KEY ELEMENTS TO ENHANCE LEARNING IN AN INTRODUCTORY AND INTERDISCIPLINARY COURSE IN REMOTE SENSING

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Abstract — *This paper describes key elements and strategies to enhance student learning in an introductory/multidisciplinary course at the University of Puerto Rico at Mayaguez (UPRM). The course, called Introduction to Remote Sensing, is the first in a series of elective courses developed at UPRM as part of the NASA sponsored program, Partnership for Spatial and Computational Research (PaSCoR). This program aims to enhance SMET curriculum by providing an alternative track in Remote Sensing and Geographical Information Systems. The course has been taught using a traditional approach and course assessment data suggested the need to design activities that address active learning and soft skills development. A major innovation was the collection of student learning profiles. Felder's Learning Style Inventory administered to the multi-disciplinary student population from UPRM's Colleges of Engineering, Sciences and Agriculture suggested a predominance of sensorial, visual, active and sequential learners. The inventory results provided the framework for the design of course activities that addressed as well as capitalized on the student diversity. Once the learning styles were determined, the course learning experiences were designed. These included satellite image comparisons, designing satellite component based on specific case studies, analysis of current technological issues including technology advantages and limitations as well as teamwork exercises, discussion of ethical issues that are relevant to the technology. A major innovation was the development of soft skills such as teamwork, written and oral communication skills. In addition to traditional assessment tools, assessment of the course included student preparation of a learning portfolio as well as faculty and course assessment by the students. The 'new' course complies with ABET 2000 accreditation criteria.*

INTRODUCTION

Science, math, engineering/technology (SMET) higher education system has experienced changes in response to stakeholders needs. These changes are driven toward the design of outcomes-based and student centered curriculums that focus not only on knowledge acquisition of the discipline but also in the development of technical and professional skills required for effective performance in the workplace. As a result, a scholarship of teaching has been promoted as seemed by the increase in funding and programs in areas related to innovation in education grants, forum for disseminating curricular innovations, and industry and academia partnerships among others. Furthermore, new accreditation criteria for SMET programs by agencies such as ABET [6] as well as institutional accreditation bodies such as the Middles States Association are promoting program revisions to address specific student learning outcomes and continuous outcomes assessment. All of these are creating a new educational paradigm based on outcomes and continuous assessment for program improvement.

Supported by NASA (grant #NCC5-340), this new paradigm provided the base for the development of an alternate multidisciplinary undergraduate curriculum track in Remote Sensing (RS) and Geographical Information Systems (GIS) at UPRM. The NASA Partnership for Spatial and Computational Research (PaSCoR) aims to develop a SMET graduate who is knowledgeable of the RS/GIS technologies and their applications and who possesses the skills and competencies either to pursue graduate school or become a successful professional in these areas.

In the PaSCoR program students from SMET programs have the option to enhance the undergraduate experience with an alternate track in RS and GIS. The track consists of 12 credit-hours in formal courses followed by a one year research experience (equivalent to 6 credit-hours) and summer internship. Upon completion, students in SMET disciplines can obtain a RS-GIS Certificate. Students from SMET disciplines are selected during their freshman year and initiated in the "PaSCoR experience" with what's called a **Summer Station**. The one week experience initiates students in the basics of undergraduate research: the nuts and bolts needed for them to become part of a research team, with other students and a faculty mentor. This intensive experience consists of a series of workshops that address among other issues team building, oral as well as poster presentations, knowledge of RS and GIS through field trips to agencies, and research presentations by faculty and upper level students [3]. After three (3) Summer Station sessions, results show that at the end of the experience students are highly motivated: 100% of the students register in the course Introduction to Remote Sensing. This is the first course in the sequence to obtain the RS-GIS certificate. This course was revised using the same approach tried successfully earlier in other Science and Engineering courses [2, 4, 5]. The strategy requires two very important elements: 1)

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faculty development and, 2) enhancement of student learning. Faculty development required preparing faculty in learning the basics on how to design an outcomes-based course and how to redesign the course syllabus to include learning objectives and outcomes, teaching activities and assessment [12]. This was followed by mentoring interaction between the professor that taught the course and a resource professor. The mentoring goal was to facilitate the design of course learning experiences using the fundamental of pedagogy with regards to learning styles, active learning strategies and outcomes assessment. This paper focuses on the second aspect: the enhancement of the student learning, which followed the faculty development process.

Course revision took into account, among other things, student learning preferences, 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 followed:

1. Establish instructional objectives using verbs that indicated actions to be performed by the students. Special attention was given to development of soft skills.
2. Determine if the instructional objectives comply with ABET 2000 accreditation criteria.
3. Design activities using student-learning styles to accomplish the course objectives.
4. Identify assessment tools in addition to the traditional exams that document student performance.

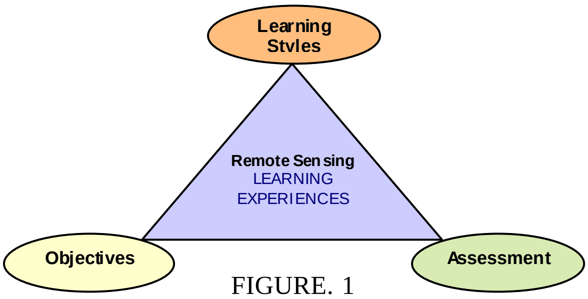

FIGURE. 1
REMOTE SENSING TEACHING METHODOLOY

A major innovation in the course was that objectives and learning outcomes drove the teaching strategies used. Bloom Taxonomy [3] facilitated the revision process by providing levels of student cognitive development with operational verbs that indicated the level that wanted to be targeted 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 the following courses objectives addressed the ABET a-k competencies:

- Be able to know, comprehend, apply and analyze general principles and techniques on the technology of remote sensing including history, current applications, electromagnetic spectrum, available remote sensing sensors and data, image processing, photo interpretation/image classification. **(competencies a, h, j, k)**
- Be able to evaluate remote sensing issues on a global scale (competencies h)
- Evaluate situations and apply principles and techniques in a critical, creative and effective manner. **(competencies a, b, e, f, k)**
- Be able to search, evaluate, comprehend, and apply current scientific literature related to the topics covered in the course to solve current issues. **(competencies i, j)**
- Present current issues related to the technology. **(competencies j)**
- Be able to work in an interdisciplinary team to solve problems in different areas of sciences and engineering from a global perspective and social content. **(competency d)**
- Develop a written report and make an oral presentation on a topic assigned on current issues as part of a team. **(competency g)**

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

DESIGNING REMOTE SENSING LEARNING EXPERIENCES

The Remote Sensing course was traditionally taught using a lecture format. However, a shift towards an active learning environment was driven by the characterization of the students preferred learning styles. The course (part of the General Engineering Department at UPRM) was taken by 41 second year undergraduate students (54% women) from engineering (72%), sciences (21%) and agriculture (7%). It must be specified that all engineering programs at UPRM are five years (5). Engineering students came from the following disciplines: electrical, computer, chemical, mechanical and industrial engineering. Science students were from biology, mathematics, physics, biotechnology, and geology. The Felder Learning Styles Model [7-11] 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

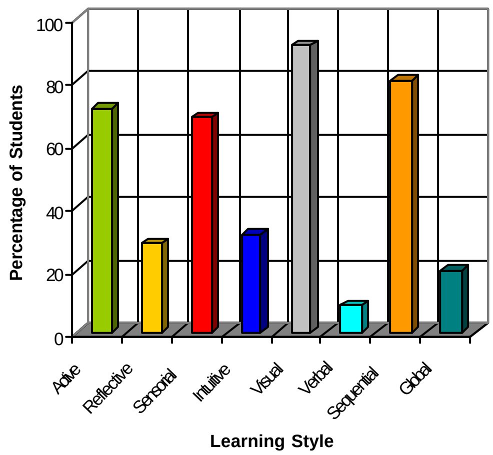

FIGURE. 2
DISTRIBUTION OF LEARNING STYLES AMONG STUDENTS

The study indicated a predominance of sensorial, visual, active and sequential learning styles in the students. Particularly surprising was a 93 % of visual learners among the students in the course. 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 learning experiences that targeted the student diversity while at the same time achieving course objectives. Lecturing was still used but the course was enriched with activities that promoted teamwork skills and active learning such as cooperative learning. Introducing students to cooperative learning involved offering students a team building skills and conflict resolution workshop. In this workshop students were divided in formal teams of 3 students that were kept together during the semester. The workshop provided the students with basic tools to initiate team integration and establish the ground rules for teamwork including how to assess team performance. Teamwork performance was monitored by criteria such as appropriate use of time, active participation, contribution with ideas, leadership in assigned tasks, people skills (respect, listen 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 spectrum of learning styles. At the same time, students learning styles were used to tailor the approach used to teach the course. Teamwork activities included formation of teams of 5 to 6 students. The team first task was to determine a team name to establish a sense of belonging to a group. Team names selected include Landsat 8, The Marvelous Pixels, ETOMER-82 (the word "REMOTE" backwards and the year when all the components were born), among others. Each team established their ground rules (as determined during the team workshop) including what the team expected from each individual and possible sanction for members that did not comply with the rules. To address the sensorial learning style during the introduction to the electromagnetic spectrum and its interaction with different objects or features over Earth, students had to decide what type of sensor they should develop for different situations. Students had to take into consideration the resolution and the wavelengths (bands) that would be included for different applications.

Another activity for sensorial and visual learners used was the student discussion of the World Trade Center/Pentagon attacks (September 11 2002) with regards to how the Remote sensing technology can be used and the social and ethical implications involved. Images were presented from Ikonos satellite from before and after the event at the World Trade Center and the Pentagon, covering the importance of having access to satellite images from the offense and defense point of view. RS/GIS videos were also used use to discuss the remote sensing technology. Intuitive and global learners benefited from problem solving activities in which students evaluated two different situations including a flood event and a fire in the Amazonian region. In both cases students had to assess the situation and understand the possible applications of remote sensing. Since the course is in remote sensing most of the examples used in class were images to address the visual learner. Many diagrams were shown in slide presentations to explain concepts such as the electromagnetic spectrum, types of sensors/image, image processing/restoration, image classification, and applications.

The MultiSpec image processing/classification software was demonstrated in an oral presentation and accompanied with examples. After this, the students had to go to the laboratory to practice with the software. Many of the students used the software for the course project. This provided useful learning activities for the active learners. This, in addition to cooperative learning, was the preferred teaching methodology used to address the active learners. Students worked in teams during problem solving exercises. Homework assignments often involved team participation as well.

For the laboratory, a municipality was assigned to each team. The group applied the knowledge learned during the course to prepare a project that was presented to the rest of the students during the Final Project Presentation. In the lecture, each team had to work in a literature review in a topic of interest to the group, related to the area of RS that was presented as a slide show presentation to the rest of the students.

Individual theoretical homework was assigned to benefit reflective learners. In these, students had to think about a further development of something discussed in class.

Finally, every topic was introduced sequentially explaining its logical connection with previous topics. Every time a new topic was introduced, it was referred to the overall, global picture and system. When a problem was explained in class, questions were asked to provoke an intuitive answer before any theoretical derivation.

REMOTE SENSING ASSESSMENT OF STUDENT LEARNING

The course assessment approach was based on the new teaching methodology that addresses learning styles diversity as well as learning outcomes. Exams and homework were still used but were enriched with tools to monitor team performance, oral and written skills and a portfolio. The portfolio was a collection of the student work that illustrates the student's competencies (5). Student's grade distribution indicated that 90 percent (90%) of the students approved the course with A, 10% with B and only one of 41 students withdrew from the course. The professor's performance was also assessed by the students using a scale of 1(low) to 5 (high) as shown in figure 4. The data suggests that areas of the course strengthened include faculty knowledge of the topic, course organization, adequacy of examples and illustrations and the effectiveness of the strategies to accomplish student comprehension.

The data also indicated high level of student satisfaction with regards to the course revision. 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 used to present to prospective employers as part of their professional portfolio.

FIGURE. 3
COURES EVALUATION (SCALE OF 1 (LOW) TO 5 (HIGH)

Criteria	Scale
Organization	3.54
Overall quality	3.32
Clarity in Exposure	3.43
Comprehension of material presented	3.61
Adequacy of materials, illustration, examples	3.93
Knowledge of subject	4.40
Explanations and illustrations	3.89
My ability to use this new information	3.79
My overall understanding of the subject	3.86

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