

The Development of Performance Model for Engineering Education System

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Abstract

This study will investigate the management and performance of engineering educational systems and try to establish a performance evaluation model for engineering educational systems. By using the performance evaluation model, schools can make a better strategy to develop better engineering educational systems and to train better engineering students. The concept of balanced scorecard will be used to construct a performance evaluation model for engineering educational systems. The balanced scorecard has been used in business successfully. This study will collect and arrange suitable performance evaluation configurations and indices by literature reviews and interviews to department heads in engineering educational systems in Taiwan. According to the four components of the balanced scorecard, a more objective performance evaluation model for engineering educational systems will be developed in this study.

Keywords: balanced scorecard, performance evaluation, strategy, engineering education

1. Introduction

In the past decade, engineering education has faced intensive pressures for changes. These challenges have resulted from a confluence of factors, including quantum leaps in computer and communications technology, structural changes in business organizations and processes (e.g., downsizing, reengineering and virtual corporations), and major shifts in student body demographics (e.g., increased proportions of adults seeking retraining or continuing education).

The fundamental nature of these forces for change suggests that responding to them also would require a fundamental rethinking of programs and approaches. The change process needs to be well designed and executed. The vastness of the strategic management literature suggests that many other models for managing change exist that also merit consideration. Performance evaluation is an essential component of whatever change process is adopted. It can provide motivation and direction, give feedback on the effectiveness of plans and their execution, and help in strategy formulation and revision. The purpose of this article is to suggest the balanced scorecard as a tool for enhancing the success of engineering education systems.

2. The Balanced Scorecard

The balance scorecard is an integrated set of performance measures comprising both current performance indicators and drivers of future performance, and financial as well as non-financial measures. For managers of organizations, the function of the balanced scorecard is to provide a holistic view of what is happening both inside and outside the organization.

The balanced scorecard's key characteristic is that the included measures are linked to the entity's mission and strategy, and are explicitly designed to inform and motivate continuous efforts toward their attainment [1-7]. As such, the balanced scorecard is an integral part of the strategic planning process, and not just a system for tracking performance after the fact.

An effective balanced scorecard generally includes a mix of outcome measures and performance drivers. Using a manufacturing setting for illustrative purposes, examples of the former are high quality and speed, while defect rates and cycle times are examples of the latter. The latter measures communicate how the desired

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outcomes are to be achieved based on assumed causal relationships among objectives and measures. In this way, the balanced scorecard articulates a theory, or model, of the organization's causal chain of performance drivers and outcomes.

Furthermore, an effective balanced scorecard embodies a balance between diagnostic measures and strategic measures. The former helps to monitor whether the organization remains "in control" and whether immediate intervention is required. In contrast, strategic measures are designed to evaluate success in achieving strategic goals. Thus, diagnostic measures capture the necessary "hygiene factors" that enable the organization to operate normally, while strategic measures help to ensure that short-term concerns are not overemphasized at the expense of the entity's strategic goals.

At the organizational level, developing the balanced scorecard involves identifying several key components of operations, establishing goals for these and then selecting measures to track progress toward these goals. The number and nature of components can be expected to vary depending on the nature and strategy of the organization, though the following four components are typical:

- (1) **customer perspective:** How do customers see us? This component track how well the organization is meeting the expectations of its customers.
- (2) **internal business perspective:** At what must we excel? This component focuses on the internal processes that the entity must perform well if it is to meet customers' expectations.
- (3) **innovation and learning perspective:** Can we continue to improve and create value? This component focuses on the infrastructure that the entity must build and sustain in order to ensure and enhance its ability to satisfy customers' expectations.
- (4) **financial perspective:** How do we look to providers of financial resources? This component tracks how well the organization is translating its operational results into financial well being.

Thus far, discussions and reported applications of the balanced scorecard have been concentrated in the for-profit sector. The lack of reported balanced scorecard applications in educational institutions, especially in the instructional functions, may be taken to imply a lack of applicability. Indeed, educational institutions do have features that can make implementation of the balanced scorecard (and the strategic planning process of which it is part) more difficult than in for-profit entities. For example, whereas for-profit entities typically can use huge bonuses or other forms of compensation to reward performance, educational institutions rarely have such resources or latitude. When combined with the sanctity accorded to "academic freedom," this can limit the ability to promote change and/or continuous improvement.

Specifically related to the balanced scorecard, one also could debate who, exactly, are the "customers" of a university. A case can be made for including students, employers, parents of students, alumni, nonalumni donors, research funding organizations, governments, the community and taxpayers. One also could argue for inclusion of the faculty and staff. With the potential for such diverse views, gaining consensus on the definition of "customers" can be challenging, yet necessary, if an effective balanced scorecard is to be constructed.

But it also is possible that the dearth of reported balanced scorecard applications in the educational sector simply reflects a lack of awareness or understanding. In any cases, as long as engineering programs will attempt change and improvement, exploring ways to improve this process would be worthwhile. It is in this spirit that we present this discussion of the balanced scorecard. Our belief in the balanced scorecard's potential applicability is based on two main factors. First, at least in the nature of operations, educational institutions are service organizations like banks and insurance companies, which have adopted the balanced scorecards with favorable reported results. More important, the survey and interview responses of some engineering-related department heads, who should be familiar with the educational environment, generally affirm that the balanced scorecard can be beneficial to their programs.

3. Comparison between the Balanced Scorecard and Existing Evaluation Methods

Comparing the balanced scorecard to the performance evaluation approaches which underpin external ratings of academic programs can further elucidate its unique features. Among the most widely publicized of such ratings are those in the media, such as Business Week and U.S. News and World Report. These focus primarily on entire programs or institutions, or only list the top-rated programs. In contrast, other services, such as The Gourman Report [8] and Educational Ranking Annual [9], provide ratings of specific disciplines.

Like the balanced scorecard, all of these external rating approaches use multiple criteria. The Gourman Report [8] uses a linear combination of 18 (differentially) weighted criteria to derive its ratings (e.g., total programs offered, faculty qualifications and productivity, quality of administration, computer facilities, research funding). In addition to issues of measurement (e.g., how to measure the quality of administration), the Report also cautions readers that because disciplines vary in their educational methodology, the significance given each criterion should vary from one discipline to another. It also emphasizes the limitations of combining complex data into a deceptively convenient numerical rating [8].

The Educational Ranking Annual [9] even more explicitly recognizes the limitations of any one ranking

methodology. It states that while educational rankings are usually based on complex measures (e.g., academic reputation, citation analysis, peer evaluations or perceptions, distinguished alumni, admissions selectivity, tuition, faculty salaries, library and computer facilities), none of these precisely reflects the institution's educational quality [9]. Rather than selecting one ranking approach, the Annual provides separate ranking based on four groups of measures:

- (1) reputation rankings derived from the opinions of college and university presidents, dean, department chairpersons, senior scholars and others;
- (2) citation analysis;
- (3) faculty productivity, measured by the number of publications;
- (4) statistical ranking derived from such information as endowment, library facilities and admissions selectivity.

Thus, existing ranking approaches do consider multiple facets of educational programs, many of which would seem appropriate even if an alternative approach (such as the balanced scorecard) were used. But unlike the balanced scorecard, these approaches do not select the various measures, nor do they organize them, based on a holistic or integrated system of performance drivers and diagnostic indicators. They also do not relate these measures to each institution's unique mission and circumstances. Because of these features, their usefulness for guiding individual programs toward continuous improvement and change would seem open to question.

4. Survey among Department Heads about Balanced Scorecard

To investigate the potential applicability and benefits of the balanced scorecard to the performance evaluation of engineering education systems, we conducted a survey of several heads of engineering-related departments in Taiwan. In the surveying process, we asked those department heads the following twelve questions.

- (1) Do you think that the balanced scorecard communicates an engineering department's goal and objectives better than the traditional mission and goals statements? In what ways is it better? Worse?
- (2) How important do you think it is to balance an engineering department's goal and objectives? To what extent and in what ways do you think the balanced scorecard helps or hinders this balancing?
- (3) To what extent do you think that the four components in the balanced scorecard encompass the essential goals and objectives for an engineering department? If you think that there are major omitted goals and objectives, under what labels would you classify such goals and measures?
- (4) To what extent do you believe that the four components are interlocked so that the success of the second (internal operations) and third components (learning and innovation) will lead to success with the first (customer satisfaction) and the fourth (financial) components?
- (5) Do the goals and measures presented by us include the key leading indicators for success in an engineering program so that departments will know at an early stage that they are on the right track to where they want to go?
- (6) Do you think that the performance measures in the balanced scorecard can be measured with affordable costs?
- (7) How easily do you think the measures in the balanced scorecard can be undermined in the implementation phase to reduce the effectiveness of the balanced scorecard system?
- (8) Do you believe that there are downsides to using diverse multiple performance indicators? Could you elaborate?
- (9) Do you think that some of the measures in the balanced scorecard may severely contradict each other? If so, what do you think can be done to overcome this problem?
- (10) How much change is necessary in your department before a balanced scorecard approach can be implemented? Could you elaborate on the nature of these needed changes?
- (11) Compared to your department's current performance evaluation system, do you think that there is a lot to be gained if a balanced scorecard is successfully implemented? What would be the major types of benefits to your department?
- (12) Overall, do you think that the gain will outweigh the costs if an engineering department were to implement the balanced scorecard?

Based on the survey, we suggest a performance evaluation model for the engineering education system according to the four components of the balanced scorecard.

Customer Perspective

- (1) Percentage of students with job offer at graduation
- (2) Number of companies recruiting on campus
- (3) Graduates recruited by Big 100 companies in Taiwan
- (4) Average starting salaries of graduates

- (5) Alumni evaluation
- (6) Graduating student survey
- (7) Accreditation
- (8) Recruiter evaluation
- (9) Professional exam-passing rate
- (10) External ranking or ratings in the press
- (11) Percentage of enrollment out of applications
- (12) Student evaluation of advising
- (13) Student satisfaction survey
- (14) Offering frequency of required courses

Internal Business Perspective

- (1) Distribution of grades awarded
- (2) Exit exam or student competency evaluation
- (3) Prerequisite enforcement rate
- (4) Number of internships available
- (5) Number of companies involved
- (6) Student evaluation
- (7) faculty-to-student ratio
- (8) Educational expenses per student
- (9) Average class or laboratory size for majors
- (10) Average class or laboratory size compared to other institutions
- (11) Number of faculty in the specialized area
- (12) Number of other schools offering the same program

Innovation and Learning Perspective

- (1) Number of faculty presentations at conferences
- (2) Number of faculty publications
- (3) Number of seminars attended by faculty
- (4) Travel budget for conference attendance
- (5) Number of courses incorporating new technology
- (6) Number of teaching innovation projects
- (7) Number of teaching workshops attended by faculty
- (8) Number of curriculum revisions in last five years
- (9) Number of new courses offered in last five years
- (10) Number of firms involved in joint activities
- (11) Number of joint activities

Financial Perspective

- (1) Annual giving to the department
- (2) Amount of permanent endowment
- (3) Amount of external grants
- (4) Enrollment trend
- (5) Level of student enrollment
- (6) Funding per student

5. Conclusions

Engineering educators and programs increasingly are seeking effective responses to the challenges of a rapidly changing technological, economic and social environment. Regardless of the change process adopted, performance measurement is essential for providing motivation and direction, and for giving feedback on the effectiveness of plans and their execution.

The balanced scorecard approach, which has been adopted by many for-profit organizations, merits consideration as a means to stimulate, focus and sustain continuous improvement effort in engineering programs. As an integral part of the strategy-formulation process, developing a balanced scorecard can improve communication and increase focus on the key success variables. And as a system of performance evaluation, it can provide timely feedback on the organization's as well as its constituents' success in attaining its goals.

The engineering-related department heads that we surveyed indicated that, like other management tools, the balanced scorecard has both strengths and weakness. But on the whole, they were quite positive about its potential benefits to engineering programs. These department heads also suggested components, goals and measure that can form an effective balanced scorecard for an engineering program. While each program has to

design its own scorecard consistent with its mission and circumstances, these suggestions can be a useful demonstration of the room for creativity in this process.

In considering whether to adopt the balanced scorecard approach, it is important to note some key challenges in its application:

- (1) The balanced scorecard embodies an implicit or explicit model of the organization - what are the key outcomes and outcome drivers, and how do these variables interrelate at a point in time as well as across time? As the department heads observed, careful construction and evaluation of this model is essential if the balanced scorecard is to provide guidance and feedback toward the desired outcomes.
- (2) Developing and implementing the balanced scorecard can be very time-consuming. An effective design and implementation process should include translating the vision and gaining consensus; communicating the objectives, setting goals and linking strategies; setting targets, allocating resources and establishing milestones; and feedback and learning. Experiences from the for-profit sector suggest that completing this process can take up to two years or more [4-5].
- (3) To the extent of measures that the scorecard includes which require subjective judgment, there may be concerns about measurement bias, reliability and susceptibility to manipulation.

However, these concerns are not unique to the balanced scorecard approach. Deriving a mission statement and translating that into goals and actions also implies a model of the organization, in addition to requiring substantial time commitments. The current movement toward using both financial and non-financial performance measures also makes issues of measurement accuracy and reliability unavoidable. In responding to these challenges, engineering educators are not operating in a vacuum. Some department heads assist in providing access to an extensive literature on measuring and modeling student learning outcomes. They also provide valuable guidance to extant knowledge about a wide range of curriculum, educational technology, student and faculty issues.

Ultimately, in evaluating the balanced scorecard and other means of supporting change and improvement, it is important to recognize that all approaches have strengths and weaknesses. The key question is not which method is perfect. Rather, it is which has the greatest excess of benefits over costs, including those arising out of its imperfections. The answer to this question necessarily depends on each institution's situation and aspiration. This paper's discussion of the balanced scorecard, along with the insights from departmental chairs, can add to the tools for initiating, guiding and sustaining continuous improvement in engineering education system.

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