HEURISTIC PROBABILISTIC APPROACH FOR PRIORITIZING OPTIMAL COURSE DELIVERY POLICIES IN E-LEARNING SYSTEMS

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Abstract

The popularity of the Internet as an information source has grown extensively. Its shear expanse and convenience is ideal to disperse information. More and more online services have now become available such as online banking, e-government, e-learning and e-commerce. Our interest lies with e-learning and in particular with the delivery of course material online. Strategic management can be understood as the collection of decisions and actions taken by business management, in consultation with all levels within the organization, to determine the long-term activities of the organization. Many approaches and techniques can be used to analyze strategic cases in the strategic management process. Among them, Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis, which evaluates the opportunities, threats, strengths and weaknesses of a system, is the most common. SWOT analysis is a significant support tool for decision-making, and is commonly used as a means to systematically analyze a system's internal and external environments. In this paper, we apply SWOT analysis to evaluate possible strategies to deliver an online course in an e-learning system. Then using probabilistic approaches we rank the strategies and select the optimal one. We present the effectiveness of the proposed approach in a case study.

Keywords: *Strategic Planning; e-learning; Loss Function; Risk Analysis*

ACM Classification: K.3.1, K.6.1, K.6.4

1. **Introduction**

Internet has significantly impacted the establishment of Internet-based education, or e-learning. Internet technology evolution and e-business has affected all industrial and commercial activity and accelerated e-learning industry growth. It has also fostered the collaboration of education and Internet technology by increasing the volume and speed of information transfer and simplifying knowledge management and exchange tasks [26]. E-learning could become an alternative way to deliver on-the-job training for many companies, saving money, employee transportation time, and other expenditures [2]. Since the adoption of Internet as the common channel for delivering teaching material in electronic form, the word e-Learning, previously used for defining the teaching methodologies involving electronic aids, has been used as synonym of distance learning through Internet. Internet makes available resources (hardware, software, data and knowledge) distributed worldwide, reaching the students or workers at their homes with a minimum connection cost.

The most common format for the Web-based teaching aids was text files or graphic presentations describing the content of the classroom lectures. Once the available bandwidth has increased, audio and video aids have been adopted too. The lack of interactivity with the teacher of such solutions has been first faced realizing online forums and direct communication based on e-mail. Then, provided enough bandwidth availability, the adoption of audio/video conferencing has been preferred.

Currently, e-Learning is based on complex virtual collaborative environments where the learners can interact with other learners and with the tutors or the teacher [23].

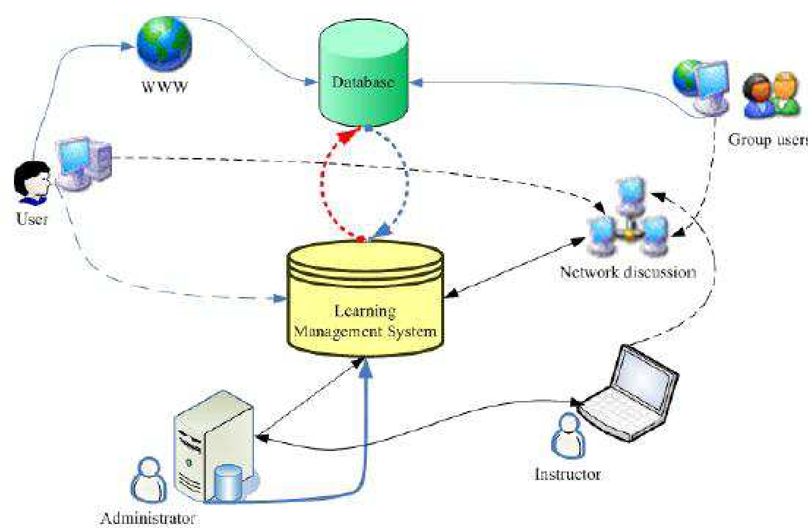

Figure 1. A configuration of e-learning system

It is possible to give the learners different synchronous and asynchronous services. The former group includes virtual classrooms and individual sessions with the teacher or tutors. The latter group includes the classic didactic materials as well as Web-based seminars or simulations always online [5]. These functions can be usually accessed by the means of software platforms called Learning Management Systems (LMSs). A configuration of e-learning system is shown in Figure 1.

The popularity of the Internet as an information source has grown extensively. Its shear expanse and convenience is ideal to disperse information. More and more online services have now become available such as online banking, e-government, e-learning and e-commerce. Our interest lies with e-learning and in particular with the delivery of course material online. More specifically, we are interested in presenting online course material in interactive and stimulating ways for students and creating an online learning community similar to that which one might experience in an actual university. In this article, we present our experience of developing an innovative collaborative e-learning system. As technologies have advanced, so too have the delivery methods for e-learning. Early forms included CDROMs and knowledge pools on the Internet, where users could access information and work through it at their own pace. This has now progressed to course and learning management systems, which provide greater support to tutors and students. Learning Management Systems (LMSs) which are now available provide course administration tools for instructors, allowing them to manage the distribution of course material and assignments. The importance of communication and collaboration within e-learning has been highlighted previously by Preece [25]; Hamburg et al. [9]; Salmon [29], and Thurmond and Wambach [36] amongst others, and as a result online forums and discussion boards have become an invaluable resource in these LMSs. They allow students to communicate with their peers and tutors thus empowering them to socialize and learn together online. While e-learning systems have improved with time, we feel that there are still some issues to be resolved before a truly stimulating and realistic learning experience can be provided online. Partaking in an online course can be a much more engaging and interactive experience for students.

2. **Properties of Virtual Learning**

Electronic education, also referred interchangeably as e-learning, is not a new instructional phenomenon. In over a century, it evolved from correspondence study, open universities, teleconferencing, networks and multimedia delivery to today's Web-based technologies. This evolution is characterized by new teaching approaches, including the adjustment of instructional materials supported by different delivery media. With the advent of the Internet, a new generation of electronic education emerged. Complementary to the other models, Internet-facilitated instruction allows for the implementation of synchronous and asynchronous interaction and opens a new series of learning opportunities for education. Increases in bandwidth technologies and worldwide access to interconnected networks enable the Internet and the World

Wide Web to develop into a viable delivery system for distance education. To accommodate this growth, the models for the development of distance instruction need to expand.

Through the use of technologies such as Virtual Reality (VR) and instant communication, students can be more visually aware of their classmates and can converse in real-time with them. They can also receive immediate feedback from their tutors and gain a sense of being present in the same place as their peers despite their remote physical locations. These shared virtual environments also facilitate simultaneous viewing of learning materials by the whole class and allow them to actively partake in group discussions about the learning content at the same time.

VR has been very popular and successful in other areas including entertainment and urban planning. It has also been extensively used within manufacturing industries and military bodies (Burdea & Coiffet [1]). In addition, the benefits of 3D graphics for education have been explored. Many 3D resources have already been developed in this area. 3D models are very useful to familiarize students with features of different shapes and objects, and can be particularly useful in teaching younger students. Many games have been developed using 3D images that the user must interact with in order to learn a certain lesson. Interactive models increase a user's interest and make learning more fun. 3D animations can be used to teach students different procedures and mechanisms for carrying out specific tasks ([24], [27]). VR has also been used extensively for simulations and visualization of complex data. For example, medical disciplines use VR to represent complex structures (Ryan, O'Sullivan, Bell, & Mooney [28]) and increasingly scientists are using this technology for visualization and in particular as a teaching aid (Manseur [20]).

The use of VR and 3D graphics for e-learning is now being further extended by the provision of entire VR environments where learning takes place. This highlights a shift in e-learning from the conventional text-based online learning environment to a more immersive and intuitive one. Since VR is a computer simulation of a natural environment, interaction with a 3D model is more natural than browsing through 2D web pages looking for information. These VR environments can support multiple users, further promoting the notion of collaborative learning where students learn together and often from each other (Kitchen & McDougall [16]).

As with a real university, students are aware of each other within the environment and they can partake in lectures, group meetings and informal chats. We feel that social interaction is vitally important within any learning scenario and so we provide many communication facilities in addition to learning content. VR can bring a great deal to an e-learning experience in these ways and in this article we discuss our techniques in detail. While we recognize the importance of pedagogy in any learning scenario, pedagogic issues relating to learning strategies and learning content are not dealt with in this article. Instead we focus on the design and usability of a 3D interface for learning, socializing and communicating online, and on providing adequate support for a variety of learning tasks.

3. **Online Course Delivery**

Redesigning a traditional course for Internet based delivery is a complex process that requires thorough planning and an implementation procedure. Knowledge of learning theories and instructional implications is a pre-requisite for successful realization of the learning objectives with the most appropriate tools and delivery components. There is several instructional design models which can be rely upon: from rapid development to systematic implementation.

The Internet has taken center stage as a preferred medium for the delivery of distance education. Many universities offer online courses that respond to the diverse distance and time needs of today's learners.

Online course instructors are often provided with tools that help them develop courses that integrate multiple types of learning strategies that facilitate learning and can appeal to learner preferences. Such learning strategies provide resources and activities that present content, prompt active exploration with content, allow learners time to reflect on content and feedback before participating, interactively engage learners with their peers, and offer instructional modules designed to appeal to a variety of learning styles and preferences (Hamilton-Pennell [10]). Learning styles are useful indicators of potential learning success because they provide information about individual differences in learning preferences from learning and information-processing standpoints (Smith and Ragan [31]).

Learning strategies are the activities used to engage learners in the learning process. They represent a set of decision result in plans, methods, or series of activities aimed at obtaining a specific learning goal (Jonassen et al. [13]). Many types of learning strategies are used to engage learner in activities such as reading, listening, collecting, thinking, collaborating, and doing. An expository presentation learning strategy suggests that effective learning requires providing content (facts, concepts, procedures, and principles) and performance activities (remembering, using, creating) using four primary presentation forms: rules, examples, recall, and practice. Instruction is more effective when it includes presentation of the appropriate knowledge form, opportunity for practice, and learner guidance. Thus, a complete lesson should consist of an objective followed by some combination of presenting rules and examples and providing practice and feedback appropriate to the learning task. Expository strategies in online environments generally include presenting online lectures with accompanying notes or specific readings followed by objective-based testing of content. Explanations are often kept simple and direct. Students usually use lecture or reading notes to complete learning activities or respond to posed questions.

Collaborative learning strategies presume that learning situations are dynamic, systemic, and changing. Learning focus is adapted to a particular situation to generate dialog among diverse communities, improve understanding, integrate different forms of knowledge about a learning problem or situation, increase rapport, trust, and respect among participants, and result in tangible improvements to a given learning situation.

Working together on learning projects provides peers with different perspectives and opportunities to investigate subject matter at varying levels, justify and defend their ideas, and build deeper knowledge. Collaborative and group work learning strategies in online learning require individuals, often at various levels, to work together to achieve a common goal. Individuals are prompted to analyze, synthesize, evaluate, and share their ideas collaboratively through virtual communication tools like email, discussion boards, or live chats.

Changing the combination and order of presentation forms depend on the effectiveness of question-driven or inquisitive presentation and discovery learning strategies. A discovery learning lesson consists of objectives followed by some combination of asking about rules and examples and providing practice and feedback, appropriate to the learning task. Such discovery learning strategies require individuals to formulate investigative questions, obtain factual information, and build knowledge, which reflects their responses to posed situations or problems. Students develop their own questions, which guide their investigations to eventually discover facts, concepts, and rules of the learning content and develop responses to the posed situation. In online discovery learning based instruction students are often presented with learning objectives from which they are given, or directed to identify, a list of resources with which they will interact and identify key information to achieve learning objectives. Through this process the learner acquires knowledge by discovering facts, concepts, and rules of the content.

Finding the optimal (shortest) learning path for user or tutor has been studied in different researches. Fazlollahtabar [7] applied a dynamic programming to find the shortest path for users in the e-learning environment. Since the learning parameters are qualitative, he used an analytical hierarchy process approach (AHP) to turn the qualitative parameters into quantitative ones. Fazlollahtabar and Mahdavi [8] proposed a neuro-fuzzy approach based on an evolutionary technique to obtain an optimal learning path for both instructor and learner. Also Tajdin et al. [34] designed an assessment method based on real-time simulators. These simulators were able to facilitate education and play the role of virtual intelligent teacher referring to student capabilities by following the feedback mechanisms. This system, which was constructed by the means of network and expert system, contained a real-time simulator core that has an inference engine based on a hypothesis testing. For analyzing user satisfaction in e-learning system, Mahdavi et al. [19] designed a heuristic methodology for multi-criteria evaluation of web-based e-learning systems based on the theory of multi-criteria decision making and the research results concerning user satisfaction in the fields of human-computer interaction and information systems. Understanding the relationships among learning styles and learning strategies holds great promise for enhancing learner perceptions of their own learning thus impacting educational practice (Claxton and Murrell [3]). The primary purpose of this exploratory study was to test whether matching learning strategies and learning style affect the achievement of students in online courses. Specifically, the level of the field-dependence and learning perceptions during expository, collaborative, and discovery learning strategies use during an online course were studied.

4. **The Proposed Model**

In this paper we initially will analyze course delivery in strategic view point via SWOT factors. Then we measure each policy using loss function and risk analysis to find the optimal one. A strategic framework to deliver an online course based on SWOT analysis in order to assist the formulation of the strategy prioritization is shown in Figure 2.

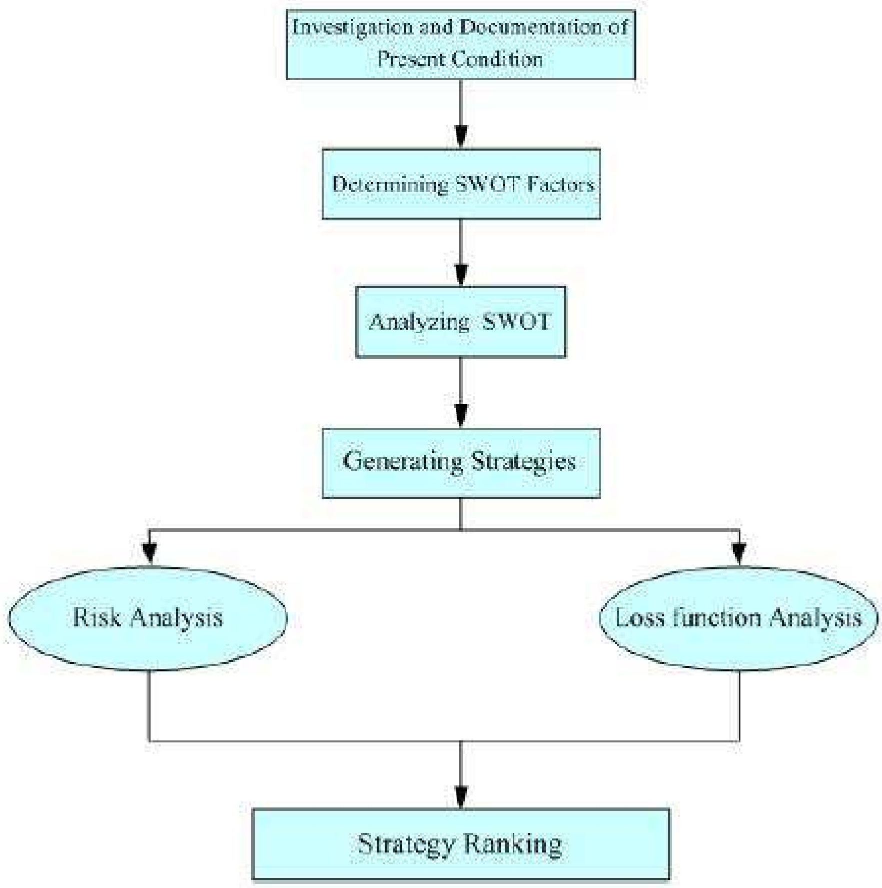

Figure 2. Strategic planning flowchart

Next section provides a comprehensive description of SWOT factors.

5. **SWOT Analysis**

Strategic management can be understood as the collection of decisions and actions taken by business management, in consultation with all levels within the organization, to determine the long-term activities of the organization (Houben et al. [12]). Many approaches and techniques can be used to analyze strategic cases in the strategic management process (Dincer [4]). Among them, Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis, which evaluates the opportunities, threat s, strengths and weaknesses of an organization, is the most common (Hill and Westbrook [11]). SWOT analysis is an important support tool for decision-making, and is commonly used as a means to systematically analyze an organization's internal and external environments (Kurttila et al. [18], Stewart et al. [32]). By identifying its strengths, weaknesses, opportunities, and threats, the organization can build strategies upon its strengths, eliminate its weaknesses, and exploit its opportunities or use them to counter the threats. The strengths and weaknesses are identified by an internal environment appraisal while the opportunities and threats are identified by an external environment appraisal (Dyson [6]). The internal appraisal examines all aspects of the organization covering, for example, personnel, facilities, location, products and services, in order to identify the organizations strengths and weaknesses. The external appraisal scans the political, economic, social, technological and competitive environment with a view to identifying opportunities and threats. The environmental SWOT analysis is indicated in Figure 3.

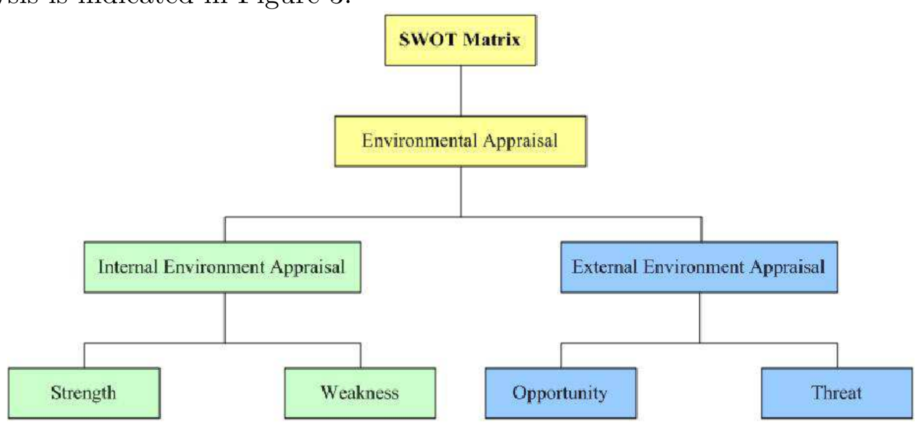

Figure 3. Environmental SWOT Analysis

SWOT analysis summarizes the most important internal and external factors that may affect the organization's future, which are referred to as strategic factors (Kangas et al. [15]). The external and internal environments consist of variables which are outside and inside the organization, respectively. The organization's management has no short-term effect on either type of variable. Comprehensive environmental analysis is important in recognition of the variety of internal and external forces with which an organization is confronted. On the one hand these forces may comprise potential stimulants, and on the other hand, they may consist of potential limitations regarding the performance of the organization or the objectives that the organization wishes to achieve (Houben et al. [12]). The obtained information can be systematically represented in a matrix (Ulgen and Mirze [37]); different combinations of the four factors from the matrix can aid in determination of strategies for long-term progress. When used properly, SWOT can provide a good basis for strategy formulation (Kajanus et al. [14]). However, SWOT analysis is not without weaknesses in the measurement and evaluation steps (McDonald [22]). In conventional SWOT analysis, the magnitude of the factors is not quantified to determine the effect of each fact or on the proposed plan or strategy (Masozera et al. [21]).

In other words, SWOT analysis does not provide an analytical means to determine the relative importance of the factors, or the ability to assess the appropriateness of decision alternatives based on these factors. While it does pinpoint the factors in the analysis, individual factors are usually described briefly and very generally. More specifically, SWOT allows analysts to categorize factors as being internal (Strengths, Weaknesses) or external (Opportunities, Threats) in relation to a given decision, and thus enables them to compare opportunities and threats with strengths and weaknesses (Shrestha et al. [30]).

Here, we identify the policies using the extracted SWOT factors. Next section gives analytical method for quantifying and ranking the strategies.

6. **Probabilistic Approaches**

Here, using loss function and risk probability distribution, we prioritize the derived strategies in previous section. For each of the strategies we calculate the loss and risk applying their probability distribution, and gain the summation. The objective is to achieve the lowest summation of loss and risk as the prior strategy and gain rank one. Next section is a short description of loss function and risk analysis.

6.1. *Loss Function*

In statistics, decision theory and economics, a loss function is a function that maps an event (technically an element of a sample space) onto a real number representing the economic cost or regret associated with the event. Less technically, in statistics a loss function represents the loss (cost in money or loss in utility in some other sense) associated with an estimate being "wrong" (different from either a desired or a true value) as a function of a measure of the degree of wrongness (generally the difference between the estimated value and the true or desired value). A common example involves estimating "location". Under typical statistical assumptions, the mean or average is the statistic for estimating location that minimizes the expected loss experienced under the Taguchi or squared-error loss function, while the median is the estimator that minimizes expected loss experienced under the absolute-difference loss function (Kozek [17]). Still different estimators would be optimal under other, less common circumstances. Loss functions in economics are typically expressed in monetary terms. For example:

$$\$ = \frac{\text{loss}}{\text{timeperiod}}. \tag{1}$$

Other measures of cost are possible, for example mortality or morbidity in the field of public health or safety engineering. Loss functions are complementary to utility functions which represent benefit and satisfaction. Typically, for utility U:

$$\text{loss} = f\left(k - U\right), \tag{2}$$

where k is some arbitrary constant. A loss function satisfies the definition of a random variable so we can establish a cumulative distribution function and an expected value. However, more commonly, the loss function is expressed as a function of some other random variable. For example, the time that a light bulb operates before failure is a random variable and we can specify the loss, arising from having to cope in the dark and/or replace the bulb, as a function of failure time. The expected loss (sometimes known as risk) is:

$$\Lambda = \int_{\infty} \lambda\left(x\right) f\left(x\right) dx, \tag{3}$$

where,

$\lambda\left(x\right)$ = the loss function,

x = a continuous random variable,

$f(x)$ = the probability density function.

Minimum expected loss (or minimum risk) is widely used as a criterion for choosing between prospects. It is closely related to the criterion of maximum expected utility. The use of a quadratic loss function is common, for example when using least squares techniques or Taguchi methods. It is often more mathematically tractable than other loss functions because of the properties of variances, as well as being symmetric: an error above the target causes the same loss as the same magnitude of error below the target. If the target is t, then a quadratic loss function is

$$\lambda\left(x\right) = C\left|t - x\right|^2, \tag{4}$$

for some constant C; often the value of the constant makes no difference to a decision, and can then be ignored by setting it equal to 1. Many common statistics, including t-tests, regression models, design of experiments, and much else, use least squares linear models theory, which is based on the Taguchi loss function.

6.2. *Risk Analysis*

In decision theory and estimation theory, the risk of an estimator $\hat{\theta}$, of an unknown parameter of the distribution, θ is the expected value of the loss function (Suresh et al. [33]),

$$R\left(\theta, \hat{\theta}\right) = EE_{\theta}L\left(\theta, \hat{\theta}\right) = \int L\left(\theta, \hat{\theta}\right) dP_{\theta}, \tag{5}$$

where dP_{θ} is a probability measure parameterized by θ. For a scalar parameter θ and a quadratic loss function,

$$L\left(\theta, \hat{\theta}\right) = E_{\theta}\left(\theta - \hat{\theta}\right)^2, \tag{6}$$

the risk function becomes the mean squared error of the estimate,

$$R\left(\theta,\hat{\theta}\right)^2 = E_\theta\left(\theta-\hat{\theta}\right)^2. \tag{7}$$

In density estimation, the unknown parameter is probability density itself. The loss function is typically chosen to be a norm in an appropriate function space. For example, for L^2 norm,

$$L\left(f,\hat{f}\right) = \left\|f-\hat{f}\right\|_2^2, \tag{8}$$

the risk function becomes the mean integrated squared error

$$R\left(f,\hat{f}\right) = E\left\|f-\hat{f}\right\|_2^2. \tag{9}$$

Here, we apply quadratic loss function to measure the loss of each strategy derived. Consequently, we calculate the probability of risk and loss for each strategy and identify the minimum as the first rank. The procedure is repeated until all the strategies are ranked.

7. **Case Study**

Here, we present a case study to illustrate the efficiency of the proposed model. This study has been implemented in e-learning center of Mazandaran University of Science and Technology. In this center a strategic plan is conducted to categorize the overall aspects of an online course delivery. Based on the aforementioned description the following SWOT matrix (Figure 4) is configured for online course delivery in an e-learning system.

Strengths: S1: The most up-to-date facilities S2: The well educated employees S3: Rapid delivery S4: The strong link between e-learning center and user	Opportunities: O1: Paying attention to modern technologies O2: Special attention to software revolution O3: Communication growth with lower costs
Weaknesses: W1: Concentration of industries in specific points W2: Using modern equipments which would incur more costs W3: Loss of relationship between user and teacher	Threats: T1: Laziness of students T2: Health danger of high tech equipments

Figure 4. SWOT matrix

Based on the above SWOT matrix the following strategies can be proposed to develop online course in an e-learning system:

- Establishing an integrated information system to facilitate data transfer among users (S3, S4, W1, O2, O3).
- The consolidated link between e-learning centers, users, and teachers (S2, W3, O1, O4).

- Entering tidy modern information technologies amongst users (S1, W2, T1, T2).
- Investing on training employees with modern methods (S2, W3, T1).

While strategies are considered to be implemented and resulted during a time period, we choose exponential distribution function for our study. The exponential probability density function is

$$f\left(x\right)=\frac{1}{\theta}e^{-\frac{x}{\theta}},\theta>0. \tag{10}$$

All of the specifications for exponential density function are held. Here, we formulate the loss and risk using exponential probability function. We assume that the target loss in the period the implementing the strategies equals 7. This value is gained based on the previous experiences of experts. Then for loss we have

$$\lambda\left(x\right)=\left|7-x\right|^{2}, \tag{11}$$

While risk is the expected value of the loss, we have the risk function considering exponential parameter equal to 2.5 ($\theta=2.5$) as follows:

$$R\left(x\right)=\int_{x}\left|7-x\right|^{2}\frac{1}{2.5}e^{-\frac{x}{2.5}}dx, \tag{12}$$

Since the variable x is continuous, therefore we have to identify an interval for each strategy to be inserted in the above integral for computations. We use confidence interval to estimate the interval for each strategy. Initially, we put the following values for SWOT parameters:

$S=+1,W=-1,O=0.5,T=-0.5.$

We calculate the value of each strategy using their SWOT factors and their corresponded values. The confidence interval is calculated using the following equation:

$$X\pm Z_{\frac{\alpha}{2}}\frac{\sigma}{\sqrt{n}}, \tag{13}$$

where X is the numerical value of each strategy, $Z_{\frac{\alpha}{2}}$ is the $\frac{\alpha}{2}$ fractile of standard normal distribution, σ is the standard deviation, and n is the number of sample which is considered 12 (the number of SWOT factors).

We consider a 0.95 confidence in decision making i.e. and while standard deviation in exponential distribution function is equal to parameter θ. As a result, the following confidence intervals are calculated for each strategy:

STRATEGY 1: $2\pm1.96\frac{2.5}{\sqrt{12}}=(0.98,3.021)$.

STRATEGY 2: $1\pm1.96\frac{2.5}{\sqrt{12}}=(0.021,2.021)$.

STRATEGY 3: $-1\pm1.96\frac{2.5}{\sqrt{12}}=(-2.021,0.021)$.

STRATEGY 4: $-0.5\pm1.96\frac{2.5}{\sqrt{12}}=(-1.053,0.053)$.

Now, we use the above intervals for the integral of risk function. Also, using the intervals we can compute the norm of the loss for the strategies. The following results in Figure 5 are gained for each strategy:

	Loss ($\lambda(x)$)	Ranking	Risk ($R(x)$)	Ranking
STRATEGY 1	4.1657	3	10.0753	1
STRATEGY 2	4	2	20.5683	2
STRATEGY 3	4.1698	4	83.3716	4
STRATEGY 4	1.2232	1	31.0311	3

Figure 5. The results of the computations

While risk is a function of loss, then we can decide based on risk ranking. Therefore, strategy one gains the first rank and so on.

8. Conclusions

Strategic planning is a significant element for implementing projects. A benefit method for analyzing different strategies is SWOT. SWOT analysis summarizes the most important internal and external factors that may affect the organization's future, which are referred to as strategic factors. The loss and risk are two parameters that each strategy faces during its implementation. In this paper, integration between SWOT analysis and probabilistic approaches is applied to evaluate varied strategies for selecting optimal online course delivery in an e-learning system. The most important advantage of the proposed approach is including probabilistic parameters in the process of strategy ranking. As future study, an implementation of the proposed model is forehead to assess the capability and validity.

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