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博士論文

Applying Balanced Scorecard and Option-pricing Methodology for E-learning Dynamic Performance Evaluation Framework Design

整合平衡計分卡與選擇權定價模型於數位學習之動態衡量與績效改善之規劃與設計

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Acknowledgments

The main goal of this study is to propose a comprehensive e-learning evaluation framework to help organizations analyze the e-learning performance of their employees, and help them make fundamental decisions. In order to maximize the utilization of the proposed model, the evaluation framework must be easy to use, easy to understand, easy to analysis and flexible to various conditions.

It is safer to consider ‘e-learning’ as a significant extension of tradition learning instead of replacement. Newer technologies don’t usually replace the older ones, just like new learning methodologies will not always replace the older methodologies. The theories of e-learning are built upon existing learning methodologies with huge difference. This study strongly emphasizes that e-learning could be the paradigm shift of traditional education. Thus, organizations must carefully evaluate their e-learning projects by treating it as a continuous improvement of long term organizational strategies.

It is worth to be mentioned that the term ‘assessment’ and ‘evaluation’ is often confused. Assessment refers to the systematic test about ‘component units’ of the system or project while evaluation is much broader than assessment that involves examining information of multiple components and overall views of the system (or project). Performance evaluation also makes judgments on the project’s efficiency and effectiveness. This study focuses on the overall contribution of an e-learning project to the organizations and thus omits the discussions on learning assessment.

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Abstract

A proper e-learning environment is one of the most important knowledge management tools in today's organizations. However, many of them lack a universal evaluation process to verify their e-learning project's performance. In an attempt to solve this problem, this study combines the balanced scorecard and the option pricing model to provide an easy to use, easy to understand, easy to analysis framework to evaluate the e-learning environment performance. It proposes an e-learning performance evaluation framework which makes three important contributions: First, it proposes a satisfactory-oriented option analysis methodology that can be applied to evaluate both quantitative and qualitative measurements in the same scale; Second, it constructs a measurement framework to integrate Kirkpatrick's model, balanced scorecard and Black-Scholes model which may be a good test-bed for e-learning project's performance evaluation; Finally, it provides an empirical study that demonstrates the analytical procedures to integrate the balanced scorecard and the Black - Scholes model for satisfactory-oriented e-learning performance evaluation.

Keywords: E-learning, learning evaluation, Black-Scholes model, options pricing approach, balanced scorecard approach

1 INTRODUCTION

E-learning is a general term involving online training delivered in a synchronous (real-time/instructor-led) or asynchronous (self-paced) format. Modern organizations consider e-learning an efficient and effective tool to enhance the knowledge of their staff members. Because most e-learning projects require considerable amounts of money, time, and human training, it is necessary to establish a performance evaluation model for organizations to make investment decisions. For instance, executives of higher education institutes need sufficient evaluation information to support their investment decisions, such as a digital library with rich streaming media, robust hardware, and extra-large amounts of instruction materials. However, it is just as difficult to measure e-learning project's performance as it is to evaluate the performance of traditional instructor-led learning. IT factors combined with e-learning environments tend to make evaluation more difficult, including change in learning behaviour, network access efficiency, or database integration. As a result, the effectiveness and efficiency of e-learning has become a controversial issue in recent years.

The main goal of this study is to propose a comprehensive e-learning evaluation framework to help organizations analyze the e-learning performance of their employees, and help them make fundamental decisions. In order to maximize the utilization of the proposed model, the evaluation framework must be 1) easy to use, 2) easy to understand, 3) easy to analysis and 4) flexible to various conditions. After detailed study and

analysis, this study first integrates the balanced scorecard approach (BSC) [1][2][3] and the Black-Scholes analysis (B&S) [4] [5] in order to model an e-learning performance evaluation framework which can be readily applied by most organizations. The remainder of this study is organized as follows. Section 2 provides an overview of the related literature, while section 3 coordinates learning evaluation theories and the balanced scorecard system to design a fundamental framework for e-learning assessment. In section 4 we apply the Black-Scholes analysis to our research via the description of its assumption, application steps, and design concept. Section 5 uses an empirical case study to demonstrate the application and analyzing procedures of the proposed framework. Finally, we draw our conclusion in section 6.

2 PRELIMINARIES

In order to construct a complete performance evaluation process of e-learning, this section provides an overview of the literature on learning evaluation, qualitative and quantitative factors, balanced scorecard approach, and options pricing models.

2.1. Learning evaluation models

The first step to design an e-learning performance framework is to study the existed e-learning frameworks. However, e-learning performance evaluation framework is rare. Thus, this study tries to search traditional learning evaluation theories for proper solutions.

Learning evaluation is a crucial topic in schools and human resource development (HRD) departments of any corporation. Although explicit assessment measures can be obtained through an objective standardized test, it is more difficult to capture tacit performance evaluation because it is a time-consuming, labour-intensive task, and the efforts often get swamped due to the bureaucratic inertia of most organizations.

Several remarkable models have tried to approach specific learning or training evaluation from an academic perspective. All these models are adapted to modern day business and social skills such as new technology ability, including the retention by and the affect upon the learner or trainee. They show that learner-reaction and practical

skills extend beyond the originally traditionally imagined manual and physical skills. One of the better known models, Bloom's Taxonomy of Learning Domains includes content knowledge, comprehension, application, analysis, synthesis, and evaluation [6][7]. Other models that focus on 'practical skills' include Dave's, Simpson's and Harrow's psychomotor domain taxonomy [8] [9][10]. Although at present computer and communication technology is still considered a relatively new arrival, these models are seen as reacting to and predicting the future trend of education.

Another well known model on HRD training, from a business perspective, is Kirkpatrick's learning and training evaluation theory [11][12] which follows the goal-based evaluation approach and is based on four simple questions that translate into four levels of evaluation. These four levels are widely known as reaction, learning, behaviour, and results. Goal-based models may help organization managers to extend their evaluation concerns from purely technical view to other organizational perspectives such as political, knowledge improvement, or return on investment (ROI) [13] [14] [15][16], and thus more flexible for cross field applications.

On the other hand, e-learning integrate not only learning domain but also IT project factors, which means, system-based approaches can also contribute to construct e-learning evaluation model. The most influential models based on the systems approach, include: Context, Input, Process, Product (CIPP) Model [17]; Training Validation System (TVS) Approach [18]; and Input, Process, Output, Outcome (IPO) Model [19].

While authors from both academic and business perspectives differ in the terminology used to describe the learning evaluation process, this study combined these works based upon Kirkpatrick's theory (mainly expanded by Phillips ROI model, [16]) and illustrates it as Figure.1. We will discuss the details in the 'Evaluation design' section.

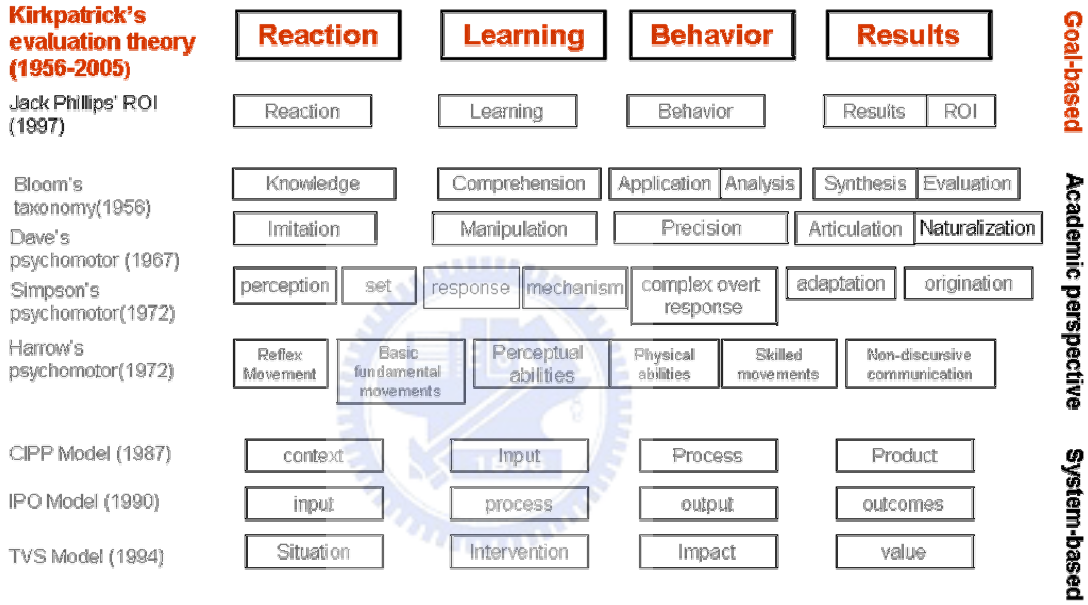


Figure 1 Comparing the of learning evaluation models

This study applies Kirkpatrick model [11] for e-learning system/environment/project performance evaluation according to the following reasons:

(1) E-learning environment is not limited the use in the nonprofit-oriented educational organizations. Many large commercial firms have provided e-learning environment to improve their employees' knowledge or meet the organization members' self-learning needs. Thus, e-learning is widely adopted

by various profit or nonprofit organizations. It is reasonable to introduce goal-based model to evaluate the e-learning system which can improve performance of the workplace for various types of organizations.

(2) Kirkpatrick's model has clearly identified that learning performance should be evaluated with knowledge, skills and attitudes perspectives. It is similar to "skill training" concept in computer-based training models. Thus, Kirkpatrick's model can be easily adopted in an e-learning performance evaluation framework to integrate quantitative and qualitative factors into evaluation process.

(3) The Kirkpatrick's model has been consistently improved in accordance to the managerial revolutions, which makes it easier to be fitted into modern managerial models and easier to be adopted by managers and analysts. Kirkpatrick's model also helps people inspect the e-learning project with omnibus views. The most important impact is that Kirkpatrick's model adopts cost perspective that has rarely been discussed in traditional education theories. For example, many schools and government institutes begin to examine the relationship between cost and e-learning systems and argue the appropriateness of '*Learning for learning's sake'*. Thus, the use of HRD training based Kirkpatrick's model for e-learning project's performance evaluation is reasonable.

It is worth to be mentioned that the term ‘assessment’ and ‘evaluation’ is often confused. Assessment refers to the systematic test about ‘component units’ of the system or project while evaluation is much broader than assessment that involves examining information of multiple components and overall views of the system (or project). Performance evaluation also makes judgments on the project’s efficiency and effectiveness. This study focuses on the overall contribution of an e-learning project to the organizations and thus omits the discussions on learning assessment.

2.2. Traditional learning and e-learning

Following the emergence of computer-based training (CBT) in 1980s, internet-based learning in 1990s, and web-based live instructor-led training in the new millenniums, the term “e-learning” means an approach that facilitates and enhances learning through both computer and communications technology. Communications technology enables the use of the Internet such as distance learning, web-based learning platforms, collaborative authoring, virtual learning communities, multi-media/rich streaming media, course management software, and digital libraries, reusable learning objects. Organizations can adapt the latest technology to improve their learning environment under budget restrictions.

However, it is safer to consider ‘e-learning’ as a significant extension of tradition learning instead of replacement [49]. Newer technologies don’t usually replace the older ones, just like new learning methodologies will not always replace the older

methodologies. The theories of e-learning are built upon existing learning methodologies with huge difference. For example, collaborate learning, active learning, or Internet cognitive courses have been widely adopted along with classroom courses or been blended together with tutorial modules. E-mails, forums, web pages, multimedia, Blog, or Wikipedia have been applied as new tools of learning. Meanwhile, the learner's behavior change from traditional learning to e-learning cannot be ignored. This study strongly emphasizes that leaning from Internet and computer-assisted tools could be the paradigm shift of traditional education. Thus, organizations must carefully evaluate their e-learning projects by treating it as a continuous improvement of long term organizational strategies.

E-learning is expected to provide a higher quality learning experience, available anytime and anywhere, effectiveness/efficiency and with an even greater cost saving regarding the traditional learning environment. However, the effectiveness/efficiency of e-learning has become a controversial issue in the past few years. Many teachers disagree that the e-learning environment is a better way for learning, while others (mostly system developers) try to verify the performance of e-learning because 'e-learning' is a fuzzy and growth domain which contain countless impacting factors which change quickly over time. For examples, e-learning materials can be instructor-led or self-directed (without instructors), scheduled or unscheduled, synchronous or asynchronous depending on the topics and organizations/trainers/learners requirements.

'E-learning evaluation' especially complex because it must integrate four distinct domain includes: learning evaluation, IT improvement, project management, organizational management as shown in Figure 2. Although the formal or informal

benefits of e-learning systems cannot be properly identified by most organizations, most organizations agree that e-learning may cause ‘paradigm shift’ of learning behavior and thus increase the organization’s tangible or intangible value.

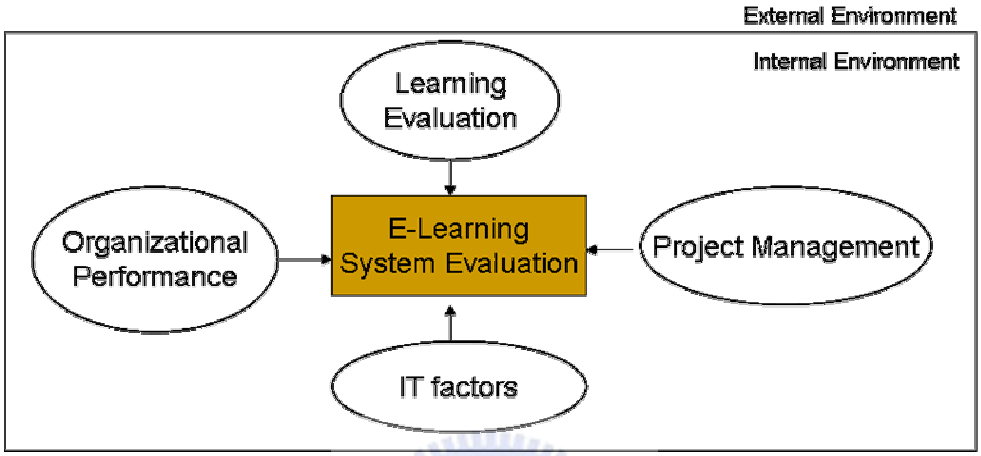


Figure 2 The impact factors of e-learning system evaluation

Some approaches [20] [49][50] have been adopted to evaluate e-learning effectiveness such as comparison with traditional learning, tools and instruments, product evaluation, performance evaluation, return on investment, or comparison with a hypothetical system. Nevertheless, all these methods lack universal and quick analytical procedures. This study tries to construct an analytical framework to evaluate e-learning project’s performance with objectives listed below:

- Be easy to understand
- Be ready to use
- Be easy to analysis
- Be readily applied by most organizations
- Performs top-down analysis

- Be target-oriented
- Provides flexibility
- Provides real time analysis capability
- Provides managerial information about the project's success

This study proposes a comprehensive framework with the above objectives by integrating learning evaluation model, balanced scorecard, and options pricing analysis for e-learning project's performance evaluation.

2.3. Balanced scorecard approaches

The balanced scorecard (BSC) was first developed in the early 1990s [1][2][3] and became widely adapted for determining business strategies. The underlying concept of the BSC is a combination of the measurement system with the management system, enabling senior management to make quick and effective strategic decisions for the future.

The most widely adapted function of the BSC is the management performance system which can be used in any size organization to align its vision and mission by demonstrating four different dimensions: financial (result), customer (reaction), internal process (operation/behavior), and capacity (learning and growth). Several articles have found that the BSC system can be adapted to the evaluation of learning performance [21], while others discussed its application in tacit knowledge management [22]][23].

All these articles can help us to organize the confusion of e-learning evaluation by means of the BSC tool, something which has never been quite done before.

Balanced Scorecard (BSC) is a methodology to solve challenges in balancing the theories of a strategy with its execution. It has the following advantages:

- The methodology is qualified for managing business strategy from top-down aligns strategic goals with objectives, targets, and metrics.
- It provides a balance between certain relatively forces:
  - ✓ Internal and external influences
  - ✓ Leading and lagging indicators
  - ✓ Financial and non-financial goals
- It cascades to all levels of the organization.

Kaplan and Norton originally addressed the four perspectives (learning, internal, customer, financial) that can guide companies as they translate strategies into actionable terms. But they do not obligate that these perspectives are necessary and sufficient conditions for success. However, BSC suggests that organizations can apply different perspectives that are more relevant to their missions or goals rather than the original ones.

It is important to note that in mission-driven organizations like schools, government, or nonprofits-oriented organization, the mission is not limited to the financial goals (but could include financial items). A BSC planning must be designed

according to the goals and missions of the organization in order to apply e-learning environment to increase the firm's competition capabilities and values.

2.4. Qualitative and quantitative approaches

Qualitative and quantitative approaches are widely adopted to evaluate e-learning performance. The qualitative research approach is generally accomplished by using the outcomes of a pilot study, the reviews of researchers, expert interviews, critical success factors method (CSFs), and questionnaires for exploring specific human problems. In contrast, a quantitative research approach represents a tangible, visible and comparable ratio. For example, assessing learner experience is a qualitative factor, while system usage could be represented as a login frequency through analyzing a system log file.

This study expands qualitative and quantitative factors (briefly listed in Table 1.) to a BSC metric which forms the questionnaire in our research. There are several important tasks that must be clarified [24] when we design a questionnaire, including both qualitative and quantitative indicators: (1) Some of the indicators will be transformed into a quantitative form by grading or specifying a numerical evaluation scale; (2) Normalizing of the indicators will be done through a general unified grading scale; (3) Defining the weights of the indicators. The main contribution of this study will be to demonstrate, based on the results, how to integrate the option pricing analysis approach into the e-learning performance evaluation.

Table 1 Examples of qualitative and quantitative factors of e-learning

Qualitative	Quantitative
• Personalization learning • Web styles preference • Collaborative learning • Communication efficiency • Developing differentiation of the learning environment • Improving the efficiency of the internal process • Improving the competitiveness, or brand or organization. • Improving user satisfaction • Improving knowledge • Developing innovation ability • Enhancing material quality • Improving synthesis of learner • Behaviour change	• The material links to other sources. • The number of illustrated examples or case studies • Usage of illustrations, photos, animations and other multimedia. • Increase/decrease of credit scores • Usage frequency • Increase/decrease the average transaction time. • Software efficiency • Hardware efficiency • The number of patents/researches/ papers/professional certificates • Increase/decrease number of users • Increase/decrease the average transaction cost

2.5. Dealing with uncertainties: real option analysis approach

Every project has to face uncertainties (risks). Each strategy manager has to deal with uncertainties. There are essential three tools (Table 2) that a manager can use to evaluate corporate risk and uncertainty: 1) capital budgeting method, 2) portfolio analysis and 3) option pricing.

The capital budgeting method is a planning process used to determine a firm's long term investment. The most representative capital budgeting method is net present value (NPV) analysis. In this method, the analyst looks at projects in isolation and determines the individual cash flow that each project may generate and discounts those to today's

value at a project-specific discount rate which indicates the perceived risk of the cash flows [25]. Risk is indirectly measured as the discount rate that represents the opportunity cost of capital.

Portfolio analysis method looks at the investment project in relation to the existed assets and projects. The most popular one is capital asset pricing model (CAPM) [26]. The manager identified individual project's relative risk contribution to the overall risk profile of the portfolio. Each project will be compared in its risk/return profile to pre-established benchmarks that the manager only allows those risk-reducing project to be added into the existed projects (portfolio) while preserving or enhancing returns.

Among the three methods, only option pricing method directly analyzes the project-specific risk. An option is a privilege sold by one party to another that offers the buyer the right, but not the obligation, to buy (call) or sell (put) the underlying asset at an agreed-upon price during a certain period of time or on a specific date. In a managerial view, an option represents the freedom of choice after the revelation of information and also the act of choosing alternatives. A "real" option is an option related to "things" such as fixed, permanent or immovable things as opposed to illusory things. Applying real options analysis (ROA) into real world applications is valuable to provide managerial insight and the analytical process is flexible to meet various conditions. The initial ROA framework focuses on the increased value of abandoning a project and liquidating the assets [27]. Thus, the core concept of ROA is based on the effectiveness of resource rearrangement to maximize the entire system performance [28]. The ROA approach treats each project (or objective) as an investment under uncertainties (risks) that also consumes a certain amount of resource (cost). If the

anticipated return (call value) of the project exceeds the consumed resource then the project is worth for investment. By abandoning less profitable projects to save resource, an organization can inject more resource into better profitable projects and obtain more values. Thus, the dynamic relocating strategy of ROA provides the flexibility for managers to fine tune their organizational resources when facing uncertainties.

Table 2 Three approaches to risk

Method	Approach to Risk	Instrument
Capital Budgeting	Indirect	Discount Rate
Portfolio Analysis	Relative	Benchmark
Option Pricing	Direct	Probability

In practical use, a typical ROA analysis uses different parameter sets compared to financial options as illustrated in Table 3.

Table 3 Financial options compared to real options

Notation	Financial option pricing	ROA approach
C	The theoretical call price	Expected revenue
P	The theoretical put price	Expected loss
S	Current value of the underlying asset	Present value of future cash flows from the asset (project)
K	Exercise price of the option contract	Cost (resources) to acquire the asset (project)
σ	Volatility of the underlying asset	Risk of the asset (project), variance of the best and worst case scenario
T	Time to maturity	Length of time option is viable
r	Risk-less interest rate	Risk-free rate of return

The ROA approach has been widely adopted for evaluating information technology investments in the early 1990s which was almost synchronized with the explosive growth of the computer and the Internet era. Applying financial models to the IT fields in prior research can be summarized into several topics. First is the topic of how to measure IT investment risk [29][30][31][32][33]. For example, Michel Benaroch proposed an approach on managing IT investment risk and illustrated how to apply this approach to an IT investment under an Internet sales channel. Chemon and Weber did early research on real options that could be applied to managing IT investment risk. Second, several published works used ROA to analyze the growth opportunities as a result of prototypes of new IT infrastructures being launched [34][35][36]. For example, Benaroch and Kauffman investigated the problem of investment timing using the Black-Scholes model in a real-world case study, dealing with the development of point-of-sale (POS) service. Third, ROA also applies to several specific topics such as electronic banking, digital government, and knowledge management [34] [23] [37].

Although ROA approach has been widely adopted by IT applications, it needs further modifications to meet the e-learning requirements. For example, while e-learning investment can be valued by money, its system performance is difficult to be monetarily evaluated. This study proposes a theoretical grounding in which the Black-Scholes model [5] and the BSC approach can be combined and applied to e-learning performance evaluation. Furthermore, it also proposes guidelines for the design to ensure that the BSC indicators follow the Black-Scholes assumptions, as discussed in section 4, followed with an empirical study in Section 5.

3 EVALUATION DESIGN

This section coordinates learning evaluation theories and the balanced scorecard approach to design a fundamental framework for evaluating e-learning activities. The key objective of this study is to provide easy to use, easy to understand, easy to analysis and flexible e-learning project performance evaluation framework.

3.1. Overview

The original idea of this study came from the research of Financial Labs design of National Chiao Tung University. In order to evaluate of the Financial Labs performance, this study searched for e-learning environment performance evaluation models but found out that there was only a few papers discussed this topic because e-learning system performance is difficult to be evaluated. Thus, this study began to design a practical framework to help strategy makers evaluate their overall e-learning environment performance.(as show in Figure 3)

The first step to establish an e-learning evaluation framework is to search for existed learning performance evaluation models from both academic and human resource fields. After comparing each evaluation theories, this study finds out that the Kirkpatrick's model is better fitted for modern e-learning situations because it is a goal-based approach model. A goal-based model basically follows a top-down decision making procedure that the responsible manager must first identify the organization's goal and make decisions based on how to achieve the goal. The top-down strategy planning method is widely adopted by organization managers. This study further

modified the Kirkpatrick's model based on the e-learning characteristics for managerial purposes.

After determined the basic evaluation theory, the second step is to design an analytical tool to help strategy makers determine their e-learning environment performance. After studied modern strategy planning tools, this study found that the BSC approach is widely adopted by modern organizations. BSC approach is also a top-down planning tool that has explicit procedures for an organization to plan and evaluate their organizational performance in a goal-oriented perspective. Meanwhile, the BSC approach is able to evaluate qualitative objectives while lots of e-learning objectives cannot be properly quantified.

In order to apply the BSC approach, a strategy maker has to firstly identify the organization's e-learning goals then properly define the major perspectives of the e-learning project while each perspective has its own goals. In order to achieve the perspective goal, the manager has to identify the objectives for each perspective and setup objective target that must be achieved. By evaluating each objective, the strategy maker can quickly understand each objective's performance and make planning decisions.

However, traditional BSC approach lacks quantitative capability for a manager to identify each objective's impact to the entire project because each objective is measured in its own scale. For example, one objective's target may be "user number exceeds 2,000" while another objective's target may be "over 90% users are satisfied with our e-learning system". Different measurement scale makes the individual impact difficult to

be addressed. For example, what is the total performance of the project if there are 10 objectives in a perspective and 5 of them failed? Traditional BSC analysis cannot answer this question. In order to identify the individual impact of each objective, this study tries to normalize all the objective performance into a single scale "satisfactory". The use of "satisfactory" is based on the intrinsic characteristic that learning performance cannot be monetarily measured. Commercial project can be evaluated by its revenue and cost but the learning performance can only be measured by its "satisfactory". The satisfactory comes from the user, the user's families, the organization and the society. The e-learning project will be successful if most people (from outside and inside) feel satisfied to the organization's e-learning environment. If all the objectives' performances are evaluated in the same scale of satisfactory, then the individual performance impact can be measured.

Although this study has modified BSC measurement method to provide more managerial information, this model cannot reveal the most important information: 1) will this project success? 2) what is the key success/failure objective? E-learning environment/system planning is a long term process. Meanwhile, the satisfactory level may change due to internal or external situations. For example, one user may suddenly feel the e-learning system is obsolete just because he occasionally visits a new web-site. It is important for a manager to deal with uncertainties and makes decisions to ensure the success of the project. There are three tools for a manager to deal with uncertainties (risks): 1) capital budgeting method, 2) portfolio analysis model and 3) option pricing models. This study applies option pricing model because it provides a direct measurement of the uncertainty via probability. Meanwhile, option pricing models also

provide well developed analytical tools to help a manager address the key success/failure factors via sensitivity analysis tools. Thus, this study is based on Kirkpatrick's model and integrates the BSC and option pricing tools to design the e-learning system performance evaluation framework.

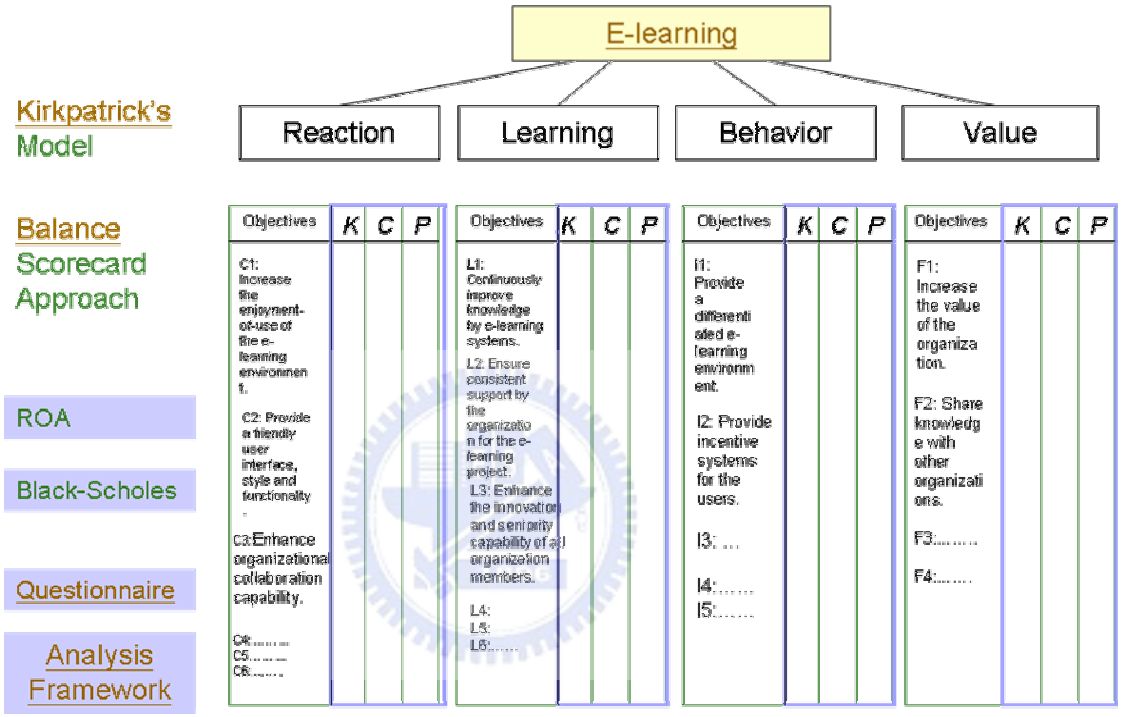


Figure 3 The overview of this study

3.2. The methodology of learning evaluation

As this study mention in preliminary section, authors from both academic and business perspectives differ in the terminology used to describe the learning evaluation process; this study combined these works based upon Kirkpatrick's theory. This theory makes it easy to integrate the qualitative and quantitative indicators of e-learning performance evaluation into four levels: reaction, learning, behaviour, and Result. Derived from Kirkpatrick's theory, the Phillips' model adds the fifth level "ROI" and

provides a more acceptable form of learning measurement which can be adapted to the well known balanced scorecard approach (BSC). In order to simplify the measurement process, the ROI level is merged into Kirkpatrick's 'result' level and which is mapped to 'Value' perspective in this study.

3.2.1. Reaction

Reaction evaluation is finding out how the learners feel about their learning experience. This can often be examined by feedback forms, verbal reaction, post-training surveys, online grading, written reports, or questionnaires. For example: *Do learners enjoy their training? Do they like the venue, style, domestics, and timing? How about their participation level?*

3.2.2. Learning

Learning evaluation is the measurement of the increase in knowledge, skill, and attitudes changed from before to after the learning experience. There are several tools that are often used to assess the learning effect, including: tests (mostly simple approach), interview or observation before/after the training, or analyzing the inconsistencies of the assessment by statistics. For instance, *do learners realize what subject they intended to be taught? How about the change in the learning curve? Do learners increase their IT capabilities?*

3.2.3. Behaviour

Behaviour evaluation is the extent to verify the behaviour change after the learners applied the knowledge they learned. Observations, interviews, or questionnaires are

performed anonymously over a period of time to assess such change. For example, *Do learners work in a more effective way after training when they are back to the job? How about the status of sharing an organizational culture? Do the learner like the training program and begin to apply the new skill?*

It is difficult but important to understand whether the knowledge, skills and/or attitudes learned in the program transfer to the job. The complexity of behaviour evaluation discourages most organization managers from even making an attempt to evaluate the Behaviour level. But Kirkpatrick suggests that 'something beats nothing' and he encourages managers/ trainers to perform some behaviour evaluation even if it is not elaborate or scientific. For example, forming a simply questionnaire to ask learners: *Are you doing anything different on the job because you attended the e-learning program? Do you plan to change some of your behaviour in the future after attended the e-learning program?*

3.2.4. Value (Result)

This perspective is typically the organizational key performance indicators such as volumes, values, percentages, timescales, return on investment, and other quantifiable aspects. For example, the result will be better quality of work, more productivity, cost reduction, fewer mistakes, increasing sales.

But in most situations on e-learning planning, the "results" are generally intangible. For example, to evaluate the organizational value, culture, social responsibility, reputation, or comparing these stuff with the other competitors. Thus, the evaluating items must be changed. The goals of each e-learning project may change and thus the

organization cannot expect to obtain “tangible” returns in all cases. This study will follow the ‘result’ concept of Kirkpatrick model and represent it to the term ‘Value’ to combine the general qualitative and quantitative factors into e-learning project evaluations.

3.3. Integration with the BSC framework

After determined the Kirkpatrick’s model as the major evaluation theory, this study began to design the e-learning project’s performance evaluation framework. This study suggests that the entire e-learning project performance cannot be simply verified by the students’ final assessment. The e-learning project must be verified by all aspects of the entire project. Thus, this study searched popular strategy planning and evaluation models and chose the balanced scorecard as the major analytical framework.

The balanced scorecard (BSC) was first proposed in the 1990s by Kaplan and Norton. In it vision, mission, and objectives are decomposed into different views, or perspectives, as summarized through the eyes of business owners, customers, managers, employees, and stakeholders. The owners are represented by the ‘Financial’ perspective, customers and stakeholders are represented by the ‘Customer’ perspective, managers by the ‘Internal Business Process’ perspective, and employees by the ‘Learning and Growth’ perspective. The objectives and the correlative weights can be seen as the complete views of a business.

Compared to the traditional Bottom-Up planning process of MIS fields [48], BSC introduces the Top-Down concept for strategy planning. BSC suggests an organization first address the project's vision and strategy by the organization's core competence to determine the major perspectives and then downward to identify individual objectives and its objective targets to evaluate the project performance. Thus, BSC approach emphasizes that the organization should use a global view to evaluate the entire project and identify those unsuccessful objectives that have to be improved.

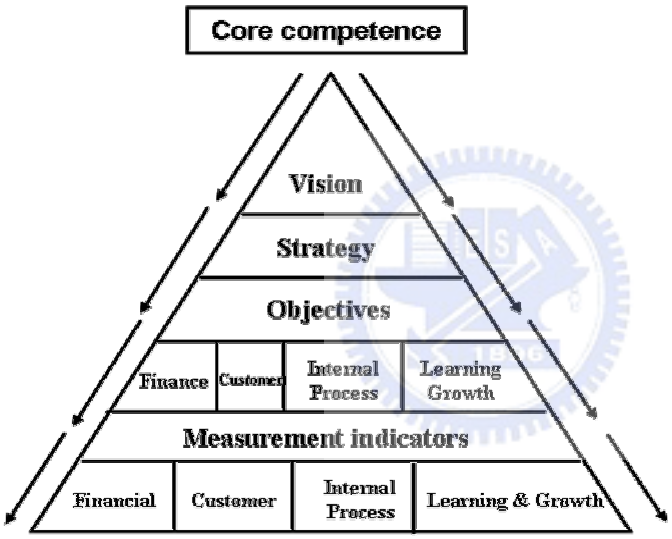


Figure 4 Balance Scorecard: from management viewpoint (Source: Niven;2002 [48])

The use of BSC approach in this study is that the Taiwan government promotes BSC concept to general firms. Thus, lots of Taiwanese organization managers and decision makers are familiar to BSC framework and feel easy to understand its applications. Introducing the BSC approach the e-learning project's performance evaluation can reduce the learning time of the decision makers. Meanwhile, BSC approach possesses definite analytical procedures that a decision maker can acquire

feasible results by predefined steps. The BSC approach has been proved and well adopted by real world organizations that can be readily to be applied for most organizations without too many difficulties. Thus, the BSC approach also meets this study's objective: "flexible", "easy to use" and "easy to understand".

The balanced scorecard (BSC) was first proposed in the 1990s by Kaplan and Norton. In it vision, mission, and objectives are decomposed into different views, or perspectives, as summarized through the eyes of business owners, customers, managers, employees, and stakeholders. The owners are represented by the 'Financial' perspective, customers and stakeholders are represented by the 'Customer' perspective, managers by the 'Internal Business Process' perspective, and employees by the 'Learning and Growth' perspective. The objectives and the correlative weights can be seen as the complete views of a business.

The BSC has evolved over time to become a full performance management system applicable to both private sector and public sector organizations, such as schools, government, or other non-profit organizations or institutes. Just by shifting the emphasis of the measurement of financial and non-financial performance, many researches ingeniously modified the vision, mission, and objectives of the four perspectives. For example, the e-learning mission may be the improvement of the overall knowledge management (KM) capabilities or increase the competitiveness of employees for a private sector firm. For a public sector organization like schools, the e-learning mission may be the increment of public reputations or improvement of educational qualities.

Based on the learning theory summarized in section 3.2 and the e-learning characteristics, this study refined the four perspectives of the BSC into Kirkpatrick's theory as (also shown in Figure 5 with a detailed description in Table 2): (1) The reaction of the students or trainees is represented by the 'Customer' perspective; (2) Learning effect of learners is represented by the 'Learning and Growth' perspective; (3) Behavioural change of all participants of e-learning is represented by the 'Internal business process' perspective; and (4)Results (including financial or non-financial factors, learning efficiency/effectiveness, social reputations, organizational value) are represented by the 'Value' perspective. Based upon the modified e-learning perspectives and B & S assumption, this study designed a questionnaire composed of the qualitative and quantitative indicators as mentioned in section 2.4 to perform a case study for the final doctoral dissertation.

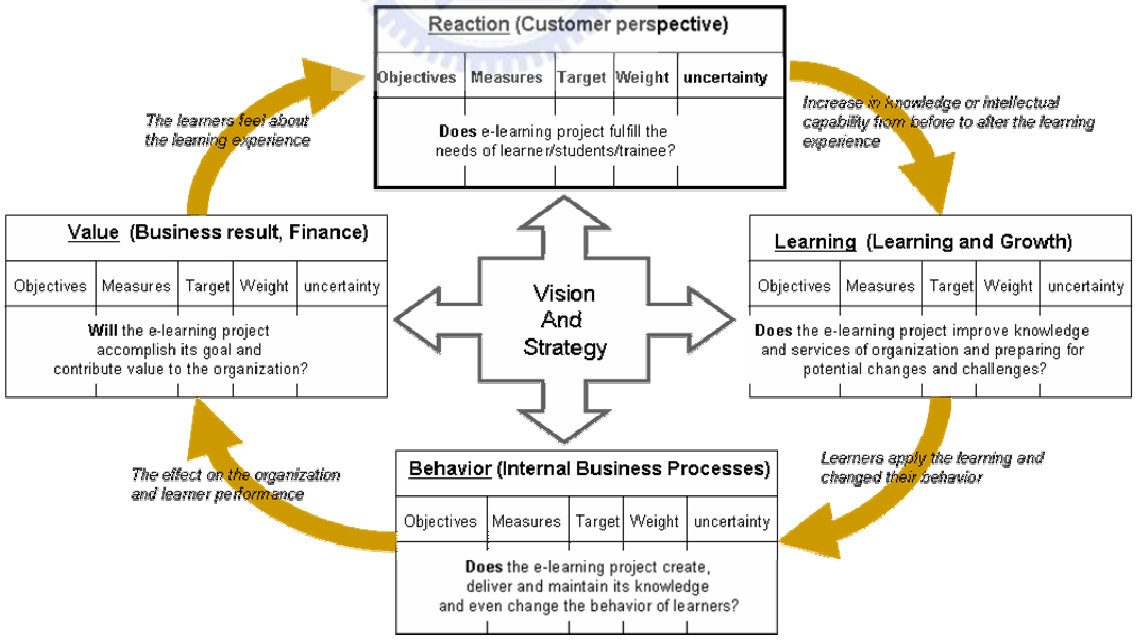


Figure 5 Applied BSC approach to e-learning performance evaluation

The performance evaluation of an e-learning project can be seen as a subset of tacit knowledge assessment, and is distinct from the traditional BSC approach of a business from several viewpoints:

(1) Schools and educational institutes are focused mainly on the learning evaluation rather than the financial return on investment. The term “learning evaluation” is different to “learning assessment”. “Learning assessment” emphasizes on the “assessment” of learning while “learning evaluation” includes qualitative factors like the behaviour change and social reputations

(2) Students (learners, trainee) play a principal role in learning activities covering all four perspectives of the BSC, and are especially representative of the ‘Customer’ perspective. However, for a nonprofits oriented firms like schools, the customers can be students, government, general publics and organization members.

(3) The cause and effect linkage of e-learning perspectives is different from the BSC’s original sequence.

A typical BSC procedure suggests that the organization first build up a strategy map to describe the relationship between four perspectives. The relationship between the four perspectives is that “learning and growth” generates the change of “internal process”, the improvement of “internal process” may obtain the positive reactions of “Customer”, and the positive reactions of “customer” will produce the “financial return”.

However, if learning performance evaluation applies the BSC approach then the cause and effect linkage should be reorganized so that the organization anticipates the positive reaction of the e-learning system can improve the overall learning effectiveness thus changes the learner’s behaviour then improves the organization’s value as described in

Table 4 The four perspectives in the balanced scorecard of e-learning evaluation

Reaction(Customer, ex. students, trainees)	
Mission: Deliver value-added knowledge/services learning. *Key question: Does e-learning fulfill the needs of the learner/students/trainee?*	
Objectives Examples: C1: Increase the enjoyment-of-use of the e-learning environment. C2: Provide a friendly user interface, style and functionality. C3: Enhance organizational collaboration capability. C4: Improve the communication between trainees and trainers.	C5: Increase user satisfaction. C6: Increase the flexibility of the learning time arrangement. C7: Provide abundant linkage to related learning materials. C8: Provide sufficient examples and case studies. C9: Provide vivid illustrations of rich multimedia materials.
Learning (Learning and Growth)	
Mission: Deliver continuous improvement and prepare for future challenges *Key question: Is the e-learning project improving the knowledge and the services of the organization, and does it prepare the organization for potential changes and challenges?*	
Objectives Examples: L1: Continuously improve knowledge by e-learning systems. L2: Ensure consistent support by the organization for the e-learning project. L3: Enhance the innovation and seniority capability of all organization members. L4: Improve IT capability of all members. L5: Improve professional skills of all members. L6: Enhance personalized learning capabilities.	L7: Ensure a logical sequence among learning materials. L8: Ensure that the learners realize what the learning subjects are. L9: Increase the learners' knowledge comprehension. L10: Increase the usage frequency of the e-learning system. L11: Increase operation familiarity with the e-learning system. L12: Create satisfied learning results.
Behavior(Internal Business Processes)	
Mission: Improve the internal business process in an efficient and effective manner *Key question: Does the e-learning project create, deliver and maintain its knowledge and services in a more efficient manner?*	
Objectives examples: I1: Provide a differentiated e-learning environment. I2: Provide incentive systems for the users. I3: Generate a nurturing organization culture. I4: Motivate effective learning activities.	I5: Improve the role playing capabilities during learning activities. I6: Encourage knowledge sharing between members. I7: Generate a change to better learning behaviour. I8: Provide an efficient and effective learning environment
Value(Finance, Results)	
Mission: Contribute to the value of the institute/school *Key question: Does the e-learning project improve the learning efficiency/effectiveness? Will the e-learning project accomplish its goal and contribute value to the organization?*	
Objectives Examples: F1: Increase the value of the organization. F2: Share knowledge with other organizations. F3: Provide a high quality knowledge and information platform. F4: Increase the reputation of the organization. F5: Improve the organization's competitiveness.	F6: Increase knowledge absorption. F7: Increase the number of research achievements. F8: Increase the number of online users. F9: Reduce learning costs.

4 APPLYING THE BLACK-SCHOLES MODEL

It has been explained by Cox and Ross (1976) that the option price is the expected value of payoff discounted at the risk-free interest rate over the risk-neutral distribution of the underlying asset [4]. In order to obtain the proper value of options, the field of finance has developed many sophisticated option pricing models to determine a contract value of the underlying asset under uncertainties. Among these option pricing models, the Black & Scholes (1973) model (B & S model) is the most popular one, and it has been widely adopted in real world applications.

Although the B & S model was originally designed to evaluate the option value, it has been widely adopted in various applications to determine the expected value of any target under uncertainties. This study applies the B & S model and makes two major contributions: (1) it provides a theoretical grounding for the B & S model so that it can be applied to BSC applications; (2) it proposes a measurement framework that enables managers to analyze and optimize e-learning performance. The final doctoral dissertation will also present an empirical case study to demonstrate the analyzing process of e-learning environments.

4.1. Option pricing concept

The term “option” is a privilege sold by one party to another that offers the buyer the right, but not the obligation, to buy (call) or sell (put) the underlying asset at an agreed-upon price during a certain period of time or on a specific date (final settlement

date). There are two major types of options existed: 1) plain vanilla option and 2) exotic options.

Plain vanilla option is the first generation options, for example, European options and American options. The payoff of a plain vanilla option is determined by the final settlement price of the underlying asset at maturity. American option allows early exercise which enables an investor executes his privilege before final settlement date. On the contrary, European option does not allow early exercise.

Besides plain vanilla options, there are three types of exotic options: 1) path-dependent options, 2) multi-factor options and 3) time-dependent options (illustrated in Table 5).

The option price of a path-dependent option is determined by the "path" of the underlying asset before maturity. The multi-factor option's price is determined by two or more underlying assets. The time-dependent option determines the price by time and the underlying asset's current value.

Table 5 Types of exotic options

Path-dependent options	**Multi-factor options**	**Time-dependent & other options**
Average rate option (Asian option)	Rainbow option	Chooser option
Barrier option	Quanto option	Forward start option
Lookback option	Basket option	Binary option
Ladder option		Compound option
Shout option		Pay-later option
		Bermudan option

This study uses European option to evaluate the BSC objectives because the proposed framework is to evaluate if the system performance can exceed the organization's target at the specific date, which perfectly fits the European option's conditions.

The option price is the expected value of the payoff discounted at the risk-free interest rate over the risk-neutral distribution of the underlying asset. Thus, given the price S and an agreed-upon price K during a certain period of time T of the underlying asset, the option value can be described as follows:

$$C = E(Max(S-K, 0))$$

$$P = E(Max(K-S, 0))$$

Where C denotes the call option price, P represents the put option price, and $E(.)$ is the expected value.

In the real world the price of most assets varies constantly, and this variation is described as volatility σ. An option pricing model is used to calculate C or P of the underlying asset under the circumstances (S, K, σ, T, r). That is to say, to obtain the expected value of $S > K$ for a call option, or $S < K$ for a put option with a given set of (S, K, σ, T, r). Because the price can be viewed as an index of the underlying asset the option pricing model is ideal to evaluate the expected value of any index S higher or lower than a target value K with uncertainty σ over a specific time T and with an anticipated growth rate r.

The most classical of option pricing approaches is the BS model, which assumes that the payoff of the underlying asset follows the geometric Brownian motion and has a

lognormal distribution with constant volatility and risk-free interest rate before maturity. Since the development of the BS model, more realistic option pricing methodologies have been developed, including: (a) the stochastic interest-rate/volatility option model [38][39][40]; (b) jump-diffusion related models [41][42]; (c) Markovian models [43][44]; and (d) stochastic-volatility jump-diffusion models [45][46]. However, all these models focus on identifying the "right" distributions and pricing options (especially financial options) using close form formulas. This study applies BS model to evaluate the BSC index because BS model formula is simple and easy to be implemented with modern spread sheet packages. The other reason is that this study designs the BSC measures under BS assumptions in order to provide reasonable evaluation procedures with theoretical supports. If this study applied other pricing model, for example diffusion model, the objective measurement procedure must be changed to generate fat-tailed distributions in stead of log-normal distributions.

4.2. BSC and ROA

Although both BSC and ROA approaches are well adopted by modern organizations for strategy planning, there is no existed application that integrates BSC and ROA for strategy planning use. Marion (2003) suggested that the integration of BSC and ROA would be ideal to provide a more powerful strategy planning framework [47], but he could not propose any practical solution to combine these two approaches. However, this study finds out that an organization can use the traditional BSC model to

perform top-down strategy planning and applies the ROA model to analyze the e-learning project's expected performance.

The difficulties of evaluating and analyzing e-learning performance were discussed in section 2. Since the option pricing model can calculate and analyze the expected value of a certain asset (or any performance index), it is ideal for managers to evaluate the performance of each e-learning BSC objective for the following reasons:

(1) E-learning investments are often made without any tangible payback that can be evaluated as a real amount of money. However, by applying the BSC to convert e-learning performance into a satisfactory index, the analyst can take this value into the option pricing model as the underlying asset price for management or strategy planning use. The decision maker can thus quantify each objective in the scale of satisfactory and obtained the expected value that each objective exceeds its target (satisfactory degree). Because all the objectives are measured in the same scale, the whole BSC framework can be treated as a satisfactory portfolio and applies sensitivity analysis to evaluate the individual impact of each objective to address the key success/failure objectives.

(2) E-learning performance varies frequently and is hard to be forecasted precisely. For example, the performance index value may change just because of the introduction of new technology, new learning material, or new learners. The option pricing model is applied intuitively in the calculation of the expected gain (call value) or loss (put value) of such index over a specific time. Thus, the manager can directly measure the uncertainties via option pricing methodology.

This study modified the ROA approach to evaluate the e-learning performance of each BSC objective with B & S model to calculate the expected value if each objective can exceed its target value.

4.3. Assumptions in the Black-Scholes model

The B & S model was originally developed to price the European option of an asset that does not pay any dividend or make distributions. The underlying asset can be a real asset (for example, gold, corn, and soybean options) or an index (for example, S & P 500 index option). The basic assumptions of the B & S model are: (1) the price of the underlying asset follows a geometric Brownian motion with lognormal asset returns, (2) with constant volatility throughout the lifetime of the contract, (3) the underlying asset's price varies continuously, (4) there are no risk-less arbitrage opportunities, and (5) this underlying asset is traded in a perfect capital market. Although virtually no asset satisfies all the assumptions described above, the B & S model still remains widely adopted by most financial experts (for example, in stock options applications). Assumptions 4 and 5 are related to financial market behaviours. However, other assumptions must be addressed in BSC related application which will be discussed in the following sections.

4.3.1. Applying the Black-Scholes formula

The core concept of the B & S model is that, assuming that there exists a portfolio containing a certain stock and its call option, adjusting the proper hedging ratio (ratio between stocks and its call options) can transiently maintain this portfolio in a risk-less

state. If there are no arbitrage opportunities, then this portfolio merely makes risk-free returns. With this concept, Black and Scholes derived the option pricing formula:

$$C = SN(d1) - Ke^{-rT}N(d2)$$
$$P = Ke^{-rT}N(-d2) - SN(-d1)$$
where
$$d1 = \frac{\ln(\frac{S}{K}) + (r + \frac{\sigma^2}{2})T}{\sigma\sqrt{T}}$$
$$d2 = d1 - \sigma\sqrt{T}$$

Note that *N(.)* denotes the cumulated normal distribution, *C* is the call option price, *P* is the put option price, *S* is the spot price of the underlying asset, *K* is the exercise price, *T* is the remaining time to maturity (in years), σ is the volatility of this underlying asset, and *r* is the risk-less interest rate. This study employs the notation of the B & S parameters, as per Table 3, to perform the BSC analysis.

Table 6 The notation for the B & S option pricing model and its application in the BSC analysis

Notation	Option pricing applications	BSC applications
C	The theoretical call price	The expected return of an index that exceeds the target value
P	The theoretical put price	The expected return of an index that fails to exceed the target value
S	Current value of the underlying asset	Current index value
K	Exercise price of the option contract	The target value that an objective must exceed
Σ	Volatility of the underlying asset	Standard deviation of an index
T	Time to maturity	Time to the next checkpoint
R	Risk-less interest rate	The anticipated growth rate of an index

Traditional ROA approach evaluates each investment as “if this investment’s revenue exceeds the cost discount the risk-less interest rate”. Thus, the *K* value of ROA

is the cost (generally total cost) of the project and the *S* value is the current value of the specific project. This study uses satisfactory index to indicate each objective's performance instead of the revenue measurement and thus the ROA parameters must be modified.

(1) The goal: The goal of an e-learning project is to satisfy all users, the organization members and society anticipations. Because many educational organizations are not profit-oriented, the performance of the e-learning project usually cannot be evaluated by its anticipated revenue. For this reason, this study uses "satisfactory" to indicate the project's performance. Each objective is evaluated by the satisfactory degree of users, organization members or decision makers.

(2) *K* value: ROA approach uses the project's cost as the *K* value (exercise value). This study uses the target value that an objective must exceed as the *K* value. ROA approach is to verify if a project's revenue can exceed its cost, however most of the e-learning objectives cannot be valued as revenue and cost. This study supposes that if an objective can exceed its target value (desired satisfactory degree) then this objective is successful. Thus, the *K* value in the proposed framework represents the objective target value.

(3) *S* value: ROA approach uses the present value of future cash flows from the asset (project) as the *S* value. Because the "value" is measured by "satisfactory", the *S* value in this proposed framework is the current satisfactory value (index value). In another words, ROA is used to estimate if the project's cash flow (*S*)

exceeds its cost (*K*) while this study uses option price to evaluate if the objective's satisfactory degree (*S*) exceeds the organization's target (*K*).

(4) *T* value: ROA treats the *T* value as length of time option is viable. This study uses the project's dead line as its *T* value. The dead line can be a checkpoint between different developing phases or just the annual checkpoint of a persistent e-learning project.

(5) σ value: This study sets the σ value as the volatility (or standard deviation) of the objective's satisfactory score. The evaluation process must be performed periodically to keep the σ value unbiased.

(6) *r* value: This study treats the *r* value as the anticipated annual growth rate of the specific objective. Generally, the *r* value must be set to zero to keep a neutral opinion. However, the *r* can be set as a negative value to indicate the anticipated decrease of a certain objective. For example, the satisfactory degree of a computer class room will decrease because there are always newer and faster computers emerged every month.

(7) *C* and *P* value: Traditionally, the call value *C* in an ROA analysis represents the projects expected revenue and the put value *P* represents the projects expected loss. This study measure each objective with its satisfactory degree, thus the call value *C* indicate the expected value that an objective exceeds its target and the put value *P* represents the expected value that an objective fails to exceed its target.

4.3.2. Designing a BSC sheet and applying the Black & Scholes model

In order to apply the B & S model associated with the BSC for evaluating the e-learning performance, the BSC index must be properly designed so that it can provide meaningful analytical information and satisfy the B & S assumptions. In order to provide a better analytical procedure, this study proposes a BSC analyzing sheet structure listed in Table 7.

Table 7 The BSC analyzing sheet

Objective Score	**Expected Growth Rate**	**Volatility**	**Previous Measure**	**Current Measure**	**Target Value**	**Objective Weight**	**Objective Index**	**Fail Index**	**Success Value**
(X)	***(r_I)***	***(σ_I)***	***(P_I)***	***(S_I)***	***(K_I)***	***(W_I)***	***(G_I)***	***(Z_I)***	***(V_I)***
Reaction (Customer, ex. students, trainees) Perspective weight: PW_C Perspective Index: PI_C *Perspective Fail Index:* PZ_C *Perspective Success Value:* PV_C									
C_1	r_{C1}	σ_{C1}	P_{C1}	S_{C1}	K_{C1}	W_{C1}	G_{C1}	Z_{C1}	V_{C1}
...	...	...	...	...	...	...	...	...	...
C_{n1}	r_{Cn1}	σ_{Cn1}	P_{Cn1}	S_{Cn1}	K_{Cn1}	W_{Cn1}	G_{Cn1}	Z_{Cn1}	V_{Cn1}
Learning and Growth (Learning and Growth) Perspective weight: PW_L Perspective Index: PI_L *Perspective Fail Index:* PZ_L *Perspective Success Value:* PV_L									
L_1	r_{L1}	σ_{L1}	P_{L1}	S_{L1}	K_{L1}	W_{L1}	G_{L1}	Z_{L1}	V_{L1}
...	...	...	...	...	...	...	...	...	...
L_{n2}	r_{Ln2}	σ_{Ln2}	P_{Ln2}	S_{Ln2}	K_{Ln2}	W_{Ln2}	G_{Ln2}	Z_{Ln2}	V_{Ln2}
Behavior (Internal Business Processes) Perspective weight: PW_I Perspective Index: PI_I *Perspective Fail Index:* PZ_I *Perspective Success Value:* PV_I									
I_1.	r_{I1}	σ_{I1}	P_{I1}	S_{I1}	K_{I1}	W_{I1}	G_{I1}	Z_{I1}	V_{I1}
...	...	...	...	...	...	...	...	...	...
I_{n3}	r_{In3}	σ_{In3}	P_{In3}	S_{In3}	K_{In3}	W_{In3}	G_{In3}	Z_{In3}	V_{In3}
Value (Finance, Results) Perspective weight: PW_F Perspective Index: PI_F *Perspective Fail Index:* PZ_F *Perspective Success Value:* PV_F									
F_1	r_{F1}	σ_{F1}	P_{F1}	S_{F1}	K_{F1}	W_{F1}	G_{F1}	Z_{F1}	V_{F1}
...	...	...	...	...	...	...	...	...	...
F_{n4}	r_{Fn4}	σ_{Fn4}	P_{Fn4}	S_{Fn4}	K_{Fn4}	W_{Fn4}	G_{Fn4}	Z_{Fn4}	V_{Fn4}

The proposed BSC analyzing sheet contains four perspectives, and each perspective consists of several objectives. The individual objective is measured periodically to estimate its score of satisfactory. The scores are then transferred into a measure to indicate its relative current value as the objective's satisfactory index. The standard deviation of a certain objective measure is called volatility. An analyst can assign the expected growth rate of each perspective by forecasting or simply by setting the expected growth rate to zero to indicate his neutral perspective. Each measure of a certain objective has its target value to be achieved after *T* years indicating the feasible performance (satisfactory degree) requirement.

Different weighting values for different BSC objectives are assigned to indicate the importance of each objective while keeping the sum of all weighting values equal to 1. If we add or remove any objective we must readjust the sum of the existing weighting values to 1. This rule assures that the BSC index follows the B & S assumption that the underlying asset does not pay any dividend and makes no distributions.

$$\sum_{i=1}^{n1} W_{Ci} = \sum_{i=1}^{n2} W_{Li} = \sum_{i=1}^{n3} W_{Ii} = \sum_{i=1}^{n4} W_{Fi} = 1 \quad \text{and} \quad PW_c + PW_L + PW_I + PW_F = 1$$

Each objective is measured in relative value compared to the last measuring point. For example, the proper measurement will be *"I am more satisfied with our e-learning system compared to last month: score 0 to 4"* rather than *"I am satisfied with our e-learning system: score 0 to 4"*. This measuring method allows an index to vary from 0

to infinity like stock indexes. If the index value is fixed in a certain range, then that index will not follow a lognormal distribution returns.

The B & S model is applied to obtain the expected value that an index exceeds its predefined target value under uncertainties as indicated in Figure 6.

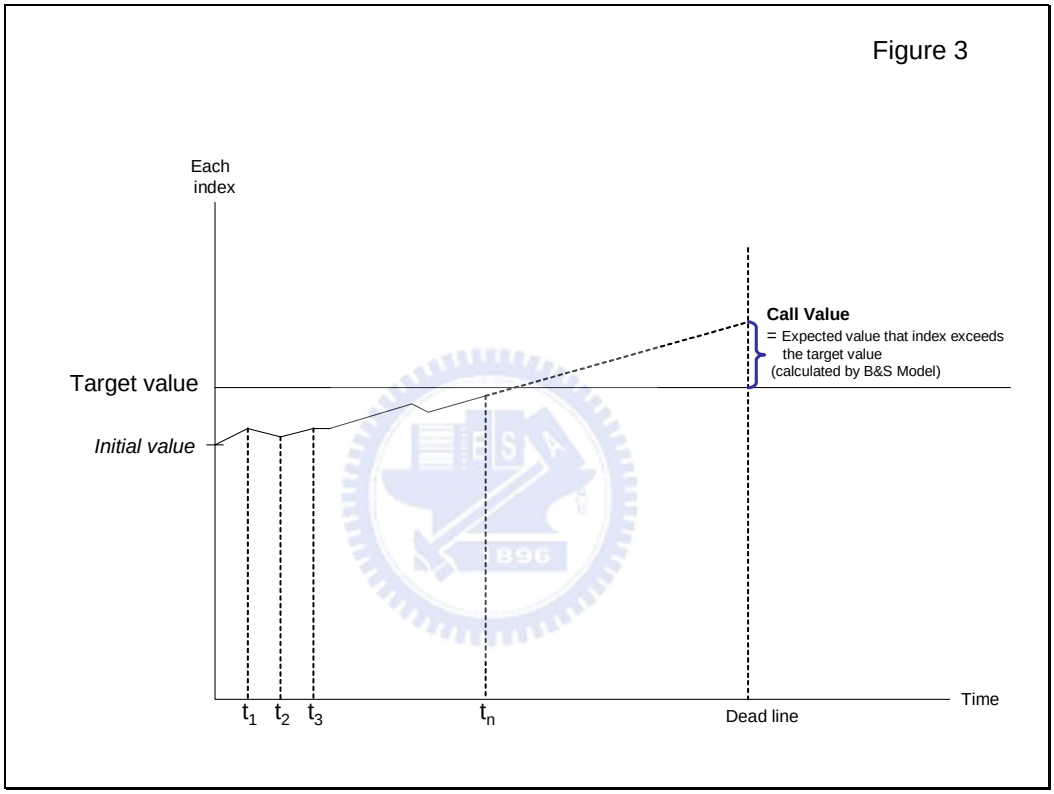


Figure 6 The call value obtained by B & S model represents the expected value of an index exceeds its target value.

The BSC index calculation steps are as follows:

Step 1. **Planning**: An organization must first identify its e-learning environment development goal and then identify the major perspectives to achieve the goal. Note that the perspective does not be limited to use the original BSC perspectives. The organization must carefully define its own perspectives according to the project's needs.

Then, the organization has to determine the objectives and goals for each perspective in the BSC sheet and identify the investigating method (data collecting or questionnaire investigation) of each objective and configure the weighting factors for indicating the importance of each perspective $\{P_{WC}, P_{WL}, P_{WI}, P_{WF}\}$ and objectives $\{W_{C1},..,W_{Cn1}\}$, $\{W_{L1},..,W_{Ln2}\}$, $\{W_{I1},..,W_{In3}\}$, $\{W_{F1},..,W_{Fn4}\}$. Based on the measurement method chosen by the organization (as mentioned in step 2 and step 3), then individually set the target values for each objective $\{K_{C1},..,K_{Cn1}\}$, $\{K_{L1},..,K_{Ln2}\}$, $\{K_{I1},..,K_{In3}\}$, $\{K_{F1},..,K_{Fn4}\}$ and the expected annual growth rate for each objective $\{r_{C1},..,r_{Cn1}\}$, $\{r_{L1},..,r_{Ln2}\}$, $\{r_{I1},..,r_{In3}\}$, $\{r_{F1},..,r_{Fn4}\}$. The growth rate can be greater (increase) or less (decrease) or equal (neutral) to zero.

- Determine the goal of the e-learning project: An organization must first identify its e-learning project's goal and perspectives and sketch the strategy maps in order to achieve the goal. This study suggests the use (but not limited) of four perspectives as Reaction, Learning, Behavior and Value. According to the strategy map, the organization can thus identify the objectives that each perspective must achieve (or be evaluated).

- Determine the perspective weights: The perspective weights can be first determined by the consumed resource (or cost) of each perspective before the deadline. For a small organization, the analyst can simply apply the budget value relate to each perspective and then adjust the weights according to the organization's needs to perform fast analysis. For a larger organization, the analyst or the decision maker can use the percentage of each perspective's total cost of

ownership (TCO) as the initial perspective weight then adjust the weights according to the organization's goals. For example, if the organization's e-learning project goal is to increase its reputations, the analyst can then increase the Value perspective weights. Note that the perspective weights can also be determined by the organization's goal and missions to the e-learning project because of the nature of "none-profit" characteristics of the specific project.

- Determine the objective weights: The analyst can initially determine the weight of each objective by its percentage of consumed resource (budget or TCO) to the perspective. Then, the analyst can individually adjust each objective's weight according to the organization's needs. If the TCO of each objective is difficult to be measured, the analyst can also give equal weighting value to each objective and then make minor adjustments. The objective weights can also be subjectively determined by the organization when identifying the individual objectives according to the organization's needs and goals. In this case, the objective weights are initially equal weighted and then be individually increased or decreased by the decision makers.

- Determine the expected annual growth rate: It is better to apply neutral perspective to the growth rate terms except the objective score can be properly forecasted. For example, if the organization plans to increase 10% employees in one year then the anticipated growth rate of e-learning users is 10%, then the growth rate can be set to 10% in order to reflect the forecasted values.

Step 2. **Obtain objective scores**: Issues questionnaires to e-learning users and IT staff members to collect intangible objectives information. In this study, the score is ranked as 0 (strongly disagree), 1 (disagree), 2 (neutral), 3 (agree) and 4 (strongly agree) to indicate the performance variation from the last checkpoint. Note that this study uses the term "agree" instead of "satisfied" in the questionnaires. All questions must be designed so that the higher score indicates the higher performance. Then, collect data to evaluate the tangible (quantitative able) objectives. All quantitative values are then compare to the last checkpoint and transform the performance into 0 to 4 scores for each objective so as to indicate the performance from strongly decreased (score = 0) to strongly increased (score = 4). The measurements of each objective must be properly designed that greater score indicates better performance to ensure all objectives are measured in the same guideline in order to avoid measurement conflictions. The questionnaires should be periodically issued to provide constant sampling rate in order to obtain unbiased volatilities.

Step 3. **Calculate the current measures**: In this study, the current measure is calculated with the following formula:

$$S_{\Gamma} = P_{\Gamma}(0.95 + X \times 0.025) \tag{4.1}$$

where $\Gamma \in \{C_1,..C_{n1}, L_1,..L_{n2}, I_1,..I_{n3}, F_1,..F_{n4}\}$

and $X \in \{C_1,..C_{n1},L_1,..L_{n2},I_1,..I_{n3},F_1,..F_{n4}\}$

This formula indicates that the current measure will be 95% of the previous measure if the score is zero; the current measure will be 105% of the previous measure if the score is 4. The 5% variance is subjectively set by this study in order that an analyzer may change this value according to his/her needs. Meanwhile, the current measure is derived from the previous measure that assures the objective measure varies in a form of X_{i+1}/X_i to emulate the underlying asset's price variation in the real world. This study assumes that if $ln(X_{i+1}/X_i)$ follows a normal distribution then X will follow a lognormal distribution as B&S model suggests. For the first time issuing of the BSC, we subjectively set $P_\Gamma = 10$ as its initial value. This situation is similar to a stock with par value equal to 10 and the daily price variation limit equal to 5% in that stock market. Note that the initial value (10.0 in this study) will not influence the final results. However, the variation limit (5% in this study) may cause some measurement impacts. This study suggests the variation limit should meet the anticipated payoff rate (or performance increasing rate) of the organization. For example, this study assumes that the organization will feel strongly satisfied if their e-learning performance increasing rate is greater than 5% for each month. Meanwhile, applying different variation limit for each objective is also reasonable. If a certain objective is particularly stable without too much variation, this objective can be applied with larger variation limit to amplify its variation effect. For example, if 99% of the learners are already extremely satisfied with the e-learning environment then the objective score will be stable because most learners will not likely feel "more" satisfied with current e-learning systems no matter what improvement will be made. In this case, any minor objective score increase will be

difficult so that this objective should be applied with larger variation limit (for example 10%) to amplify its contributions and difficulties.

After calculating the current measures, the volatility can be derived as a standard deviation in nature log *ln(.)* from its previous measures. If we assume that the future volatility behaves like its previous *n* measures (implies a constant volatility), then the periodically standard deviation can be calculated:

$$\sigma_{\Gamma}' = Std(P_{\Gamma,t}, P_{\Gamma,t-1}, ...P_{\Gamma,t-n}) \tag{4.2}$$

where *Std(.)* denotes the standard deviation function.

Suppose the BSC is periodically measured every *t* days, then the annual volatility will be:

$$\sigma_{\Gamma} = \sqrt{\frac{365 \times (\sigma_{\Gamma}')^2}{t}} \tag{4.3}$$

- Determine the objective's target value: The objective targets are determined by the satisfactory degree of the organization. The original BSC framework determines each objective target in a quantified measurement like "effective user number must exceed 2,000" or "effective online materials must exceed 1,000" at the deadline. However, the quantified measurement can also be represented as the degree of satisfactory.

  A typical ROA assumes that the revenue of an investment must exceed its cost (*K* value). However, the ROA approach lacks the capability to describe the "satisfactory" degree. This study suggests that the revenue of an ideal investment

must exceed its cost to avoid the loss and also create "satisfied" profits. Thus, this study redefined the basic ROA hypothesis that a successful objective must exceed its target value (*K* value) and create satisfied results.

Suppose an objective has an initial value v_0, a success value v_1 and a strongly satisfied value v_2. Thus, the objective must keep its increment rate larger than slope m_1 to avoid fails while the increment rate larger or equal to slope m_2 will be strongly satisfied as illustrated in Figure 7. In order to be consistent with the scale used in the questionnaire, a "strongly satisfied" level equals to 4 points and a "neutral" level equals to 2 points.

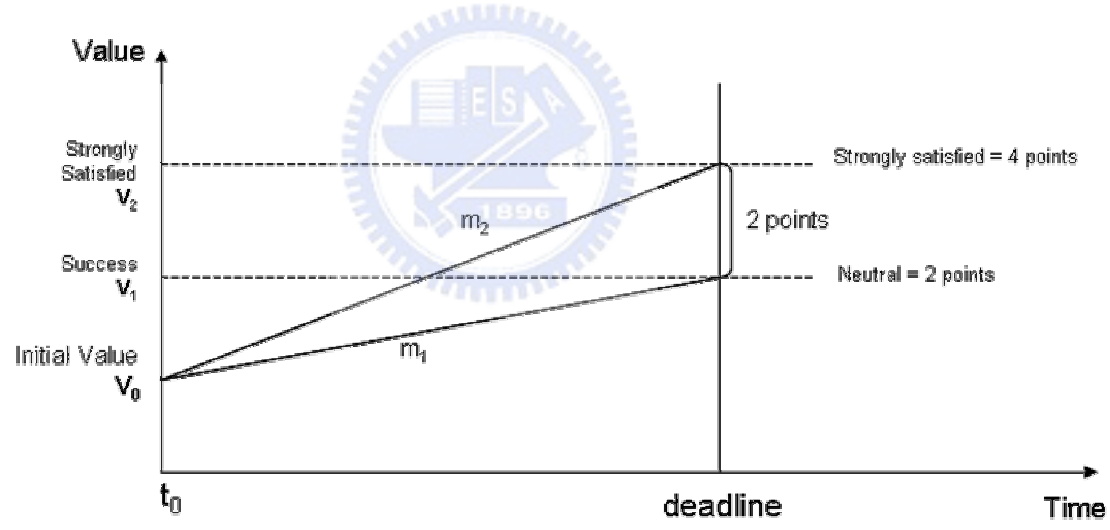


Figure 7 The relationship between success and strongly satisfied values.

For a quantitative objective, the objective score can be measured as (with continuous compound interest rate method):

$$m_1 = e^{\frac{\ln(\frac{v_1}{v_0})}{cp}}$$

$$m_2 = e^{\frac{\ln(\frac{v_2}{v_0})}{cp}}$$

$$score = 2 + \frac{cv - m_1}{(m_2 - m_1)/2}$$

where *cv* indicates the current incremental rate, *cp* indicates the checkpoint counts.

For a qualitative objective, the objective score can be measured as (with average incremental rate because the "satisfactory" cannot be treated as continuous compound interest rate):

$$m_1 = \frac{3 \times ct + 4 \times cs + 2(cp - ct - cs)}{cp}$$

$$m_2 = 4$$

$$score = 2 + \frac{cv - m_1}{(m_2 - m_1)/2}$$

where the objective's success point is measured as "at least *ct* satisfy counts and *cs* strongly satisfy counts cumulated" before deadline. Because the performance is evaluated by its slope (incremental rate), the target value *K* equals to the objective's initial value.

Example 1. Quantitative objective: transfer the target "effective user number must exceed 2,000" into the satisfactory measurement.

The success condition of "user number" is "must exceed 2,000" indicates that this objective is failed if the final user number less than 2000, however if the "user number" exceeds 2,200 the organization will be strongly satisfied. Suppose that there are 6 months before the deadline and the user number is 1,400 at last month. The satisfactory investigation is regularly performed each month and the current user number is 1,491 at this month.

The user number has to be increased 6.12% ($e^{\frac{\ln(2000/1400)}{6}}$ =1.0612 = 6.12% increment) each month. However, if the user number increased 7.82% ($e^{\frac{\ln(2200/1400)}{6}}$ =7.82% increment) the result will be strongly satisfied.

The current user increment rate is (1491-1400)/1400 = 6.5%, thus the objective score is (0.065 - 0.0612)/((0.0782-0.0612)/2) + 2 = 2.44

Note that if the user increment rate is 6.12% then the satisfactory is "neutral" because it can merely hit the success point if anything unchanged. If the user increment rate larger than 7.82% than the objective is "strongly satisfied" this month.

This study suggests that the target value of each quantitative/qualitative objective equals to its initial value and uses increment rate (the slope) to indicate its performance.

Example 2: Transfer the score of a quantitative objective into its objective measure.

Continued by Example 1, suppose the initial value of this objective is 10, and a strongly satisfy (agree) will increase its index value by 5%. Applying formula (4.1) the objective measure is 10 * (0.95 + 2.44 * 0.025) = 10.11 this month.

For the qualitative objectives, the target value *K* can be equalled to its initial value because objective index less than its initial value directly indicate the dissatisfactory of the users or organization members. Then, the decision maker can setup the objective's success condition by the counts of cumulated "agreed" (or satisfied) scores that must be achieved.

Example 3, obtain a qualitative objective's score.

Suppose that the time to deadline is 6 month as in Example 1. Consider the objective *"do you feel more satisfied about our e-learning system compared to last month?"* The organization setups the success point as "there must be at least three cumulated counts of an *agree* score achieved before the deadline"

Note that neutral = 2 points, agree/satisfied = 3 points and strongly agree/satisfied = 4 points. According to the objective's success point, the cumulated score should be larger than (3 points) * (agree counts) + (2 points) * (remaining counts) = 3 * 3 + (6 – 3) * 2 = 15 points. Thus, the monthly objective score must be larger than 15/6 = 2.5 to exceed the target value.

Suppose that the questionnaire obtained this month indicates that the above objective's questionnaire score is 2.8 points. Thus, the score of this objective = 2 + (2.8 – 2.5)/((4 – 2.5)/2) = 2.4

Step 4. **Apply the B & S model to obtain the Call and Put values of each objective**: In this study an objective index is defined as a value that indicates that the expected gain for each objective exceeds its target value after *T* years. An objective fail index is defined as the expected value that an objective fails to exceed its success condition.

$$\begin{cases} G_\Gamma = [S_\Gamma N(d1) - K_\Gamma e^{-r_\Gamma T} N(d2)] \times W_\Gamma \\ Z_\Gamma = [K_\Gamma e^{-r_\Gamma T} N(-d2) - S_\Gamma N(-d1)] \times W_\Gamma \end{cases} \tag{4.4}$$

where

$$d1 = \frac{\ln(\frac{S_\Gamma}{K_\Gamma}) + (r_\Gamma + \frac{\sigma_\Gamma^{\,2}}{2})T}{\sigma_\Gamma \sqrt{T}} \tag{4.5}$$

$$d2 = d1 - \sigma_\Gamma \sqrt{T} \tag{4.6}$$

Comparing the expected success and fail values can provide the objective's success index. In order to provide a meaningful value, this study uses logarithm value that positive means success and negative means fail:

$$V_\Gamma = \ln(\frac{G_\Gamma}{Z_\Gamma}) \tag{4.7}$$

Although many applications only apply call values, put values are also equally important. The call value is the expected value that an objective exceeds the target value. Thus, call values can be applied to justify if the e-learning performance can exceeds the predefined target. Meanwhile, put values can also be applied to justify if the e-learning performance will fail to exceed the targets. Compare the put and call values, a manager can more informatively determine the e-learning performance under uncertainties. For

the analytical purpose, applying option analysis for put values can also help the manager to address the most critical objectives that may lead the e-learning project to fail. Consequently, a manager can apply call values analysis to address the key successful objectives while using put values analysis to determine the key failure points.

Step 5. **Calculate the BSC index value**: The perspective index value indicates the total performance summarized from its objective indexes:

$$PI_C = PW_C \times \sum_{i=1}^{n1} G_{Ci} \quad , \quad PI_L = PW_L \times \sum_{i=1}^{n2} G_{Li} \quad , \quad PI_I = PW_I \times \sum_{i=1}^{n3} G_{Ii} \quad ,$$

$$PI_F = PW_F \times \sum_{i=1}^{n4} G_{Fi} \tag{4.8}$$

The perspective fail index indicates the expected fail value that the entire perspective fails, which can be summarized from its objective indexes:

$$PZ_C = PW_C \times \sum_{i=1}^{n1} Z_{Ci} \quad , \quad PZ_L = PW_L \times \sum_{i=1}^{n2} Z_{Li} \quad , \quad PZ_I = PW_I \times \sum_{i=1}^{n3} Z_{Ii} \quad ,$$

$$PZ_F = PW_F \times \sum_{i=1}^{n4} Z_{Fi} \tag{4.9}$$

Similarly, the perspective's success can be calculated as:

$$PV_C = \ln(\frac{PI_C}{PZ_C}), PV_L = \ln(\frac{PI_L}{PZ_L}), PV_I = \ln(\frac{PI_I}{PZ_I}), PV_F = \ln(\frac{PI_F}{PZ_F}) \tag{4.10}$$

The BSC index value can be summarized from four perspective indexes:

$$BSC\ index = PI_C + PI_L + PI_I + PI_F \tag{4.11}$$

Also, the BSC fail index value can be summarized from four perspective's fail indexes:

$$BSC\ Fail\ Index = PZ_C + PZ_L + PZ_I + PZ_F \quad (4.12)$$

And the BSC success value can be calculated as:

$$BSC\ Success\ Value = ln(BSC\ index/BSC\ Fail\ Index) \quad (4.13)$$

The BSC index indicates that the total weighted expected value of the e-learning system performance exceeds its goal after *T* years (illustrated in Figure 8). However, the most important index is the "success value" which can directly represent the project's condition by "success = larger positive numbers" and "fail = larger negative numbers". The analyst can also apply similar formula to calculate a BSC fail index by replacing call value with its paired put value. If the put values are issued, then the BSC fail index can be compared to BSC index to verify the strength of success and fail possibilities. For example, if the BSC index is 0.5 and the BSC fail index is 0.3 then the analyst can be aware that it is likely the e-learning performance will exceed the predefined target but he also understand that it still has the possibility of 37.5% (0.3/(0.3+0.5)) to fail if everything keeps unchanged. However, by using the "success value" as ln(0.5/0.3)=0.51, the decision maker can quickly understands that the project is fine because it gets a positive number.

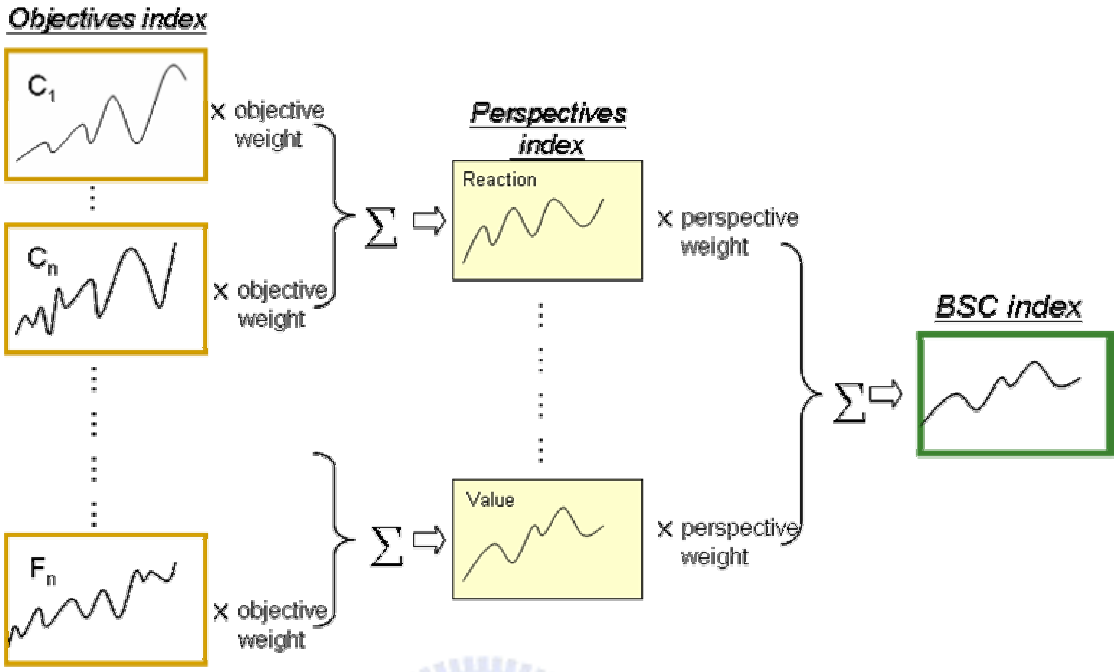


Figure 8 The BSC index is summarized from perspectives indexes and objective indexes.

A BSC index is merely a usefulness value if the manager can not perform a meaningful analysis. Therefore we use the B & S model to calculate the expected value of the BSC index to verify that the performance of e-learning under the current condition can exceed the target goals. Furthermore, being derived from the B & S model, this BSC index can be analyzed by general option analysis methodologies. For example, applying a sensitivity analysis can determine which objective can yield the most significant performance gains (with call values) and which objective can yield the most significant performance loss (with put values). The analytical process will be introduced in Section 5.

5 CASE STUDY

This section presents a simplified case study to demonstrate the BSC index with the B & S model analysis process. The original data was collected from a business college at 1/2/2006, 3/3/2006 and 3/4/2006 by issuing questionnaires to students to investigate the satisfactory degree of each BSC objective. The students were randomly selected in each test with grade 2, 3 and few grade 4 students. All of the sampled students are familiar with Internet applications. The first test is collected from 56% male and 44% female students; the second test is made by 6% male and 94% female students; the third test consists 71% male and 29% female students.

The objective counts of {Reaction, Learning, Behavior, Value} perspectives are {9, 12, 8, 9}. The major task of this BSC index is to analyze the current e-learning project's performance and to explore if the performance can exceed the predefined target value at 1/1/2007.

The major objective of this case study is to demonstrate the analytical procedure of the proposed framework to evaluate an e-learning project's performance. The test results may be influenced by the following factors:

- Development strategies of the e-learning project
- Representatives of questionnaire attendants
- Test frequency
- Number of attendants

The proposed framework is to motivate the managers to enhance the e-learning project performance by observing each objectives scores and expected success/fail values. The test frequency can be modified to obtain more real-time information. For example, the test frequency can be changed from monthly into weekly or daily intervals by web-based online questionnaire systems in order to provide more real-time performance information.

5.1. Calculating the BSC index

The BSC index is obtained through the following steps:

Step 1. Planning

The goal of the e-learning system to the investigated organization is to enhance the teaching effectiveness and increase the general reputations to the society. The four perspectives are Reaction, Learning, Behavior and Value. The perspective weights are individually determined by the decision maker in order to represent their importance, for example, $PW_C=0.25$. In order to achieve the e-learning project's goal, the objectives of each perspective are determined, as for example, C1: "Enjoyment of current e-learning environment". The questionnaire evaluated this objective as "Do you feel more satisfied about our e-learning environment compared to last month? [□Strongly Disagree □Disagree □Neutral □Agree □Strongly Agree]". According to the previous investigations, it is difficult to successively obtain "satisfied" (questionnaire score larger than 3.0) every month. This study objectively setup the success point of C1 is "at least 3 cumulated satisfied score must be achieved".

After determining the objectives, this study objectively assigned objective weights to each objective for illustration, for example, $W_{C1}=0.09$. Note that the objective weights should be determined according to the e-learning project's mission and goals. In order to keep a neutral perspective, the anticipated growth rate r_I are set to zero. The initial value and K value of each objective are set to 10.

Step 2. Obtain objectives scores

With the questionnaire collected at 3/4/2006, this study set Strongly Disagree = 0, Disagree = 1, Neutral = 2, Agree = 3 and Strongly Agree = 4 to score each question. The questionnaires were then issued to randomly selected students and staff members. All questionnaires were summarized with Microsoft Excel to determine the mean value of each objective. For example, the objective score of C1 is the mean value of question C1 collected from the questionnaires. As a result, the questionnaire score of C_1 equals to 2.26 in the investigation performed at 3/4/2006. Based on the success point "at least 3 cumulated satisfied score must be achieved", the objective score of C1 can be thus calculated as illustrated in Example 3. The objective score of C1 is 1.94.

Step 3. Calculate current measures

The current measures were calculated in this step. For example, the previous measure of C1 collected at 1/2/2006 and 3/3/2006 is 10.08 and 10.12, the current measure of C1 is $S_{C1}= 10.12(0.95+1.94*0.025) = 10.11$. The volatility of C1 can thus be calculated as $\sigma_{C1}'=Std(10.08,\ 10.12,\ 10.11)= 0.0208$. Because we collect the questionnaires every 30 days (t = 30), thus, $\sigma_{C1} = \sqrt{\frac{365 \times (0.0208)^2}{30}} = 0.0727$

Step 4. Apply B & S formula

Because the decision maker want to explore if the performance can exceed the organization's goals at 1/1/2007, the time to maturity can be calculated as $T = (1/1/2007 – 3/4/2006)/365 = 0.75$ years. The objective index of C1 can be calculated by the B & S formula with parameters $(S, K, \sigma, T, r) = (S_{C1}, K_{C1}, \sigma_{C1}, T, r_{C1}) = (10.11, 10.0, 0.0727, 0.75, 0)$. Applying the B & S formula, (4.5) $d1 = 0.1977$ and (4.6) $d2 = 0.1347$, thus $G_{C1} = 0.3086 * 0.09 = 0.0278$ by (4.4).

Step 5. Calculate the BSC index value

The BSC sheet can be completed by applying (4.11) with objective measures and its objective weight as shown in Table 5. For example, the perspective index of Reaction is $(G_{C1} + G_{C2} + ... + G_{C9}) = (0.0278 + 0.0838 + ... + 0.0467) = 0.5511$. The perspective fail index of Reaction is $(Z_{C1} + Z_{C2} + ... + Z_{C9}) = (0.0183 + 0.0822 + .. + 0.0487) = 0.5711$ and the perspective success value equals $ln(0.5511/0.5711) = -0.0356$.

Table 8 The completed BSC analyzing sheet.

Objective	Objective Score (X)	Expected Growth Rate (r_I)	Volatility (σ_I)	Previous Measure (P_I)	Current Measure (S_I)	Target Value (K_I)	Objective Weight (W_I)	Objective Index (G_I)	Fail Index (Z_I)	Success Value (V_I)
Reaction (Customer, ex. students, trainee)										
Perspective weight: 0.25										
Perspective Index: 0.5511, Perspective Fail Index: 0.5711, Perspective Success Value: -0.0356										
C1:Increase the enjoyment-of-use of e-learning environment	*1.95*	*0*	0.0727	*10.12*	*10.11*	*10.00*	*0.09*	*0.0278*	*0.0183*	*0.4169*
C2:Provide friendly user interface, style and functionality	*1.61*	*0*	0.1716	*10.11*	*10.01*	*10.00*	*0.14*	*0.0838*	*0.0822*	*0.0187*
C3:Enhance organizational collaboration capability	*1.78*	*0*	0.1270	*10.15*	*10.10*	*10.00*	*0.08*	*0.0394*	*0.0314*	*0.2259*
C4:Improve the communication between trainees and trainers	*1.75*	*0*	0.1239	*10.11*	*10.05*	*10.00*	*0.13*	*0.0587*	*0.0529*	*0.1050*
C5:Increase user satisfaction	*1.61*	*0*	0.2229	*10.01*	*9.91*	*10.00*	*0.12*	*0.0866*	*0.0973*	*-0.1169*
C6:Increase the flexibility of learning time arrangement	*1.58*	*0*	0.1857	*10.04*	*9.94*	*10.00*	*0.12*	*0.0730*	*0.0804*	*-0.0961*
C7:Provide abundant linkage to related learning materials	*1.61*	*0*	0.2002	*9.99*	*9.89*	*10.00*	*0.09*	*0.0571*	*0.0668*	*-0.1566*
C8:Provide sufficient example and case studies	*1.58*	*0*	0.2075	*9.98*	*9.87*	*10.00*	*0.12*	*0.0781*	*0.0931*	*-0.1758*
C9:Provide vivid illustrations of rich multimedia materials	*1.71*	*0*	0.1256	*10.05*	*9.98*	*10.00*	*0.11*	*0.0467*	*0.0487*	*-0.0426*
Learning and Growth (Learning and Growth)										
Perspective weight: *0.27*										
Perspective Index: 0.5226, Perspective Fail Index: 0.4962, Perspective Success Value: 0.0519										
L1:Continuously improve knowledge by e-learning systems	*1.92*	*0*	0.1042	*10.08*	*10.06*	*10.00*	*0.025*	*0.0098*	*0.0083*	*0.1658*

L2:Ensure consistent support by organization for e-learning project	*2.15*	*0*	0.2944	*10.13*	*10.17*	*10.00*	*0.1*	*0.1107*	*0.0942*	*0.1615*
L3:Enhance the innovation and seniority capability of all organization members	*1.92*	*0*	0.0556	*10.03*	*10.01*	*10.00*	*0.1*	*0.0199*	*0.0185*	*0.0721*
L4:Improve IT capability of all members	*2.25*	*0*	0.2979	*10.15*	*10.21*	*10.00*	*0.05*	*0.0573*	*0.0468*	*0.2021*
L5:Improve professional skills of all members	*1.88*	*0*	0.1363	*10.11*	*10.08*	*10.00*	*0.025*	*0.0128*	*0.0108*	*0.1672*
L6:Enhance personalization learning capabilities	*1.82*	*0*	0.0973	*10.09*	*10.04*	*10.00*	*0.025*	*0.0090*	*0.0079*	*0.1296*
L7:Ensure logical sequence among learning materials	*1.68*	*0*	0.1412	*10.06*	*9.98*	*10.00*	*0.15*	*0.0718*	*0.0744*	*-0.0364*
L8:Ensure learners realize the learning subjects	*1.95*	*0*	0.0724	*10.08*	*10.07*	*10.00*	*0.15*	*0.0430*	*0.0328*	*0.2722*
L9:Increase knowledge comprehension	*1.95*	*0*	0.0388	*10.06*	*10.05*	*10.00*	*0.005*	*0.0008*	*0.0006*	*0.3719*
L10:Increase e-learning system usage frequency	*1.75*	*0*	0.1118	*10.02*	*9.95*	*10.00*	*0.1*	*0.0362*	*0.0409*	*-0.1210*
L11:Increase e-learning system operational familiarities	*1.75*	*0*	0.1121	*10.04*	*9.98*	*10.00*	*0.27*	*0.1018*	*0.1070*	*-0.0495*
L12:Create satisfied learning results	*1.68*	*0*	0.1500	*10.03*	*9.95*	*10.00*	*0.1*	*0.0495*	*0.0540*	*-0.0874*
Behaviour (Internal Business Processes) Perspective weight: *0.24* Perspective Index: 0.9568, Perspective Fail Index: 0.7951, Perspective Success Value: 0.1851										
I1:Provide differentiated e-learning environment	*1.97*	*0*	0.3437	*10.29*	*10.28*	*10.00*	*0.075*	*0.1010*	*0.0797*	*0.2366*
I2:Provide incentive systems for users	*1.76*	*0*	0.2733	*10.22*	*10.16*	*10.00*	*0.2*	*0.2061*	*0.1745*	*0.1662*
I3:Generate healthy organization cultures	*2.24*	*0*	0.3886	*10.24*	*10.30*	*10.00*	*0.15*	*0.2264*	*0.1819*	*0.2189*
I4:Motivate effective learning activities	*1.43*	*0*	0.2708	*10.22*	*10.07*	*10.00*	*0.05*	*0.0487*	*0.0451*	*0.0770*
I5:Improve the role playing capabilities during learning activities	*1.76*	*0*	0.1232	*10.11*	*10.05*	*10.00*	*0.2*	*0.0901*	*0.0806*	*0.1112*
I6:Encourage knowledge sharing between members	*2.24*	*0*	0.1527	*10.11*	*10.17*	*10.00*	*0.1*	*0.0619*	*0.0453*	*0.3129*

I7:Generate better learning behavior change	*1.70*	*0*	0.1361	*10.14*	*10.07*	*10.00*	*0.1*	*0.0506*	*0.0439*	*0.1421*
I8:Provide efficient and effective learning environment	*2.17*	*0*	0.3626	*10.18*	*10.22*	*10.00*	*0.125*	*0.1720*	*0.1441*	*0.1771*
Value (Finance, Results)										
Perspective weight: *0.24*										
Perspective Index: 0.9308, Perspective Fail Index: 0.8208, Perspective Success Value: 0.1259										
F1:Increase organization value	*2.71*	*0*	0.6595	*10.39*	*10.57*	*10.00*	*0.05*	*0.1304*	*0.1019*	*0.2463*
F2:Share knowledge to other organizations	*2.10*	*0*	*0.3082*	*10.31*	*10.34*	*10.00*	*0.125*	*0.1571*	*0.1149*	*0.3125*
F3:Provide high quality knowledge and information platform	*2.37*	*0*	*0.2767*	*10.20*	*10.29*	*10.00*	*0.025*	*0.0280*	*0.0207*	*0.3036*
F4:Raise organization reputations	*2.17*	*0*	*0.1860*	*10.18*	*10.22*	*10.00*	*0.1*	*0.0767*	*0.0543*	*0.3447*
F5:Improve organization's competitiveness	*1.70*	*0*	*0.1828*	*10.18*	*10.10*	*10.00*	*0.2*	*0.1375*	*0.1167*	*0.1640*
F6:Increase knowledge absorption	*1.43*	*0*	*0.2846*	*10.14*	*10.00*	*10.00*	*0.1*	*0.0980*	*0.0981*	*-0.0015*
F7:Increase the number of research achievements	*1.70*	*0*	*0.3139*	*9.98*	*9.90*	*10.00*	*0.1*	*0.1027*	*0.1126*	*-0.0914*
F8:Increase the number of online users	*1.29*	*0*	*0.3156*	*10.11*	*9.93*	*10.00*	*0.1*	*0.1048*	*0.1119*	*-0.0660*
F9:Reduce learning costs	*1.70*	*0*	*0.1339*	*10.11*	*10.03*	*10.00*	*0.2*	*0.0957*	*0.0896*	*0.0658*

Applying (4.8), the BSC index value is *0.5511 * 0.25 + 0.5226 * 0.27 + 0.9568 * 0.24 + 0.9308 * 0.24 = 0.7319*. Similarly, the BSC fail index is *0.5711 * 0.25 + 0.4962 * 0.27 + 0.7951 * 0.24 + 0.8208 * 0.24 = 0.6645* and the BSC success index is *ln(0.7319/0.6645) = 0.0966*. These values indicate that with an initial value of 10, the expected value that the overall e-learning performance exceeds its target value at 1/1/2007 is 0.7319, the expected fail value is 0.6645 and the entire project is nearly neutral to success (slightly success but possibly fail), if everything remains unchanged. According to Table 5, the weakest perspective is Learning & Growth, which obtained the lowest perspective index value (0.5226) while the most dangerous perspective is Reaction because its success value is negative. If the manager wants to keep the e-learning performance balanced, he must inject more efforts to increase the customer (students and trainees) satisfaction.

The E-learning Project Performance Summary Report

Global View

Current Status: 0.0966.

Neutral, but possible to fail

Perspective View

Reaction: *-0.0356*

Current status: Slightly under performance, possible to fail.

Alerting objectives: *C5, C7, C8*

Notice objectives: *C6, C9*

Learning & Growth: *0.0519*

Current status: Neutral, but possible to fail

Alerting objectives: *L10*

Notice objectives: *L7, L11, L12*

Behavior: *0.1851*

Current status: Optimistically above neutral.

Alerting objectives: *None*

Notice objectives: *None*

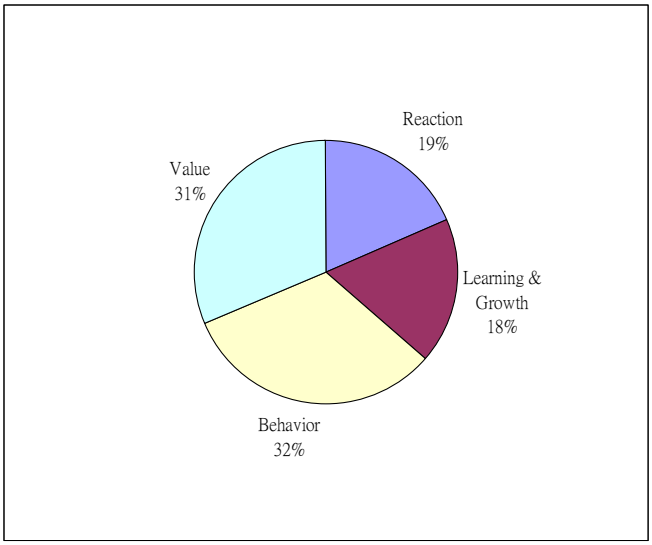
Value: 0.1259

Current status: Above neutral

Alerting objectives: *None*

Notice objectives: *F6, F7, F8*

Overall performance contributions:



Top 10 performers:

Objective	Objective Index	Fail Index	Success Value
C1:Increase the enjoyment-of-use of e-learning environment	*0.0278*	*0.0183*	0.4169
C3:Enhance organizational collaboration capability	*0.0394*	*0.0314*	0.2259
L8:Ensure learners realize the learning subjects	*0.0430*	*0.0328*	0.2722
L9:Increase knowledge comprehension	*0.0008*	*0.0006*	0.3719
I1:Provide differentiated e-learning environment	*0.1010*	*0.0797*	0.2366
I6:Encourage knowledge sharing between members	*0.0619*	*0.0453*	0.3129
F1:Increase organization value	*0.1304*	*0.1019*	0.2463
F2:Share knowledge to other organizations	*0.1571*	*0.1149*	0.3125
F3:Provide high quality knowledge and information platform	*0.0280*	*0.0207*	0.3036
F4:Raise organization reputations	*0.0767*	*0.0543*	0.3447

Last 10 performers:

Objective	Objective Index	Fail Index	Success Value
C8:Provide sufficient example and case studies	*0.0781*	*0.0931*	-0.1758
C7:Provide abundant linkage to related learning materials	*0.0571*	*0.0668*	-0.1566
L10:Increase e-learning system usage frequency	*0.0362*	*0.0409*	-0.1210
C5:Increase user satisfaction	*0.0866*	*0.0973*	-0.1169
C6:Increase the flexibility of learning time arrangement	*0.0730*	*0.0804*	-0.0961
F7:Increase the number of research achievements	*0.1027*	*0.1126*	-0.0914
L12:Create satisfied learning results	*0.0495*	*0.0540*	-0.0874
F8:Increase the number of online users	*0.1048*	*0.1119*	-0.0660
L11:Increase e-learning system operational familiarities	*0.1018*	*0.1070*	-0.0495
C9:Provide vivid illustrations of rich multimedia materials	*0.0467*	*0.0487*	-0.0426

5.2. Option sensitivity analysis

Sensitivity analysis is an analysis process widely adopted by option traders. This analytical process measures how an option price responds to a small change in certain factors. By performing sensitivity analysis, the decision maker can obtain additional information that is valuable for strategy planning and resource relocating.

(1) Delta: Refers to *N(d1)* of the B & S formula. Delta indicates the ratio that the underlying asset's price change will affect its option price. For example, *Delta(Γ)=0.5* means that the call value will increase 0.5 point if S_Γ increases 1 point. This factor can be applied to search the most efficient objective that can improve the BSC index value.

$$Delta = \frac{\partial C}{\partial S} = N(d1) \qquad (5.1)$$

The Delta values listed in Table 6 are multiplied by the objective weight and the perspective weight to indicate the real impact on the final BSC index value. In this case, we found that I2 is the most efficient objective (*Delta(I2)= 0.0401*) to increase the BSC index value.

(2) Gamma: Is used to evaluate the sensitivity of Delta or the acceleration of S_Γ. This factor can be used to determine the potential efficiency of each objective.

$$Gamma = \frac{\partial^2 C}{\partial S^2} = \frac{N'(d1)}{S\sigma\sqrt{T}} \quad \text{where} \quad N'(d1) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}d1^2} \qquad (5.2)$$

In this case L9 (= 1.1665) obtained the largest Gamma value indicates that L9 is the most potential objective to increase the entire e-learning project's performance.

(3) Vega: This factor can be used to evaluate the impact of volatility change to its call price. Vega can help the analyst address the most volatility sensitive objective in the BSC sheet.

$$Vega = \frac{\partial C}{\partial \sigma} = S\sqrt{T}N'(d1) \tag{5.3}$$

The Vega values listed in Table 6 are multiplied by the objective weight and the perspective weight to indicate the real impact on the final BSC index value. In this case, we found that I5 is most sensitive (*Vega(I5) = 0.2418*) to the volatility change in our BSC objectives.

(4) Rho: Is used to evaluate the influence of the risk-less interest rate. It can help the analyst to address the most valuable objective if the anticipated growth rate has changed.

$$Rho = \frac{\partial C}{\partial r} = TKe^{-rT}N(d2) \tag{5.4}$$

(5) Theta: Is used to evaluate the impact between time to maturity and the call price. It can help the analyst to address the most sensitive objective to *T*.

$$Theta = \frac{\partial C}{\partial T} = \frac{\sigma SN'(d1)}{2\sqrt{T}} + rKe^{-rT}N(d2) \tag{5.5}$$

In this case, we multiplied the Theta with the objective and the perspective weights. This study found that I3 is the most sensitive objective (*Theta(I3) = 0.0351*) if the e-learning check point varies from the pre-determined check point 1/1/2007.

Table 9 The option sensitivity analysis sheet

Objective	Objective Weight (W_I)	Objective Index (G_I)	Call	**Delta	Gamma	**Vega	**Rho	**Theta
Reaction (Customer, ex. students, trainee)								
C1:Increase the enjoyment-of-use of e-learning environment	*0.09*	*0.03*	*0.31*	*0.0083*	*0.6148*	*0.0493*	*0.0598*	*0.0018*
C2:Provide friendly user interface, style and functionality	*0.14*	*0.08*	*0.60*	*0.0119*	*0.2672*	*0.0772*	*0.0795*	*0.0066*
C3:Enhance organizational collaboration capability	*0.08*	*0.04*	*0.49*	*0.0071*	*0.3554*	*0.0442*	*0.0493*	*0.0028*
C4:Improve the communication between trainees and trainers	*0.13*	*0.06*	*0.45*	*0.0112*	*0.3683*	*0.0719*	*0.0773*	*0.0045*
C5:Increase user satisfaction	*0.12*	*0.09*	*0.72*	*0.0100*	*0.2083*	*0.0657*	*0.0638*	*0.0073*
C6:Increase the flexibility of learning time arrangement	*0.12*	*0.07*	*0.61*	*0.0099*	*0.2494*	*0.0659*	*0.0652*	*0.0061*
C7:Provide abundant linkage to related learning materials	*0.09*	*0.06*	*0.63*	*0.0073*	*0.2326*	*0.0492*	*0.0476*	*0.0049*
C8:Provide sufficient examle and case studies	*0.12*	*0.08*	*0.65*	*0.0098*	*0.2248*	*0.0655*	*0.0629*	*0.0068*
C9:Provide vivid illustrations of rich multimedia materials	*0.11*	*0.05*	*0.42*	*0.0091*	*0.3672*	*0.0607*	*0.0622*	*0.0038*
Learning and Growth (Learning and Growth)								

L1:Continuously improve knowledge by e-learning systems	*0.025*	*0.0098*	*0.39*	*0.0029*	*0.4369*	*0.0181*	*0.0200*	*0.0009*
L2:Ensure consistent support by organization for e-learning project	*0.1*	*0.1107*	*1.11*	*0.0121*	*0.1512*	*0.0724*	*0.0748*	*0.0107*
L3:Enhance the innovation and seniority capability of all organization members	*0.1*	*0.0199*	*0.20*	*0.0109*	*0.8260*	*0.0726*	*0.0790*	*0.0020*
L4:Improve IT capability of all members	*0.05*	*0.0573*	*1.15*	*0.0061*	*0.1482*	*0.0362*	*0.0378*	*0.0054*
L5:Improve professional skills of all members	*0.025*	*0.0128*	*0.51*	*0.0029*	*0.3327*	*0.0181*	*0.0198*	*0.0012*
L6:Enhance personalization learning capabilities	*0.025*	*0.0090*	*0.36*	*0.0028*	*0.4693*	*0.0181*	*0.0198*	*0.0009*
L7:Ensure logical sequence among learning materials	*0.15*	*0.0718*	*0.48*	*0.0163*	*0.3264*	*0.1085*	*0.1110*	*0.0077*
L8:Ensure learners realize the learning subjects	*0.15*	*0.0430*	*0.29*	*0.0175*	*0.6254*	*0.1085*	*0.1254*	*0.0039*
L9:Increase knowledge comprehension	*0.005*	*0.0008*	*0.16*	*0.0006*	*1.1665*	*0.0036*	*0.0043*	*0.0001*
L10:Increase e-learning system usage frequency	*0.1*	*0.0362*	*0.36*	*0.0105*	*0.4141*	*0.0722*	*0.0727*	*0.0040*
L11:Increase e-learning system operational familiarities	*0.27*	*0.1018*	*0.38*	*0.0290*	*0.4117*	*0.1954*	*0.2011*	*0.0110*
L12:Create satisfied learning results	*0.10*	*0.0495*	*0.49*	*0.0082*	*0.3083*	*0.0550*	*0.0552*	*0.0041*
Behavior (Internal Business Processes)								
I1:Provide differentiated e-learning environment	*0.075*	*0.1010*	*1.35*	*0.0156*	*0.1265*	*0.0906*	*0.0941*	*0.0156*
I2:Provide incentive systems for users	*0.2*	*0.2061*	*1.03*	*0.0401*	*0.1631*	*0.2415*	*0.2516*	*0.0330*
I3:Generate healthy organization cultures	*0.15*	*0.2264*	*1.51*	*0.0315*	*0.1114*	*0.1808*	*0.1841*	*0.0351*
I4:Motivate effective learning activities	*0.05*	*0.0487*	*0.97*	*0.0098*	*0.1671*	*0.0602*	*0.0611*	*0.0082*

I5:Improve the role playing capabilities during learning activities	*0.2*	*0.0901*	*0.45*	*0.0377*	*0.3703*	*0.2418*	*0.2606*	*0.0149*
I6:Encourage knowledge sharing between members	*0.1*	*0.0619*	*0.62*	*0.0201*	*0.2914*	*0.1207*	*0.1374*	*0.0092*
I7:Generate better learning behavior change	*0.1*	*0.0506*	*0.51*	*0.0191*	*0.3340*	*0.1209*	*0.1310*	*0.0082*
I8:Provide efficient and effective learning environment	*0.125*	*0.1720*	*1.38*	*0.0258*	*0.1211*	*0.1506*	*0.1527*	*0.0273*
Values (Finance, Results)								
F1:Increase organization value	*0.05*	*0.1304*	*2.61*	*0.0091*	*0.0614*	*0.0475*	*0.0446*	*0.0157*
F2:Share knowledge to other organizations	*0.125*	*0.1571*	*1.26*	*0.0211*	*0.1399*	*0.1209*	*0.1303*	*0.0186*
F3:Provide high quality knowledge and information platform	*0.025*	*0.0280*	*1.12*	*0.0042*	*0.1571*	*0.0242*	*0.0263*	*0.0033*
F4:Raise organization reputations	*0.1*	*0.0767*	*0.77*	*0.0164*	*0.2365*	*0.0966*	*0.1098*	*0.0090*
F5:Improve organization's competitiveness	*0.2*	*0.1375*	*0.69*	*0.0312*	*0.2469*	*0.1935*	*0.2077*	*0.0177*
F6:Increase knowledge absorption	*0.1*	*0.0980*	*0.98*	*0.0154*	*0.1607*	*0.0960*	*0.0947*	*0.0137*
F7:Increase the number of research achievements	*0.1*	*0.1027*	*1.03*	*0.0151*	*0.1475*	*0.0953*	*0.0906*	*0.0150*
F8:Increase the number of online users	*0.1*	*0.1048*	*1.05*	*0.0152*	*0.1461*	*0.0955*	*0.0914*	*0.0151*
F9:Reduce learning costs	*0.2*	*0.0957*	*0.48*	*0.0299*	*0.3418*	*0.1934*	*0.2047*	*0.0129*

(**: multiplied with objective weight and perspective weight)

Using the sensitivity analysis, the decision maker can obtain additional information to determine the most effective objectives, the most potential objectives, the most satisfactory sensitive objectives and the most time sensitive objectives summarized below:

Table 10 Summarized information in sensitivity analysis

View point	Additional information	Most Sensitive Objective
Entire project	Most effective objectives	I2
	Most potential objectives	L9
	Most satisfactory sensitive	I5
	Most time sensitive	I3
Customer perspective	Most effective objectives	C2
	Most potential objectives	C1
	Most satisfactory sensitive	C2
	Most time sensitive	C5
Learning & Growth perspective	Most effective objectives	L11
	Most potential objectives	L9
	Most satisfactory sensitive	L11
	Most time sensitive	L11
Behavior perspective	Most effective objectives	I2
	Most potential objectives	I5
	Most satisfactory sensitive	I5
	Most time sensitive	I3
Value perspective	Most effective objectives	F5
	Most potential objectives	F9
	Most satisfactory sensitive	F5
	Most time sensitive	F8

6 CONCLUSION

This study proposed a framework integrating the BSC and the B & S model to evaluate e-learning performance. The applications of this framework are not limited to the e-learning field. It can be readily adopted to evaluate any BSC-based investigations if the objectives are designed in relative measurement methods. By integrating the B & S model into the BSC analysis, the proposed framework provides a standard set of analysis methodology that has been widely adopted by experienced option traders with great success. The entire framework can be easily implemented by an analyst using popular spreadsheet packages like Microsoft Excel. With the help of an empirical case study, it will be easier to understand the entire evaluation process and realize the analytical benefits of this framework. It will also provide valuable and easy to understand information, such as the weakest objective, the most efficient objective, the most time sensitive objective, and the most volatility sensitive objective.

Future research will focus on: introduction of other financial engineering methodologies to provide more analytical methods in this BSC/B&S framework, and on investigating the possibility of applying this framework to perform investment analysis in e-learning and knowledge management applications. Lasting addition, we are working on fine-tuning the present framework to enhance its analytical capabilities.

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Appendix A. Questionnaire

Note to the respondents: Please answer all the questions as compared to last month.

Example: Please answer "Do you feel more satisfied about our e-learning environment?" the same as "Do you feel more satisfied about our e-learning environment compared to last month?"

Reaction(Customer, ex. students, trainees)					
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C1.Do you feel more satisfied about our e-learning environment?	☐	☐	☐	☐	☐
C2.Do you feel more satisfied about the interface, the style and the functionality of our e-learning environment?	☐	☐	☐	☐	☐
C3.Do you agree that our e-learning environment can enhance organizational collaboration capability?	☐	☐	☐	☐	☐
C4.Do you agree that our e-learning environment can improve the communication between trainees and trainers?	☐	☐	☐	☐	☐
C5. Do you agree that our e-learning environment can increase user satisfaction?	☐	☐	☐	☐	☐
C6. Do you agree that our e-learning environment can increase the flexibility of the learning time arrangement?	☐	☐	☐	☐	☐
C7. Do you agree that our e-learning environment can provide abundant linkage to related learning materials?	☐	☐	☐	☐	☐
C8. Do you agree that our e-learning environment can provide sufficient examples and case studies?	☐	☐	☐	☐	☐

C9. Do you agree that our e-learning environment can provide vivid illustrations of rich multimedia materials?	☐	☐	☐	☐	☐
Learning (Learning and Growth)					
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
L1. Do you agree that our e-learning environment can continuously improve knowledge by means of the e-learning system?	☐	☐	☐	☐	☐
L2. Do you agree that our e-learning environment can ensure consistent support from the organization for the e-learning project?	☐	☐	☐	☐	☐
L3. Do you agree that our e-learning environment can enhance the innovation and seniority capability of all organization members?	☐	☐	☐	☐	☐
L4. Do you agree that our e-learning environment can improve the IT capability of all members?	☐	☐	☐	☐	☐
L5. Do you agree that our e-learning environment can improve the professional skills of all members?	☐	☐	☐	☐	☐
L6. Do you agree that our e-learning environment can enhance personalized learning capabilities?	☐	☐	☐	☐	☐
L7. Do you agree that our e-learning environment can ensure logical sequence among learning materials?	☐	☐	☐	☐	☐
L8. Do you agree that our e-learning environment can ensure learners to realize what the learning subjects are?	☐	☐	☐	☐	☐
L9. Do you agree that our e-learning environment can increase knowledge comprehension?	☐	☐	☐	☐	☐

L10. Do you agree that our e-learning environment can increase the usage frequency of the e-learning system?	☐	☐	☐	☐	☐
L11. Do you agree that our e-learning environment can increase operational familiarity with the e-learning system?	☐	☐	☐	☐	☐
L12. Do you agree that our e-learning environment can create satisfactory learning results?	☐	☐	☐	☐	☐
Behavior(Internal Business Processes)					
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I1. Do you agree that our e-learning environment can provide a differentiated e-learning environment?	☐	☐	☐	☐	☐
I2. Do you agree that our e-learning environment can provide an incentive system for users?	☐	☐	☐	☐	☐
I3. Do you agree that our e-learning environment can generate a nurturing culture in the organization?	☐	☐	☐	☐	☐
I4. Do you agree that our e-learning environment can motivate effective learning activities?	☐	☐	☐	☐	☐
I5. Do you agree that our e-learning environment can improve the role playing capabilities during learning activities?	☐	☐	☐	☐	☐
I6. Do you agree that our e-learning environment can encourage knowledge sharing between members?	☐	☐	☐	☐	☐
I7. Do you agree that our e-learning environment can generate a change towards a better learning behavior?	☐	☐	☐	☐	☐
I8. Do you agree that our e-learning environment can provide an efficient and effective learning environment?	☐	☐	☐	☐	☐
Value (Results, Financial)					

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
F1. Do you agree that our e-learning environment can increase the value of the organization?	☐	☐	☐	☐	☐
F2. Do you agree that our e-learning environment can share knowledge with other organizations?	☐	☐	☐	☐	☐
F3. Do you agree that our e-learning environment can provide high quality knowledge and a good information platform?	☐	☐	☐	☐	☐
F4. Do you agree that our e-learning environment can increase the reputation of the organization?	☐	☐	☐	☐	☐
F5. Do you agree that our e-learning environment can improve the competitiveness of the organization?	☐	☐	☐	☐	☐
F6. Do you agree that our e-learning environment can increase kowledge absorption?	☐	☐	☐	☐	☐
F7. Do you agree that our e-learning environment can increase the number of research achievements?	☐	☐	☐	☐	☐
F8. Do you agree that our e-learning environment can increase the number of online users?	☐	☐	☐	☐	☐
F9. Do you agree that our e-learning environment can reduce learning costs?	☐	☐	☐	☐	☐