Abstract
The purpose of this paper is to propose an information system application to manage the quality of service in an educational environment. Information systems support management by providing storage of captured data relevant in describing the process and in measuring the effectiveness of its results; manipulation of such data and reporting of variances between actual and expected performance; and often, particularly with decision-support or knowledge-based systems, recommendations for improvements to alleviate or minimize those variances.

Service quality is generally identified as the measure of success of an organization’s endeavors to provide the service requested by its clients. The client receiving the service defines this success. The problem with this perspective is that metrics are rarely directly measurable, relevant for the processes involved in the operation, clearly understood by the clients, or applicable for all clients. Additionally, in education, the client does not see the full results until several years after graduation. To address these problems, we have adopted and applied a systematic approach to the analysis of the undergraduate industrial engineering process and the design of an information system to manage the process to ensure service quality. The purpose of this study is to provide academic units with an objective assessment of their capabilities, processes and service delivery, and a clear measurement of their service performance within the confines of the expectations and needs of its stakeholders.

Introduction
Information Systems (IS) applications are becoming an essential part of daily life. Every day, all kinds of businesses rely on the power of information technologies to facilitate and improve the management of information - saving time and money, and improving productivity. Management Information Systems (MIS) support management by providing information for decision making. They facilitate the capture and storage of data relevant in describing processes and in measuring the effectiveness of their results; the manipulation of that data; and the reporting of information such as actual and expected performance. Information technologies (IT) are used in all of these IS activities. IT help to improve both the efficiency and effectiveness of organizational processes and departmental functions by integrating their operations, redesigning processes, improving networks and overall cost-effectiveness, and increasing total systems effectiveness through business scope redefinition1.

Service Quality is generally identified as the measure of success an organization’s endeavors to provide the services requested by its clients. The traditional approach for quality improvements
is ordinarily centered in manufacturing processes, the quality of service from the point of view of the producers, and the way that the companies see their products through the eyes of their customers. Statistical process controls are used in this approach to insure that products comply with all the specifications when they reach customers.

Total Quality Management (TQM) philosophy relies on a continuous improvement of processes through statistical control and training of people in the principles of quality management. In this way, TQM tries to reduce defects during production, eliminating mass inspections while focusing on customers. TQM can be implemented in order to realize an efficient and cost effective information infrastructure\(^1\). The TQM model encourages working hand-in-hand towards a common goal through specific improved processes. This model also can be applied for assessing opportunities, threats, strengths and weakness of organizations in relation to both the external environment and the internal context. TQM creates a customer–oriented, service-focused organizational environment that facilitates intelligent information exchange\(^1\).

Another interesting approach to service quality is Quality Function Deployment (QDF). QDF can be used to identify performance measurements that reflect customers’ requirements, and to ensure that these performance measurements are used and quantified in redesigned processes\(^2\). QFD originated in Japan in 1970 as a systematic technique for identifying the product features that contribute the most to the product quality and customer satisfaction\(^2\). It is based on a matrix approach that maps the customer requirements with the means to achieve them. A series of charts are developed for mapping relationships between the customer requirements and processes\(^2\), similar to the way in which Entity Relationship Diagrams (ERD) and Dataflow Diagrams (DFD) interact in the analysis of systems.

Six sigma is another of the recent methodologies for quality improvement. It relies on the reduction of the variability in products and processes with the intention of preventing defects\(^3\). This technique aims to define and measure the variation present during the beginning of the product life, discovering their causes, and creating efficient operational mechanisms to control and moderate the variation.

One of the most important elements of quality products is the way in which the product fulfills the needs, requirements, and expectations of customers. However, one problem in this perspective is that the metrics to evaluate customer satisfaction are rarely directly measurable, relevant for the processes involved in the operation, clearly understood by the clients, or applicable for all clients. Furthermore, in an education environment (and specifically higher education), customers may not fully see the results until several years after their graduation. In order to address these problems, we have adopted and applied a systematic approach to the analysis of the undergraduate industrial engineering education process and the design of an information system to manage the process of ensuring service quality.

The purpose of this study is to provide academic units with an objective assessment of their capabilities, processes and service delivery and a clear measurement of their service performance within the confines of the expectations and needs of its stakeholders. Measuring quality without automated tools is time consuming and labor-intensive\(^4\). Additionally, improving quality is a task
that demands routine measurement and, for that reason, IT can be used to help with both quality measurement and quality improvement.

Several successful attempts to applying Information Systems in the improvement of service quality have been made in the past. For example, Information Systems have been used for the measurement and improvement of quality in healthcare environments, in the hospitality industry, and in integrated delivery systems. These studies have demonstrated the suitability of the information systems approach to the management of quality and performance data within the quality improvement programs. The IS approach also provides a solid structure to monitor, analyze, manipulate, store and report the information related to the management units of service quality improvement processes.

Additionally, many studies trying to measure higher education quality and the value added are also being implemented. “Measuring Up 2000” (the state-by-state report card for higher education) uses six categories to measure the quality of the education. The categories included in the study were preparation, participation, affordability, competition, benefits, and learning. An important factor of improving quality of service in an educational environment is measuring current service performance. Historically, The IE department’s quality of educational services has been measured by applying surveys to students, employers and alumni. These surveys are focused on identifying strengths and opportunities for improvement of the undergraduate engineering education. They also are used to measure performance and skills of the students after their graduation.

This approach has not been conducted in a consistent manner, and the information has not been managed to provide useful output for strategic decision-making. Recording the survey results and manipulating the data has been a very time consuming task. The department needed a better way to handle the feedback in order to efficiently analyze the data and to generate the indicators capable of measuring the services performance.

Currently, The University of Tennessee is also introducing a comprehensive and flexible e-learning software package (The Course info Blackboard 5.5 from Blackboard Inc.). This software allows instructors to include learning materials, class discussions, and even tests online, but its interface is not yet easily customizable to all the specific requirements related to the measurement of service performance in an educational environment.

How is quality defined in an educational environment? A good education should not only improve student’s capabilities and knowledge and promote the process of analysis but also comprehend a wide spectrum of different aspects such as: active and proactive learning, the gaining of skills in communications, sharing of knowledge, interpretation and use of data, and the use and application of technologies as well. Education should also provide students with a better educational value and a better operational performance and preparation for their future careers.

Furthermore, a good education program for Industrial Engineering, according to the Accreditation Board for Engineering and Technology (ABET), “…must demonstrate that graduates have the ability to design, develop, implement, and improve integrated systems that
include people, materials, information, equipment, and energy… It should contain in-depth instruction to accomplish the integration of systems using appropriated analytical, computational, and experimental practices…. And must provide evidence that the program faculty understand professional practice and maintain currency in their respective professional areas… Giving the program faculty with the responsibility and sufficient authority to define, revise, implement, and achieve program objectives.

Methodology
The systematic approach to the analysis of the undergraduate industrial engineering education process and the development of a supporting Information System is presented in Figure 1. During the analysis phase, the educational system is divided in its major components to study and to understand the way in which they interact. Next, the IS is designed to help the organization meet the requirements and expectations of its users and stakeholders. Once this phase is completed, the process continues with the development and the implementation of the new procedures, tasks, modules and interfaces. However, after its implementation, the IS requires continuous support. New requirements need to be met and the results and indicators need to be analyzed. Finally, the IS is revised to incorporate feedback performance information, and then process starts again.

Figure 1. Information System approach.

Stakeholders
One of the most important steps in the analysis of the system is the identification of the customer and stakeholders. This critical step allows analyst to identify some of the major requirements and interactions to help them understand how the system works as a whole. A system approach to TQM for example, considers every interaction necessary between the various elements of an organization. The entities relationship approach take a conceptual view of the organization.
system units and its interactions, for that reason, we analyzed the interactions between the different entities of the system with an Entity relationship diagram presented in Figure 2. In this figure, Entities are resented in boxes, and its correspondent relationships, in diamonds. The major entities analyzed were the stakeholders (students, faculty, alumni, employers and Administration) and other entities whose relationships and interactions are essential in the new system such as: courses, indicators, and surveys.

![Figure 2. Entity Relationship Diagram.](image-url)

Customers are the users of the products or services, but they alone do not define all of the requirements of the system. The stakeholders include all the major owners, users, analyst, designers, and developers of the system\textsuperscript{10}. The stakeholders embraced in this study included the students, faculty, staff, and administration of the department of industrial engineering in the University of Tennessee. However, the requirements of these stakeholders are not the same and can be considered as two different types: requirements directly related to the organization education services and the requirement of the stakeholders themselves.\textsuperscript{11} Additionally, other important element that must be considered is the type of involvement that the stakeholders have in the system.

Students are not only one of the key elements in education, but also, they play an essential role in the assessment of the education quality. Because they are one of the most important stakeholders, their requirements and expectations are essential in the analysis and design of a system to manage processes and establishing indicators capable of ensuring service quality and improving educational services. Students have reported high satisfaction with web courses in full online classes and in combination of face to face and online instruction\textsuperscript{12}. Furthermore, given the right tools, students can manage their own academic progress much more independently of the current advising system\textsuperscript{13} making their own “right” decisions.

For example, in order to select their classes, students may consider helpful information, the background, interest, and achievements of their instructors. Broad class descriptions are usually
available in course catalogues, but this information is usually very general and the way that classes are taught usually changes between instructors and departments and one teaching style is maybe more suitable for a specific type of student than for the others. Unfortunately, this kind of information is not officially available, and students must rely on subjective opinions based on previous experiences of classmates or friends. Sometimes students also waste time registering in courses that at the end do not fulfill their expectations; which is not acceptable under a customer perspective. A possible solution could be using ratings from each course instead, to make an informed choice for selecting courses, course sections and schedules.

But, what do students want? They want to be prepared. They want to learn - not just memorize lectures or textbooks. They are worried about their ability to get well-paid jobs and about developing the skills required to successfully interact in their job environment and to perform all their functions and responsibilities. Faculty often focuses on grades as feedback\textsuperscript{10}; but students may see grades not only as an evaluation of their performance, but also as their primary goal – making grades a detractor to learning. Students also require good advising, tutoring and the information capable of enable them to make their “own” right decisions.

Unfortunately, the analysis of student perspective of satisfaction in education is a dynamic phenomenon\textsuperscript{10}. Student perception of quality changes with the time, in the same way as their expectations and goals change, they are more worried on what they will accomplish during their studies and upon graduation\textsuperscript{10}. Moreover, Education Methodology is also changing with the incorporation of new technologies. This fact may also alter student’s necessities, expectation and goals, during their education.

Community and employers are also important stakeholders that must be considered. Community expectations regarding the quality of education are focused on the way that education encourages the responsibilities to the public and the need to practice good citizenship. These responsibilities refer to ethical practices, protection of public health safety and environment, not only meet the local state and federal laws, but also considering them as opportunities for improvement beyond compliance\textsuperscript{11}. Thus, student should impact society on a proactive manner and must satisfy ethical practices in all interactions with their communities.

On the other hand, Employers expectations and requirements for educational services addresses the issue that students graduate with abilities, skills, attitudes and values that guarantee their competence\textsuperscript{11}.

Finally, while department administration expectations may sometimes focus to the utilization of resources available in an efficient and effective way. The faculty, on the other hand, is also concerned about the student’s learning, their development with intellectual independence, the improvement of their ability to think critically\textsuperscript{10} and the degree of students’ commitment to their courses.

**Systems Requirements**

Besides stakeholders’ requirements, there are also other kinds of requirements that need to be considered. These requirements correspond to the ones a system needs in order to guarantee that it will work effectively and efficiently. The system should be designed in a way that it can be revised periodically, with parameters, functions and indicators that can be verified over time.
For the users, one of the most important requirements includes the design of a system with the capability to minimize the amount of input efforts, facilitate the analysis of data and produce accurate and easy to read performance indicators. This requirement will result in a more user friendly environment and a greater acceptance rate of the system. However, there are other desirables characteristics that the system need to include such as: integrity, reliability, accuracy, timeless, security, and confidentiality.

Other important elements to keep in mind during the analysis and design phases of a system within organization are the vision, mission, principles, goals and strategies of the organization itself. Considering the organization philosophy and strategies during the design will enable the system to be more compatible with the organization and will empower the achievement of its goals. In an information system analysis, it is important to verify that the system objectives and the business strategies are aligned. Also, the long-term versus the short-term objectives must be clearly delineated; otherwise, incompatibilities between the organization and the modules of the system, may arise.

The development of the information system begins with analysis of the organization. The IE department of the University of Tennessee (UTKIE) has the following vision, missions, principles, strategies and goals:

Vision:
“To be nationally recognized as a leader in academic excellence with superior reputation in teaching research and professional service.”

Mission
“To serve the diverse constituencies of students, business, industry, and government in an effective and efficient manner, continuously improving the quality of service provided in areas of teaching, research, and professional service. All faculty, staff and students of the departments are partners in striving towards the goals of this mission.”

Guiding principles
- “High quality broad based flexible undergraduate education.
- A curriculum consisting of a solid foundation in engineering and general education.
- Flexibility, depth, breathing graduate-level programs.
- Receptive, encouraging and supportive learning atmosphere for students.
- Provide conducive working environment for faculty and staff.”

Goals
- “Continue to improve upon the reputation of excellent teaching throughout the curricula.
- Provide curriculum connectivity and relevance from undergraduate through PhD programs.
• Increase research productivity to boost graduate programs and enhance national ranking.
• Increase archival publications to enhance national visibility and reputation of the department.

Strategies
• From strategic alliances with others academics departments for teaching and research.
• Develop a department balance in teaching, research and consulting engagements.
• Develop proactive and supportive programs for faculty and staff development.
• Institute formal develop program in conjunction with college and university programs.
• Engage the support of alumni advisory board in achieving the goals herein outlined.

After considering the department’s vision, mission and goals; the vision, mission objectives and strategies of the IS were defined for consistency with those of the department. The vision is to produce information to ensure that the department provides good education services at the best quality and efficiency through continuous improvement of processes and educational methodology. The Objective is to facilitate continuous improvement of the education quality services for the undergraduate students. The Strategy is to motivate the administration, faculty, and students to participate in the continuous improvement of the education process.

Performance Measurement
In order to provide academic units with an objective assessment of their capabilities and clear measurements of their performance, it is important to have some kind of measurement. Consequently, performance measurements should identify how the requirements provided by students and stakeholders are currently being met. One of the possible approaches to achieve this goal is by using some kind of indicators.

Indicators are usually defined as numerical information that helps to quantify inputs, outputs and performance of programs, processes and services in organizations\textsuperscript{11}. Indicators are used when measurements relate to performance but are not a direct measure of it or when measurement are predictors of the performance\textsuperscript{11}.

Additionally, to establish an adequate measurement basis in the system, it is necessary to think about why the evaluation is required\textsuperscript{1}. In this project, evaluation would measure quality and resource utilization. This provides academic units with an objective assessment of their capabilities, processes and service delivery. It would also provide a clear measurement of their service performance within the confines of the expectations and needs of its stakeholders.

Other essential issues in evaluation are addressed by answering the following questions\textsuperscript{14}:
• Who should evaluate?
• What aspects should be evaluated?
• When should evaluation be done?
• What kind of measurements will be used?
• What data is needed to be collected?
• How the Data should be presented?
• What are the key performance indicators for tracking of the progress?

These questions can easily be answered by using systems analysis and design techniques such as Data Flow Diagrams (DFD) and Entity Relationship Diagrams (ERD). DFDs illustrate the flow of data and the processing of information through the system. A dataflow model, using a top-down design strategy, was applied for the analysis of the information flow. Some of these DataFlow Diagrams are shown in Figures 3, 4, and 5.

Figure 3 shows the context DFD, in which the external entities are represented in boxes and information flows are shown as arrows. External entities may include some of the stakeholders but should also include all the essential external units to which the new system is required to share information.

![Figure 3. Context Diagram](image)

Figure 4 shows the Level-0 DFD. This diagram represents all the subsystems or major processes and information flows within the system. Here, processes are represented as bubbles and the flows as arrows. As an example, the major processes included in this unit are: teaching, administration of department, research, alumni relationships, employer relationships and community services. The information flows included in this level are those in the context level and those between the major processes.
Figure 4. Data Flow Diagram Level-0

Figure 5 displays the teaching and the research processes DFDs for level 1. This level includes all the major sub-process units and the information flows for each of the major process in more detail. As in level 0, the sub-processes are also represented as bubbles and information as arrows. The data stores correspond to the major files or records of DBMS and are represented as open boxes.

Figure 5. Data Flow Diagrams Level-1
Once indicators have been established, it is possible to detect and identify problems, deficiencies and possible areas, tasks or processes suitable for improvement. Performance measurement also enables the determination of the problems’ magnitude. Unfortunately, establishing indicators alone is not sufficient. Measurement also requires a basis of comparison to judge the current performance levels against the levels intended. This practice allows management and administrative units to identify and implement corrective actions in order to obtain the level of optimization and improvement needed.

Additionally, indicators are not only used to measure performance, they also can be utilized to measure impact. Impact indicators can confirm that some plan or action has been successful or is having a real effect.

Some important characteristics that are recommended for the selection of good indicators are:

- Performance indicators should be relevant to the organizational goals.
- Informative.
- Able to be changed according with the needs of the organization.
- Reliable.
- Valid.
- Understandable.
- Acceptable and fair.
- Not corruptible.
- Not corrupting.
- Cost effective.

Other important considerations for indicators are: to use as few as possible, employee those who allow comparability and are flexible to reflect diversity and change, not to focus on one aspect of performance to the detriment of the others, and to use as much readily available data as possible.

After identifying good indicators, targets for each performance measurement, should be identified in order to establish a solid basis of comparison, these targets should be defined for both, short-term and long-term planning horizons. Process targets are usually intended to make changes in what people do, while impact targets are aimed at improving the quality of service.

When defining Targets, several zones can be identified:

- The Historic zone: Includes targets with levels already reached or that are behind current performance.
- The Comfort zone: In which improvements are considered easy to reach.
- The Smart zone: Where the targets are so ahead of the current performance that imply a real difference.
- The Unlike zone: Which represents high level aspirations very difficult to achieve.

Unfortunately, it is important to keep in mind that trying to measure performance of education is not always easy, while some factors can be easily quantified, some others elements or outcomes may take years to measured.
The indicators selected for the system are shown in Figure 6. The indicators are grouped according with the stakeholders. As can be appreciated, indicators also are closely related with the industrial department goals and can be used to measure their achievement.

![Figure 6. Indicators](image)

**Information Management**

Gathering the required information for the systems can be implemented in several different ways. For example, to determine stakeholder satisfaction or dissatisfaction, several methods such as surveys, formal or informal feedbacks and interviews are usually recommended. This information can be gathered on the internet, through personal contact or a third party, or by mail. For other more specific information, historical records and registration data can be analyzed.

Performance Information will be available to academic units and administrators by using queries and reports, while course information will also be available to students and advisors through the internet.

**Back-up and Recovery procedures of the System:**

In order to guarantee all the vital and important information of the system, it is recommended to implement different 3 types of backups: Full, differential and incremental.

Full backups of all the important data, files and records of the system, should be performed at least once a month. Differential backups, which save the information and files modified after the last backup, should be performed once a week. The Incremental back-ups need to be made daily, keeping the last information safe in case of emergency.

In the case of hardware failure, back up equipment should also be available on a convenient location, for the normal operation of the processes. In case of delay in the recovery process,
operations will be performed in a simplified manner, using the elements available. Operations will also be performed under the coordination and supervision of an emergency committee conformed by at least one of the supervisors or director of the areas affected.

**File Retention Periods**

A DBSM system (Figure 7) will maintain the students, faculty, courses, surveys results, employers and alumni information stored in files. These files should be preserved and modified by the system administrator and programmers using the information available in the documentation. The major tables for the system have been normalized to 3NF, they include Students, Courses, Sections, Class-roll, Faculty, Grants, Surveys, Alumni, Employers, Targets and indicators. Each table contains at least a primary key which uniquely identifies each record.

![Figure 7. DMS Schema](image)

The files and records for the differential and incremental backups should be kept until the next full backup is performed. However, it is also very important to maintain an updated copy of the most essential information, records, and files in a safe place that should be in a different physical location of the main system back-up. In case of an emergency, the system administrator or person responsible in each location should perform backups.

**Testing Required for the System**

Before the implementation and changeover can take place, the system also requires validation and verification tests. These tests will guarantee that the system works as was previously intended in its design. For the test implementation, a top down approach is recommended in order to reduce cost, errors, and to facilitate the system integration between the different modules. Data for the test would be provided by final users using the historical data available in the department.

Tests should be performed in each module or unit first. Only when each module accomplishes a satisfactory level, the complete system test can proceed. An acceptance test performed by final users is also required. Alpha tests would then be performed using a moderate quantity of data.
and information on each main process. Finally, when satisfactory results are obtained, the beta test can be conducted.

**Training**
The users training for the new system will be provided before the changeover can take place. Final users will be divided in to different groups according with their role and interaction with the new processes.

System administrators and programmers will receive training focus on the system structure, module integration, maintenance and operation. They also need to know how to make modifications and how to solve possible problems.

Operators and final users will receive training on user’s interfaces, data manipulation, and output generation. They will also be instructed on the changes that the new system will generate in the organization’s normal processes and operations, and their new responsibilities with the system.

Administrators and faculty members will receive training referring the general structure of the system, their new responsibilities within the organization, and the new procedures and features available for their use.

**Changeover Method**
The changeover method recommended for the system is a mixture of parallel and phased. The critical activities of the system should be performed in parallel with the older system in order to increase operation’s reliability and security. The performance of the new options, operations and features would be analyzed and compared with those of the old method in order to detect possible flaws. Using a phased changeover method will allow us to analyze changes and to customize the system to the specific requirements by case. This option will also ensure that the new system works as intended for each, before proceeding with the others.

**Final Remarks**
As designed, the system will signal quality problems and will provide a better management of the information. However, the process of improving the quality of service in an educational environment it is not a single step, increasing student’s performance and learning requires constancy and continuity that may include periods of several years. During this time, analysis and measurement of the results need to be effectively transmitted to the administration and management divisions in order to fully support decision making. This feedback process would effectively enable academic units to align new strategies and actions plans according with the results, and to adapt, revise, or modify any objective, programs, courses and policies as it is required, in order to improve the students’ education.

An early involvement of users and stakeholders during all the phases of the project plays an essential role for the successful acceptance and implementation of the systems. Only in that way, it is possible to effectively understand the customer’s needs and preferences and really adjust to the changes of their requirements. Teamwork and collaboration among staff and faculty should be encouraged in order to enhance the validation of the system.
Benefits of the New System

Although is very difficult to estimate the exact benefits that the new system would generate, it is possible to establish some of its more favorable impacts:

- Improvement of users’ satisfaction,
- More rapid processing of users request,
- Faster and easier access to information,
- Reduction of information duplication,
- Information will be updated more often,
- Easy preparation of reports,
- Improved method for the scheduling of tasks, and
- Improved resource utilization.

Training is an important element for all of the people involved with the new system and a good documentation is also required for the implementation of the project. The documentation should also provide the necessary information in order to prepare any possible modifications according with changes within the Department, the curriculum, the University, the stakeholders and the external entities of the system.

It is also important to ensure that the systems guarantee the integrity, reliability, accuracy, fast access, security and confidentiality of the information, using reliable hardware and software are and user friendly interfaces.

The system should be periodically revised, in order to maintain the its processes, hardware, and software with the current educational and stakeholders’ needs and requirements. The motivation and participation of the final users is also a very important aspect that cannot be disregarded. If users are pleased with the new system and agree to use it, it should provide them with all the benefits for which it was designed.

The realization of this project has confirmed the growing and important impact of information technologies in education and learning institutions. Using information technology in higher education institutes will continue as one of the most important trends in the next years.

Furthermore, information systems will maintain its present and increasing integration into service performance area, and will maintain its direct involvement into quality improvement processes by giving the stakeholders, the information and decision support they need it, when they require.

In conclusion, the present paper has described the analysis and design of an information system to manage quality of service for the Industrial Engineering Department of the University of Tennessee. The continuous application of the methodology proposed will maintain to improve service quality and provide academics units with an objective assessment of their capabilities, processes and service delivery, and a clear measurement of their service performance. This process will allow the department to develop an enhanced and more efficient utilization of its resources and to monitor the quality development of the services that it provides.
References


Bibliographical Information

Dr. Denise Ford Jackson, P.E.
Associate Professor
Ph.D., The University of Tennessee
RESEARCH AREAS: Information systems analysis and design; performance measurement

PROFESSIONAL AFFILIATIONS & AWARDS: Outstanding Faculty Advisor, College of Engineering, 1997-98. Institute of Industrial Engineer.

Jose Solarte
MS Student and Graduate Assistant The University of Tennessee.
RESEARCH AREAS: Information Systems and Data Mining Applications.