solve problems in a cooperative way, lacking the skills and motivation to continue learning [1]." As a result, the higher education system is experiencing a shift in the educational paradigm, from teacher-centered to learner-centered. More recently the new ABET accreditation criteria requires engineering programs to respond to constituents needs. This criteria is driving institutions to re-conceptualize the way programs are revised which in turn, spell the need for learning environments that are cooperative and outcomes based. In response to this scenario an innovative information technology based science, math and engineering/technology (SMET) curriculum in Remote Sensing (RS) and Geographical Information System (GIS) was designed at University of Puerto Rico, Mayagüez (UPRM). The Partnership for Spatial and Computational Research (PaSCoR) was established in 1998 through a PAIR-NASA grant (#NCC5-340) as an interdisciplinary outcome-based and student centered curriculum. The program aims to develop the skilled scientist and engineering needed in the workplace. The major goal of this program is a graduate knowledgeable of the RS/GIS technology and applications that possess the skills to graduate school or becomes a successful professional.

The Pattern Recognition, one of the required courses from the Electrical and Computer Engineering Department in this curriculum was revised. The revision took into account, among other things, student-learning preferences, and course activities to match learning diversity, soft skills development, as well as integrated assessment of the learning process. The planning process to revise the course (Figure 1) was as follows:

1. Establishing instructional objectives using verbs that indicated actions to be perform by the students. Special attention was given to development of soft skills.
2. Determine if the instructional objectives complied with ABET 2000 accreditation criteria.
3. Design activities using student-learning styles to accomplish course objectives.
4. Identify assessment tools in addition to the traditional exams to evaluate student performance.
5. Communicate to the student course innovations by providing a syllabus that included objectives, learning activities and assessment strategies.

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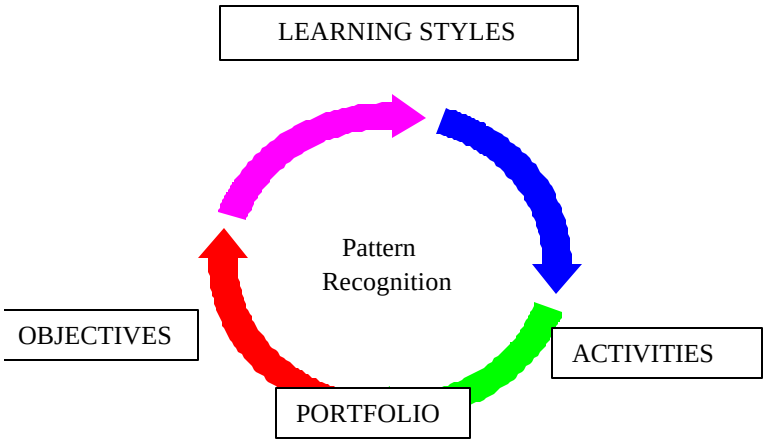
FIGURE 1



Pattern Recognition Course Objectives-

A major innovation in the teaching of the Pattern Recognition course was to think on the knowledge and skills learned in the course with regards objectives and learning outcomes. Bloom Taxonomy (3) facilitated the revision process by providing levels of student cognitive development with operational verbs that indicate the level that we were targeting in the classroom. In this way we provided the student with a learning experience that ranged from the lowest to the higher levels of learning in the cognitive domains (i.e., knowledge, comprehension, application, analysis, synthesis and evaluation). Furthermore, course objectives were compared with ABET a-k competencies (9) to determine how the course complied with the new accreditation criteria. This comparison suggested that among the course objectives that respond to a-k competencies were:

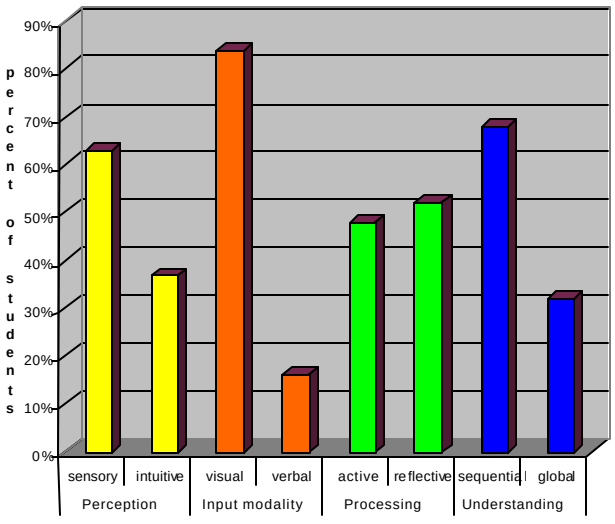
1. Able to know, comprehend, apply and analyze principles and techniques such as classifiers, clustering, neural network and image analysis (competencies a, b, k)
2. Evaluate different models of machine learning and its applications (competencies e, j, k).
3. Define the components of a pattern recognition system. (competency a)
4. Describe concepts of detection and classification of pattern and objects, training and learning of intelligent software used in decision making (competency a
5. Analyze data collected by different sensors and model and contrast the different approaches in pattern recognition (competency b)
6. Ensemble pattern recognition system to solve problems such as fingerprint verification. . (competencies e, h)
7. Able to work in teams to solve problems in medicine marine science environmental science, geology and agriculture from a global perspective and societal context (competencies d, h)
8. Development through oral presentations and written reports the ability to communicate in teams (competency g)

This exercise was the key to transform the teaching methodology for it suggested the need of re-conceptualizing the lecturing format that was the traditional strategy for teaching the course. It also helped the professor in the selection of the assessment.

Designing Pattern Recognition Course Activities

Up to the time of this revision during academic year 1999-2000, the ECE Pattern Recognition course was traditionally taught using a lecture format. However, revision in lieu of the issues presented in this paper, characterization of the learning style of the students drove a shift toward an active learning environment. This course is usually taken by upper levels students with an even distribution among students majoring in electric or computer engineering options. At the time of this revision 53% were women in the section taught with the new elements. The Felder Learning Styles Model [4-9] was used to determine the student learning preferences (see Figure 2). Students identified their learning styles preferences using the questionnaire on learning styles available at http://www2.ncsu.edu/unity/lockers/users/f/felder/public/RMF.html

FIGURE 2
Student Learning Styles (Felder, 1988)



The study indicated a predominance of sensorial, visual, active and sequential learning styles in the students. Students were informed of different learning strategies to enhance

learning depending on their learning preferences. The information empowered the student in a learning to learn process that provided tools to enhance their performance in the course. Also the data provided the faculty with useful information to design course experiences that target the student diversity at the same time that course objectives were achieved. Lecturing was still used but course was enriched with other activities that promote teamwork skills and active learning (e.g., cooperative learning). The introduction of cooperative learning involved offering a workshop to students in team building skills and conflict resolution. In the workshop students were divided in formal teams of 3 students that were kept together during the semester. The workshop provided the student with basic tools to initiate team integration by bringing the students through the following process:

Exercise 1- Do you like working in teams? Previous experiences in teams.
Exercise 2- Why and where team skills are important?
Exercise 3- Identify the learning style preference of each member of the team and used to develop the team learning profile.
Exercise 4- Use the team profile to determine how this diversity may enrich or interfere with team performance.
Exercise 5- Conflict resolution.
Exercise 6- Identify criteria that will be importance in monitoring team performance.
Exercise 7- Prioritize the criteria and assign value from assessment.

The criteria identified by the students were used to generate an assessment form to document student development of team skills taking in consideration student perceptions. The assessment used the following criteria: appropriate use of time, active participation, contribution with ideas, leadership in assigned tasks, people skills (respect, listening to others), quality of work and management of team conflicts. Students performed a self-evaluation of team skills followed by a peer evaluation. In class activities were designed to address the all spectrum of learning styles. Sensors benefit by hands on demonstration by the professor. The students had to reproduce and modify the demos in order to accomplish specific tasks and to obtain results. Examples are demos and laboratory reproductions are detecting bits "1" and "0" under noise with laboratory reproduction, neural network classification, and fingerprint verification system. Theoretical homework was given with well established methodologies explained in class to derive rules of classification based on probability and statistics. Intuitive learners were involved by introducing every new topic with a problem to be solved. Through questioning, students were encouraged to find a good intuitive solution on class. The laboratory reproductions of the demos had to be modified to apply the theory in real data. The students have to design and implement a Neural Network classifier that optimizes the classification performance. Finally, they had to design and implement a pattern recognition system. Since the course is in pattern recognition, most of the examples used in class were images to address the visual learner. Many diagrams were shown in transparencies to explain concepts such as detection, classification, decision boundaries, satellite image analysis, and fingerprint image analysis. Many demonstrations in class, using MATLAB, were done. Lectures were given in class with verbal presentations were equations were verbally explain and derived.

Active learning was addressed through cooperative learning. In the problems used to introduced a topic in class, the students contributed to find a solution by applying what they new before any theoretical discussion of it. A demo was given in class and then students had to modify it in the laboratory to apply it to data in order to obtain other results. Teamwork was used to enable interaction between students for demos reproduction, and for the assigned projects. However, individual theoretical homework were assigned to benefit reflective learners. In these the students had to think about a further development of something discussed in class.

Finally, every topic was introduced sequentially explaining its logically connection with previous ones. The solutions of problems in class were found in a logical derivation of formulas and equations. Homework that requires logical and sequential derivations was assigned. Since the global learners benefit from knowing from the beginning of the class that the course will lead to the design of a pattern recognition system, every time a new topic was introduced, it was referred to the global system to be designed and implemented. When a problem was explained in class, question were asked to provoke an intuitive answer before any theoretical derivation.

Pattern Recognition Assessment of Student Learning

Transformation of the teaching methodology with activities that addressed a wide range of learning styles requires modification of the evaluation procedures. Exams and homework were still used but were enriched with tools to monitor team performance, oral and written skills and a student portfolio. The portfolio was a collection of the student works that illustrated the student's competencies (5). The portfolio included the student learning profile, a final project written report, teamwork assessment, and ethic analysis of cases. Also, student included in their portfolio one activity from the course (exam, homework, quiz, cooperative learning activity, the workshop in ethics or teambuilding skills) with a reflection page addressing the following questions: Why did you choose this activity? What skills you developed with the selected activity? How this activity will help you become more effective as student,

as a professional and as a member of the society? This reflection provided a window to the student learning process.

The teacher was also assessed by the student using a scale of 1(low) to 5 (high). Student evaluations indicated 100% of the students rated as high the revise course with regards organization, quality and explanations and illustrations. Ninety four percent (94%) of the students rated the course as high with regards clarity of exposure, adequacy of materials, teaching methodology, faculty knowledge of subject and ability to transmit knowledge. The data indicated high student satisfaction with regards to the course revisions introduced. Furthermore, students indicated what the most liked aspect of the course was the presentation of information with a lot of applications, in addition as feeling motivated to learn. At the end of the course students were provided with individual certificates for the workshops in teambuilding skills and ethics as a way to exemplify the importance of enriching the curriculum with initiatives that are of importance for the profession and can be use to prospective employers as part of their professional portfolio.

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REFERENCES

[1] Advisory Committee to the National Science Foundation Directorate for Education and Human Resources. 1996. Shaping the Future: New expectations for undergraduate education in science, mathemathics, engineering and technology. National Science Foundation. Arlington, VA Page iiii

[2] Barr, R. B., and J. Tagg. From teaching to learning- a new paradigm for undergraduate education. *Change.* November-December1995:13-25

[3] Bloom B.S. and D.R. Krathwohl. Taxonomy of Educational Objectives. Handbook 1: Cognitive domain. Addison Wesley, New York, 1984.

[4] Buxeda, R.J. and D. Moore, "Using learning styles data to design a microbiology course", *Journal of College Science Teaching,* vol XXIX, no. 3, pp. 159-164, Jan 2000.

[5] Buxeda, R.J. and D. Moore. "Expanding a Learner-Centered Environment using Constructivist Portfolio". *Journal of Microbiology Education*. In print. May 2001

[5] Felder R.M. " Meet your students: Stan and Nathan", *Chemical Engineering Education*, Spring, pp. 68-69, 1989.

[6] R.M. Felder, " Meet your students: Susan and Glenda", *Chemical Engineering Education* 24(1): 7, 1989.

[7] R.M. Felder, "Reaching the second tier- Learning and teaching styles in college science education", *Journal of College Science Teaching.* 23(5), pp. 386-290, 1993.

[8] R.M. Felder, and L.K. Silverman, "Learning and teaching styles in engineering education", *Engineering Education.* 78(7): 674, 1988.

[9] Engineering Accreditation Commission, Accreditation Board for Engineering and Technology, *Criteria for Accreditating Programs in Engineering in the Unites States*, ABET, Baltimore, 1996-1997,p7