Project-Oriented Capstone Course: Integrating Curriculum Assessment Utilizing Industry Partner and Student Input

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I. Abstract

The need for industry feedback concerning possible competency gaps in an Industrial Technology program was fulfilled in part by means of a senior-level capstone project experience. Students in their final semester of the program from a range of majors (industrial technology management, electronics technology, occupational health and safety, and computer integrated manufacturing) were assigned to an array of industrial projects at various manufacturers in the local area. Each student completed a minimum of 100 industry-supervised hours on his or her project.

While capstone projects are commonly used for the purpose of evaluating the student skill set, the capstone experience may also be utilized as a feedback mechanism for faculty to determine competency gaps in the industrial technology curriculum. Through a structured series of communications between the academic and industrial project partners, it is possible to amend classroom instruction in response to rapid changes in demand for particular skills in the local manufacturing sector.

Our study highlights the analysis tools necessary for such a feedback mechanism, a ranking of identified competency gaps, and curriculum changes that have been made over the course of using this feedback process.

II. Introduction

While senior-level capstone projects are traditionally used to assess learning outcomes[1,5], the project may also be used to help fulfill a need for feedback concerning program strengths and competency gaps[2].

At Jacksonville State University, there is a small industrial technology department that serves approximately 200 students in four different academic majors: electronics technology, occupational safety and health, industrial technology management, and computer-integrated manufacturing technology. In their final semesters, students complete industrial projects at various manufacturing facilities in Northeast Alabama. Each student works individually (i.e. not a team project) and completes a minimum of 100 industry-supervised hours on his or her project. In most cases, the student completes a project in his or her area of academic major.

Prior to beginning the projects, prospective industrial supervisors complete a survey to identify professional and technical competencies necessary in newly hired graduates. The technical skills listed on the survey include both technical skills and so-called "soft skills". Because the senior level students who participate in the capstone project course are one semester away from graduating, it is expected that these individuals should have the majority of employer-desired skills. After the senior completes his or her project placement, the supervisor then completes a post-project survey to evaluate that individual student's skill set.

Another feedback method that the department uses is feedback from the students themselves who are involved in the industrial projects. Students complete both pre- and post-project self-evaluations to determine their perceived abilities in the same set of core technical and soft skills.

The receipt of these four separate surveys provides valuable feedback to the faculty, not only providing the employer's perspective, but the student's opinion concerning his or her ability level. The system is redundant so that those skills or areas of incompetence that may not be evident to the employer may be revealed in the student survey. The entire faculty evaluates all feedback, and any implemented changes are then approved through the university's curriculum committee.

III. Need for Feedback

Industrial technology programs are unique entities. Such programs emphasize teaching the student the skills necessary to implement the latest technology, rather than develop the latest technology. Because of this, it is crucial that such programs maintain close relationships with the industries and manufacturers whom they serve. Without this close connection, a program can have competent instructors who are teaching out-of-date technology. Because the majority of JSU technology graduates begin their careers in the Northeast Alabama area, this relationship is particularly important.

The need for feedback is also rooted in the requirements of the accrediting bodies[3]. The National Association of Industrial Technology (NAIT)[7] accredits JSU's Industrial Technology program. NAIT specifies that the institution have an assessment plan that incorporates evaluation of student learning outcomes and competencies. Program assessment should measure student mastery of competencies and then use these results to improve the program. While some of that feedback is fulfilled by way of an active industrial advisory committee, it is valuable to supplement that feedback with the opinions of local industrial personnel who may not be members of the advisory board. The perceptions of students may further reinforce the feedback system.

Finally, colleges and universities with programs similar to JSU's may be able to increase enrollment by better communicating with industry and graduating students who possess skills that are in demand by local industry. It continues to be the focus of this department to concentrate on the local manufacturing sector and foster a commitment of communication and response to this sector. As the different programs within the department produce graduates with the specific skills demanded by the manufacturers, the fruits of the relationship are apparent: a consistently high job placement rate after graduation, and secondly, local companies who encourage their employees without degrees to enroll in the Technology program to earn their baccalaureate degrees.

While past studies have questioned the viability of using the capstone course as an outcomes assessment tool, it is becoming apparent in this particular situation that the capstone course experience provides a pivotal opportunity for employers, educators, and students to share opinions concerning the strengths and opportunities for improvement in the program.

IV. Capstone Project Description

Traditionally, capstone projects are used strictly as a student learning outcomes assessment tool. This course is no different. Students are placed with different manufacturers in Northeast Alabama where they complete a specific project taking a minimum of 100 hours. Projects range from design projects for electronics majors to developing safety programs for occupational health and safety majors. In most cases, the student works on a project directly related to his or her major.

Students complete a written project proposal that is approved both by the industrial supervisor and the faculty advisor. Upon completion of the project, the student completes a project report and presents the results of his or her project to the faculty of the technology department. Students must demonstrate the successful solution to a specific problem presented in the initial proposal.

Upon project completion, the employer assesses the student's technical and soft skills. The student is also assessed by the faculty advisor (for the written report) and by the entire faculty for the oral presentation. Because of the wide range of project topics that are covered by the students, the assessment of the students' skills focuses on the skills that should be learned during the core coursework in the Technology curriculum. These ten courses provide the technical and soft skills that should be evidenced in any successful project experience.

V. Feedback Methods

This particular curriculum review uses a two-pronged approach. The first method is distribution of surveys to both the manufacturer prior to and after completion of the capstone project. The second method is distribution of surveys to the student before the project begins and once it is complete.

Before starting his or her supervision of the student project, the manufacturer answers a series of questions about the core skills desired in a prospective new hire technologist. These skills fall under the following general categories: computer, math and analytical, writing and communication, safety, and general abilities (which are all soft skills). Each of these skills can be rated on a scale between critical (5) and unnecessary (1). For example, the prospective employer is asked to rate "formal presentation skills" or "AutoCAD skills" on this scale.

Also prior to the beginning of the project, the student is asked to fill out an anonymous survey, rating his or her skills in the same core skills areas. The student rates himself or herself on a scale between excellent (5) and weak (1) for each particular skill on the questionnaire. The purpose of this part of the survey (rather than solely questioning the student after the project) is to expose those areas where the student may feel that he or she has a solid grasp of the material, but then upon putting that skill to the test in the work environment, finds that it is insufficient. Conversely, the student may be adept in a particular area, but lack the confidence in his abilities until put to the test in the workplace.

Post-project, the manufacturing supervisor rates the student in each of the core skill areas. The supervisor rates the student between weak and excellent, based on the employer's perceptions of the student. In some cases, the supervisor does not observe the student using some of the core skills, and thus ranks that skill as NA (not assessed). The student also completes a post-project survey of his or her perceived strengths and weaknesses in the core skills.

Another less formal method of feedback is the roundtable discussion method, which occurs approximately once during a semester. During this informal meeting, industry personnel express their needs for particular skills in the workplace or their particular satisfaction with specific qualities exhibited by the students. This feedback is also considered when evaluating the survey results.

VI. Results and Discussion

It is pertinent to note that the data collected during these surveys were not statistically analyzed, due to the small sample size. The data were examined empirically, analyzed by department personnel and changes were implemented in the event that the feedback was deemed beneficial by the departmental faculty and advisory council.

Employer Expectation and Post-Project Assessments: Industrial supervisors were asked to rank all core curriculum skills for new technology program graduates on a scale between critical (5) and unnecessary (1). The results of these surveys are summarized in Table 1.

Table 1. Ranking of Desired Skills by Potential Employers

Core Skills Receiving All Critical/Important Rankings	Core Skills Receiving Not Important/Unnecessary Rankings
▪ Ability to effectively solve problems	▪ Microsoft Project skills
▪ Ability to quickly understand an industrial process and product	▪ Willingness to maintain a professional appearance, appropriate to the job
▪ Ability to prioritize tasks	▪ Computer programming skills
▪ Ability to interpret and follow instructions	▪ Microsoft Access skills
▪ Ability to collect data properly and efficiently	▪ AutoCad skills
▪ Ability to be on time	▪ Pro Engineer skills
▪ Ability to keep a deadline	▪ Basic calculus skills
▪ Ability to accept instruction and criticism appropriately	
▪ Technical writing skills	
▪ Willingness to ask for assistance when necessary	
▪ Ethical decision making skills	

The most important skill identified by the supervisors both on the written survey and during the roundtable discussions with these supervisors was "the ability to effectively solve problems". Given that the base of manufacturers who hire graduates from the Technology program tend to be small businesses (generally fewer than 500 employees) it is understood that the graduate will be responsible for a variety of tasks that may extend further than the individual's original job description. These companies are more often than not looking for an individual who can "hit the ground running" and autonomously adapt quickly to the working environment. In doing so, these employees may begin to contribute towards the success (and often, survival) of the small business in question.

The second most critical skill identified by the manufacturers involved was "the ability to quickly understand an industrial process and product". This skill goes hand-in-hand with problem solving skills. An understanding of the process is essential in order for the employee to improve or troubleshoot the process. The graduate should be able to quickly grasp the industrial process as a whole in addition to the sub-processes that are part of the production process.

Table 2. Post-Project Assessment of Core Skills by Industrial Supervisors

Rank	Core Skill
1	▪ Ability to follow appropriate safety guidelines
2	▪ Microsoft Excel skills ▪ Ability to interpret and follow instructions ▪ Ability to be on time ▪ Ability to keep a deadline
3	▪ Ability to prioritize tasks ▪ Ability to collect data properly and efficiently ▪ Ability to accept instruction and criticism appropriately ▪ Conversation with others/informal speaking skills
4	▪ E-mail use ▪ Willingness to ask for assistance when necessary ▪ Willingness to maintain a professional appearance, appropriate to the job ▪ Effective calculator use ▪ Ability to effectively solve problems ▪ Ability to quickly understand an industrial process and product ▪ Telephone skills
5	▪ Microsoft Word skills* ▪ Microsoft PowerPoint skills*
6	▪ Business writing skills* ▪ Technical writing skills* ▪ Formal presentation skills*
7	▪ Ability to correctly measure dimensions*
8	▪ Unit conversion skills* ▪ Statistical analysis skills*
9	▪ Ethical decision making skills*
10	▪ Computer programming skills*
11	▪ Microsoft Access skills* ▪ AutoCad skills* ▪ ProEngineer skills*
12	▪ Algebra skills*
13	▪ Microsoft Project skills** ▪ Trigonometry skills** ▪ Scientific and engineering notation skills** ▪ Basic calculus skills**

*Indicates that this skill received at least one "Not Used" score
**Indicates that this skill received all "Not Used" scores

Of particular interest is the fact that nine of the eleven skills ranked as "critical" or "important" were soft skills. Conversely, seven of the nine skills ranked as "not important" or "unnecessary" were technical or mathematical-related skills.

After the students completed their respective projects, each industrial supervisor completed the same questionnaire and ranked the student in each of the categories on a scale of "excellent" (5) to "weak" (1). A summary of these final surveys is shown in Table 2. An additional ranking was added, "not used", for those skills that were never observed during the course of supervising the project.

By and large, the employers' post-project assessments mirrored those post-project surveys completed by the students. An exception to this was in the area of "Microsoft Excel skills". Students scored their Excel skills at a median level, while employers rated the students' use of Microsoft Excel as "excellent". It could be that the supervisor did not observe the learning curve experienced by the student, only the final results of the Excel work assigned. As a result, the student may still have doubts as to his or her adeptness with Excel, while the supervisor is pleased with the final results.

The employers' highest expectation of the "ability to effectively solve problems" scored slightly above the median on the employers' post project surveys. This is the most evident weakness in curriculum revealed through the feedback process thus far. Problem solving is the most highly valued skill by employers, yet students have not proved to the employers that they are effective problem solvers.

Student Pre- and Post-Project Self-Assessments: The results of the students' pre- and post-project assessment surveys are summarized in Table 3. Prior to embarking on their projects, the students completed surveys that examined the same categories as those ranked by the employers. Students rated their perceived level of competence in each area between "excellent" (5) and "weak" (1). Students completed the same surveys at the conclusion of their projects. The results of the pre- and post-project surveys are compared to one another, and are also compared to the feedback received from the pool of employers and supervisors.

The results of the student self-assessment surveys complemented the employer expectations surveys with one notable difference: students initially scored their "ability to effectively solve problems" near the median, as opposed to the employers, who ranked the importance of this skill at the top of the list.

Only two core skills received all "excellent" or "good" scores on the student pre-assessment survey. Conversely, on the post-project assessments, there were a total of fourteen (14) core skills receiving all "excellent" or "good" scores. This change exhibits either 1) an overall increase in confidence in all participants, or, 2) a demonstration that the experience of the industrial project gave the students additional training that was not received during classroom instruction. Given the relatively short duration of the project, (100 industry-supervised hours), it can be assumed that the increase in "excellent" and "good" scores is due to an increase in confidence across the board as students put their classroom learning to the test in "real world" situations.

Reinforcing the theory that competence was realized during the course of the industrial project, twenty-one skills received "need improvement" or "weak" scores on the pre-project assessment, as opposed to only twelve core skills receiving this rating after completion of the projects. Interestingly, students believed prior to the survey that they had excellent capabilities to be on time, but after completing their projects, but after completion of the projects, the students agreed that their abilities to be on time were in need of improvement!

Those core skills showing the greatest degree of improvement over the course of the industrial project were 1) ability to prioritize tasks, 2) business writing skills, 3) ability to collect data properly and efficiently, and 4) Microsoft Word and PowerPoint skills.

Table 3. Core Skills Receiving "Excellent" or "Good" Ratings By All Students

Pre-Project Assessment – Core Skills, Excellent/Good Scores
▪ Ability to be on time ▪ Ability to keep a deadline
Post-Project Assessment – Core Skills, Excellent/Good Scores
▪ Ability to keep a deadline ▪ Microsoft Word skills ▪ Microsoft PowerPoint skills ▪ E-mail use ▪ Ability to prioritize tasks ▪ Ability to collect data properly and efficiently ▪ Willingness to ask for assistance when necessary ▪ Ability to accept instruction and criticism appropriately ▪ Ethical decision making skills ▪ Willingness to maintain a professional appearance, appropriate to the job ▪ Effective calculator use ▪ Ability to effectively solve problems ▪ Business writing skills ▪ Ability to follow appropriate safety guidelines

The skills showing the greatest decline between pre-project and post-project assessment were 1) ability to be on time, 2) algebra and scientific/engineering notation skills, 3) ability to interpret and follow instruction, and 4) ability to keep a deadline.

The perceptions of the students reinforce the feedback received from the manufacturers. After studying the surveys, it seems that the Technology Department curriculum needs an increased focus on the application of problem solving models across all four degree programs. This is something that is currently being investigated by the faculty and with the help of the department's Industrial advisory committee. Teaching of problem solving methodologies is already present in the curriculum, but hands-on experiences (such as the senior project) are clearly necessary as well.

Another conclusion drawn from the feedback received is that the department curriculum seems to be adequate with respect to Microsoft Word, PowerPoint, and business writing skills. Students are required to develop these skills over the entire four years of their college experience. Thus, it was encouraging that the students and employers both perceive that students are prepared for the work force in these areas.

One of the most interesting findings was the necessity to increase the application of "soft" skills, in particular, the ability to be on time and keep a deadline. In other words, the faculty must work with the students to foster personal responsibility. Personal responsibility appears to be a key component of many of the soft skills desired by employers. Whether it is the student taking responsibility for a decision, or taking the initiative to investigate a solution to a problem, it is apparent that personal responsibility is essential for students to achieve success in the workforce. This connection was not recognized in prior observations (i.e. less formal observations prior to this survey program).

Finally, is apparent that the department needs to incorporate curriculum designed to improve the practical application of math skills, in particular, algebra skills. The department has already responded to this need by increasing the number of credit hours in the technical mathematics course. The extra hour added to the course will be dedicated to supervised tutoring and problem solving sessions.

VII. Closing the Feedback Loop

The purpose of the two "before and after" surveys is to provide a redundant system for evaluating the curriculum in the different technology programs at JSU.

Providing the industrial supervisor with only a post-project survey would be sufficient for evaluating the student in question, and this method has been used in the past. However, the problem with providing only an opportunity for post assessment is that the faculty never learns from the supervisor in a formal manner what skills are desired in the first place. It is not the purpose of the pre-project survey to match the student to the project, but rather to collect the critical information about what the customer (i.e. the person who may be hiring our graduates) desires in the skills of new technologists. It is a critical link in the program assessment process -- one that is often overlooked. While it is a challenge at times to collect the information from the supervisor, it is well worth the effort to collect the information.

All employers were quite pleased with the projects completed by the students. Several students received offers of permanent employment after completing their projects, indicating the success of the current department curriculum.

VIII. Next Steps

In response to the results of the feedback received from employers, potential employers, and students, the department has already made some initial changes to its curriculum and will continue to work towards satisfying the needs of industry while remaining in compliance with our accrediting body's guidelines.

The department is currently in the process of developing several specific courses as a result of this feedback. While not identified on the surveys distributed to employers, we received via roundtable discussions that two expectations in addition to those identified through surveys are 1) project management skills and 2) an understanding of current manufacturing management models. In response to this feedback, the department is developing three specific courses: 1) manufacturing processes, 2) project management, and 3) manufacturing management.

The department is also in the process of identifying courses where practical problem solving can be implemented, whether in the form of labs, workshops, factory experiences, or team tasks. We are also investigating opportunities to incorporate problem solving into curriculum across all majors.

Finally, the department has implemented several new policies with the intent to develop the level of personal responsibility among the student population. The department has a new attendance policy, a new "missed examination" policy, and a late assignment policy. All of these serve to reward students for responsible behavior, and promote personal qualities that will carry over to the workplace.

IX. Conclusions

The Technology Department at JSU intends to continue this feedback program in the hopes of keeping the lines of communication open with the manufacturing community in the Northeast Alabama region. We are already reaping the fruits of this program in the form of job offers for our students and positive responses to our program. As the Department strives to keep in touch with current manufacturing needs, it is conceivable that this feedback program will result in even greater rewards such as the expansion of the Technology program and increased enrollment.

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