

# INTEGRATION OF INDUSTRY INTO COMPUTER SCIENCE EDUCATION

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## Abstract

The Department of Computer Science (DoCS) at Tennessee State University (TSU) has actively been involved in integrating industry into computer science education. Our main goal is to strengthen partnership among businesses and our department through participation in project-based learning and teaching experiences with real-life business problems. In this process, business/industry partners come together with faculty members to design projects for the courses we offer. A typical project for a course is shaped with collaboration of the faculty and the corresponding industry partner for that course to fit it into the course contents and objectives. Industry partners actively participate in developing project, evaluating students' progress, guiding students, communicating with students, and assessing students' performances. This kind of active learning highly improves the student learning outcomes by providing additional motivation, professionalism, feedback from real industry partners, and strengthening team spirit among our students. The DoCS has successfully completed three (3) such projects in Fall-2003 and Fall-2004 semesters.

## 1. Introduction

The DoCS has been involved in the Corporate Scholar Solutions (CSS) program of the Center for Information Technology Education (CITE) since Spring-2002. CITE is an NSF-funded center that aims at improving the IT workforce pipeline in the State of Tennessee. It promotes the use of CSS Projects to strengthen partnerships among businesses and educational institutions through participation in problem-based learning experiences with real-time business problems. The CSS program is designed to partner educational institutions and their IT students with area businesses and industries to provide a "real-world, real-time" issue/problem as the context for IT learning [1].

The DoCS successfully completed two CSS projects with Saturn Corporation and Electronic Data System (EDS) as industry partners in Fall-2003 and Fall-2004 for our *Computer Programming with Java* and *Event Driven Programming* courses, respectively. Saturn is a car manufacturer that started production in 1990 and EDS is a large service company that provides services to Saturn Corporation [2,3]. The business problems that our students were asked to solve

in these two courses were similar, however, the techniques and tools used were different. Another project with MIS Systems [4] was conducted in our *Algorithms* course in Fall-2004.

The following innovative teaching and learning activities we have been performing in those projects:

1. Industry partners and faculty members work together to develop a project according to the course objectives and industry partners' needs. This provides a unique opportunity for the faculty members to keep themselves up to date with current technology and business activities.
2. Industry partners visit classrooms to talk to students directly to explain the project in a professional manner and set the expectations. These types of visits highly motivate students and improve students' performance.
3. Students work in teams consisting typically of four (4) students. This helps them develop skill in working teams, communicating and presenting effectively. In addition, each team leader directly communicates with the industry partner via face to face meetings, tele-conferences, and/or video-conferences.
4. An e-mail group consisting of faculty members, industry partner, and students is set up for discussion and communication purposes. There were almost one hundred (100) discussion messages posted for one of our courses in Fall-2003.
5. Instructors are able to assess his students' learning - not only important IT course content but also problem solving, communication, critical thinking, and collaboration skills.
6. Industry partners evaluate students' progress and the final products they develop. This helps faculty members assess students' learning.

CSS projects target students ranging from freshman to senior and they differ from capstone projects that mainly target senior students. In addition, the entire class works on the same problem whereas only a group of students are involved in capstone projects.

This paper investigates how to partner with industries to design problem-based computer science course projects. It also discusses how industries can be integrated in student learning assessment process. This paper is organized as follows: Section 2 gives a detailed description of the problem. The characteristics of the projects are discussed in Section 3. A sample project along with student solutions is given in Section 4. Finally some conclusions are drawn and future work is motivated in Section 5.

## **2. Problem Statement**

Computer Science (CS) curricula contain courses ranging from application-based courses such as *programming* and *robotics* to theoretical courses such as *algorithms*. Some course projects involve active learning techniques that improve not only students' technical skills but also their soft skills including communication, presentation, team work, and management skills. The scope in such a project is usually determined by the course instructor and the student learning is assessed by the same instructor. The main limitations can be listed as:

1. Students do not develop the technical and soft skills that industries need for immediate employment.
2. Student learning assessment is limited. The instructor is usually the only person who assesses the students learning.
3. Students develop limited professionalism skills since the project participants are limited to the instructor and students.
4. Students sometimes do not get motivated since they cannot see immediate real-life applications.

The DoCS has partnered with several businesses to extend the scope of our class projects. The industry partners get actively involved in design, implementations, and evaluation of the problem-based projects. The benefits of such partnership can be listed as:

1. A student who completes several projects gain technical and soft skills that the IT industry needs. For example, they communicate with the industry partner throughout a semester to learn more about the application domain and business problem and to get technical assistance. They submit a technical report and make at least two presentations during the semester.
2. Students develop high level professionalism skills since they work with real industry partners. For example, they should satisfy not only the instructor but also the people who work in industry.
3. Industry partners help assess student learning during the semester. For example, they evaluate the students' mid-semester progress as well as their final presentation and product.

The students *gain experience on working in interdisciplinary teams, develop project management skills, and improve written and oral communication skills*. These expectations overlap with some of the attributes that engineering graduates must have in order to satisfy some of the ABET criteria [5,6,7].

### 3. Characteristics

The CSS projects are designed to improve student learning by providing opportunity to work on real-life problem-based projects with industry partners. The CSS project process, explained in detail below, is well established at the DoCS.

***Establishing Partnership:*** Identifying a suitable industry partner is the first step in the process. Our department has a CSS coordinator who works with local industries and businesses to establish partnerships. Individual faculty members are also involved in identifying potential industry partners. Many of our faculty members already have well-established connections with local industries. In addition, CITE organizes workshops and meetings to bring industries and academic institutions together.

***Designing Project:*** The course instructor and industry partner meet several times to design a project that is consistent with the course objectives. The project is shaped into the course objectives and contents so that the curriculum can keep its integrity. The draft project is usually

designed before the semester starts. However, it is tailored to the exact needs of the students during the first half of the semester.

**Interaction with Students:** The interaction occurs at different levels:

1. The industry partner(s) and students meet face-to-face at least four (4) times during a semester. The industry partner teams visit the classroom in the second week of the semester to introduce themselves, present the business problem, and explain the application domain. The students have a site visit to the business partner by mid-semester. The business partner teams visit the classroom again in the third quarter of the semester to evaluate the students' progress. They also attend the final presentations to assess student learning. Evaluation forms to assess technical and soft skills are completed by the industry partner teams.
2. The instructor, student team leaders, and business teams have weekly conference calls that last about an hour. The student team leaders attend the second half of the conference call to express the problems they are facing and their progress.
3. An email group list including the instructor, students, and business partner teams is created. The students can freely ask any problems that they have. The industry partner is expected to reply within a day so that we can have a smooth progress. There were over one hundred (100) emails posted to the group in one of our projects.

**Time Commitment:** The business partner(s) and instructor are encouraged to work together to design a suitable project before the semester starts. This necessitates time commitment of both parties. However, most of the discussion takes place via phone or email.

In general, the overall interaction with students (meetings, tele-conferences, email communication, prototype evaluations, final product evaluations, and site visits) during the semester requires time commitment from the business/industry partners. For example, one of our industry partners devoted four (4) personnel, each spending around two (2) hours per week. Each business/industry partner is provided with an estimated amount of time and personnel commitment for a potential CSS project.

**Assessment:** The students are expected to submit a final technical report that clearly explains project requirements, design, implementation, alternative approaches, and results. They have two presentations during a semester. The technical report, final product, and presentations are evaluated by the instructor and business partners. In addition, the business partners evaluate the students' progress twice during the semester from technical perspective. This helps the students as well as instructor change the course of action if necessary.

Table 1 illustrates of possible assessment tools for evidence of learning in CSS projects as compared to normal project based and traditional learning environments. **C** = communication skill, **P** = professionalism **CK** = content knowledge, **AE** = adaptive expertise.

Table 1  
Assessment tools for evidence of learning

	<b>CSS Project Based</b>	<b>Normal Project Based</b>	<b>Traditional</b>
<b>Class Emails</b>	C	C	
<b>Project Emails</b>	P,C		
<b>Conference Calls</b>	P,C		
<b>Demonstrations</b>	P,C,CK,AE	C, CK	
<b>Reports</b>	P,C,CK,AE		
<b>Presentations</b>	P,C,CK,AE		
<b>Evaluations</b>	Instructor, faculty, industry partner	Instructor	
<b>Deliverables</b>	P,CK,AE		
<b>Tests, Assignments</b>	CK	CK	CK

#### 4. Sample Project

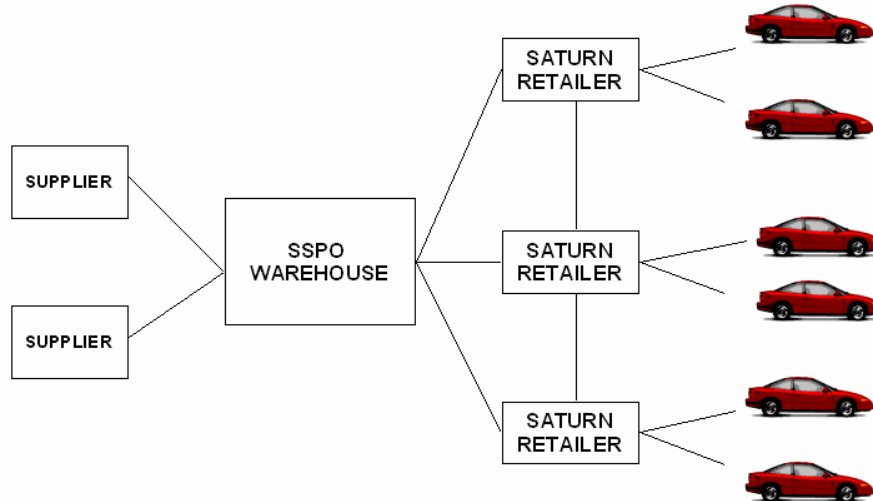
This section describes the CSS project and process that our *Computer Programming with Java* course had in Fall-2003 with Saturn Corporation and EDS.

**Class Project Description:** Saturn is a car manufacturer that started production in 1990. It has two (2) manufacturing facilities located in Spring Hill, TN and Wilmington, DE. They currently have around three (3) millions unit in operation. The Service parts Operations (SSPO) is a big division in Saturn Corporation. SSPO distributes parts to Saturn's 438 retailers all over the country. They have more than 18,000 dealer orderable parts and more than \$324m annual sales. SSPO have some Regional Parts Consultants (RPCs) who act as the main link between SSPO and Saturn's dealers. Their main job is to make sure that the dealers have just enough inventories (not more or less than needed) and evaluate the dealers. They travel a lot all over the country to increase Saturn's productivity. RPCs are the link between SSPO and dealers as shown in Figure 1.

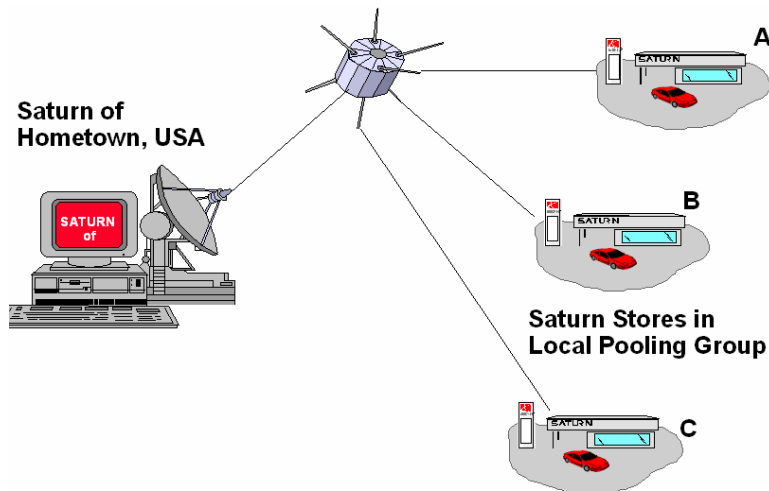
The RPCs have been using a database system developed entirely in Microsoft Access. It provides many different user interfaces, have more than twenty (20) tables and many queries. The RPCs use a local database in their computers during the day and then they synchronize their database with the main database located in Saturn SSPO as shown in Figure 2.

The system that is currently under use has some very fundamental problems and Saturn is planning to replace this system. *The first problem* is the user interface is very primitive and not user friendly. *The second problem* is Microsoft Access is a very limited database and synchronization becomes a very big problem when multiple users try to synchronize their

database simultaneously. Hence MS Access must be replaced with another database such as Oracle. Saturn and EDS teams have requested our students to come up with a solution to those problems and our students have been redesigning the current system by using Java programming language.



**Figure 1.** The supply chain diagram.



**Figure 2.** RPC synchronization.

**Approach:** Students communicated with the business partners during the semester and a professional manner emerged as the instructor observed the quality of these communications (email, telephone conference calls, presentations to the business partner and other faculty). A unique feature of this CSS implementation was the creative ways the instructor was able to assess his students' learning - not only important IT course content but also problem solving, communication, critical thinking, and collaboration skills. Going through the CSS learning cycle afforded multiple opportunities for assessment and refinement of the teams' solutions.

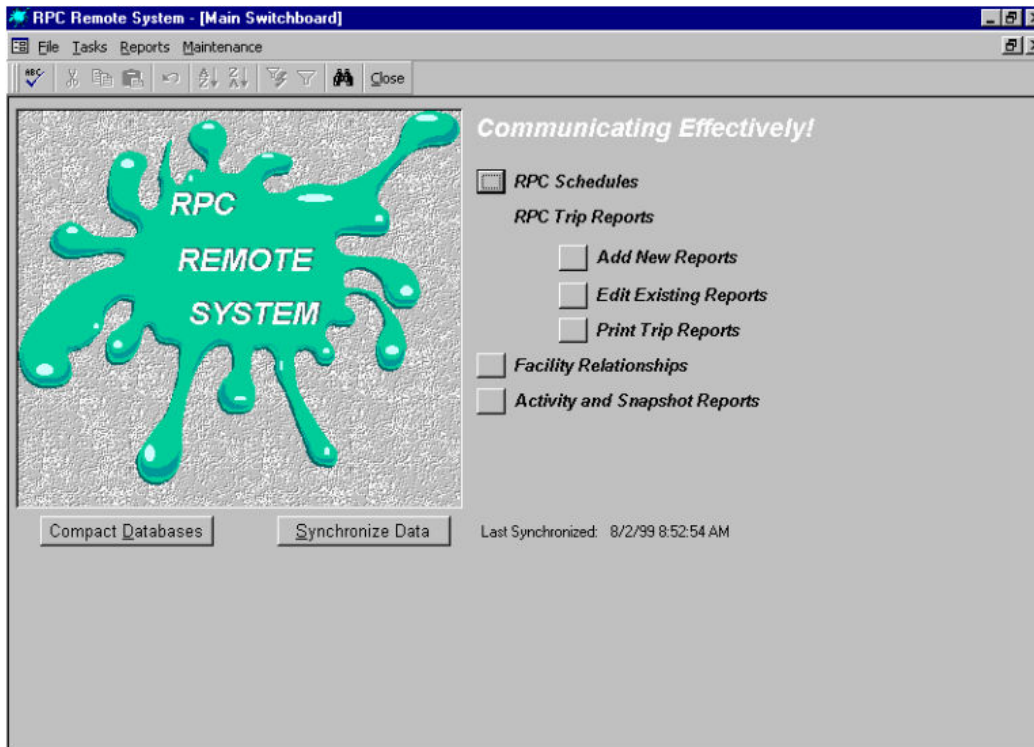
**Results:** The teams of students redesigned the current system by using Java programming language but considered Visual Basic programming language as an alternative solution. Java was preferred since it is platform independent and the system designed can be used in any operating system. It also has unique database connectivity Application Programming Interface (API) that provides a seamless connectivity to virtually any database. In other words, the solution affords the flexibility of using any database such as Microsoft SQL Server and Oracle. Figure 3 shows an example current user interface in MS Access and Figure 4 illustrates the same user interface redesigned in Java by our students. Although, Figure 4 displays only a small piece of the front-end (the user interface) of the system, the entire back-end (the database structuring and data management) had also been developed.

**Business Partner Assessment:** Assessing the student learning and the quality of the final product was relatively easy for the business partners since they had been involved during the entire process, from the early stages of the project design to the actual final product. They were updated regularly by the instructor and students via face-to-face meetings, tele-conferences, and emails. In addition, the students provided two presentations, one (1) mid-term demonstration, and a final report to ensure gradual progress. Finally, the business partners were asked to fill an evaluation form to assess individual and group performance of each team at the end of the semester. They evaluated the students' technical as well as soft skills. The business partners' assessment is partly used by the instructor in grading the projects submitted by each team.

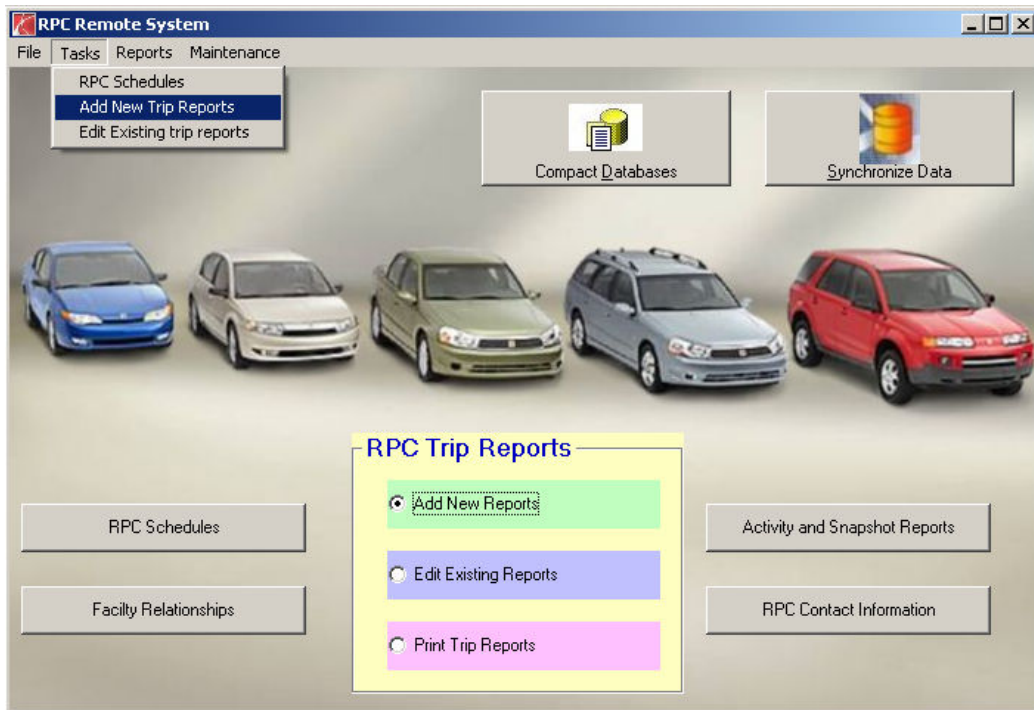
We received the following comments from our business partners: "Saturn and EDS business partners engaged the student teams as extensions of our companies' technical staffs. Both Saturn and EDS professionals utilized current business processes and communication techniques to help the student teams gain a better understanding of how technical projects are completed in the corporate business world. Our activities with the TSU students were designed to help foster a collaborative project environment. The results of the TSU student teams efforts were right-on, and enabled the Saturn and EDS team to evaluate several potential solutions to our business problem. The CSS experience brought a fresh set of creative ideas to help us solve our business problem. We have benefited from our experience with our TSU education partner."

## 5. Conclusion

This paper describes an elegant way of partnering academic institutions with industries to develop problem-based projects that improve students' technical and soft skills for immediate employment. The DoCS at TSU has successfully completed three (3) such projects and it plans to expand this initiative in future. We plan to expose our students to problem-based active learning in the freshman-level course called *Introduction to Engineering*. They will have one or two more projects in the sophomore- and junior-level programming courses such as *Computer Programming with Java*, *Event-Driven Programming*, *Object-Oriented Programming*, *Data Structures and Algorithms*, and *Structured Problem Solving and Programming*. The last project before *Senior Project* will be at the senior level in one of the *Software Engineering*, *Algorithms*, or *Operating Systems* courses.



**Figure 3.** An example user interface from the current system.



**Figure 4.** An example redesigned interface (the same as Figure 3).



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## **Biography**

### **Ali Sekmen, Ph.D.**

Ali Sekmen is an Assistant Professor of Computer Science at Tennessee State University. He received his Ph.D. degree in Electrical Engineering from Vanderbilt University, Nashville, Tennessee. He holds B.S. and M.S. degrees in Electrical and Electronics Engineering from Bilkent University, Ankara, Turkey. He has published over 40 research papers in robotics, intelligent systems, and signal processing. He was a member of Intelligent Robotics Laboratory of Vanderbilt University between 1997-2000. Previously, he was an Assistant Professor of Electrical and Computer Engineering at Tennessee State University. He has been involved in research projects including human-robot interaction, intelligent systems, mobile robots, humanoid robots, and component-based software systems development. Dr. Sekmen is a member of the Institute of Electrical and Electronic Engineers (IEEE).