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Learner satisfaction for a hybrid course in probability

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ABSTRACT

Success of any training system is based on satisfaction of the user and factors affecting this satisfaction. This article studies satisfaction of a hybrid training system (which is a combination of e-learning and traditional training systems) for Probability and Statistics for Engineers at Shahid Behashti University in Iran. Using the related literature, this article derives a model for factors which impact on learner satisfaction in the hybrid training system. Validation of the model is verified using the Bayesian Structural Equation Modeling. The findings state that *Perceived usefulness* and *Course flexibility* are factors which provide more positive effect on the course satisfaction. While *Attitude toward e-learning*, *Computer anxiety*, and *Perceived interactions with others* are factors which provide negative effect on the course satisfaction. Several suggestions based upon the results have been given.

Keywords: *e-learning; student satisfaction; Bayesian Structural Equation Modeling.*

1. INTRODUCTION

Traditional face-to-face learning system, typically, occurs in a teacher-directed environment with interpersonal interaction in a live synchronous environment. This learning environment is costly with less access flexibility. On the other hand, the electronic learning (e-learning) environments that have grown and expanded dramatically as a new technology which expands the possibilities for communication, interaction and multimedia input has many limitations and suffers from a lack of social interaction between learners and instructors (Wu et al. 2008). The hybrid training system is a solution for such barriers of both traditional and e-learning systems. Roughly speaking, a hybrid training system refers to training system which combines face-to-face classroom instruction with some elements of an online system. In recent years, the hybrid course has become a part of the educational landscape. The goal of hybrid courses is to join the best features of in-class teaching with the best features of online learning to promote active independent learning and reduce class seating time (Garnham & Kaleta, 2002). Moreover, Arbaugh (2000) pointed out that hybrid courses may be accompanied benefits of both on-site and e-learning techniques to reduce disadvantages of both techniques. To have a successful hybrid course, an instructor must invest significant time and effort in redesigning a traditional course. Since, online activities require special abilities, equipments, etc. of learners.

Probability and Statistics for Engineers is one of the challenging courses for both instructors and students in engineering. Overloading of the course content, time limitation, and simultaneous offering the course with several difficult courses (such as fundamental of physics, multivariate calculus, differential equations) transform an interesting course to a difficult one. Many instructors and authors believe that mathematics and statistics are such subjects which need a face-to-face training system and cannot be taught, completely, by an online training system (Broadbent, 2001 and Chapnick, 2000). Sands (2002) described how one may integrate online activities with classroom work to obtain a successful hybrid course. To overcome such barriers and limitations, Payandeh & Omidi (2010) suggested a hybrid training system for the course, which (**i**) the course contents teach in a face-to-face environment (on-site part); (**ii**) Class materials, in some interactive slides, companies with some new examples and more advanced materials teach in an online environment (online part); (**iii**) student will be evaluated using the regular midterm(s), final exam (which take in the traditional manner), and several quizzes and assignments (which take using the online environment). Readiness of such hybrid training system have been studied by Payandeh & Omidi (2010).

This article, using the related literature, derives several factors which can effect on learners satisfaction of the hybrid training system. Then, it employs the Bayesian Structural Equation Modeling to measure effect of such factors on the students' satisfaction.

2. VARIABLES AND THEORETICAL FRAMEWORK

Anderson (1973) defined satisfaction as an ex-post evaluation of consumers' initial (trial) experience with the service, and is captured as a positive feeling (satisfaction), indifference, or negative feeling (dissatisfaction). Therefore, a consumer satisfies whenever his affect from his experience fit with his expectation. The

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satisfaction comes after the use. Later, Internet was responsible from the apparition of a new concept ``e-satisfaction''. Hise & Szymanski (2000) defined e-satisfaction as the consumers'

- **Attitude toward e-learning, say F_1:** Arbaugh (2002) and Hong et al. (2002) pointed out, a student who has a positive viewpoint about e-learning. He participates in an online course, effectively. This factor contains variables: `I believe that working with computer is' difficult, complicated, required technical ability, appropriated only for patient users, and appropriated only for young people, say respectively $X_1, \dots, X_5$.
- **Computer anxiety, say F_2:** Piccoli et al. (2001) pointed out, users' proficiency and their attitude towards computer may effect, positively, on their e-satisfaction. This factor includes variables: `working with computer makes me' nervous, uncomfortable, and confused say respectively X_6, X_7, X_8.
- **Self-efficacy, say F_3:** Joo et al. (2000), Thompson et al. (2002) defined self-efficacy as learners' ability to evaluate their ability in using Internet to perform activities related to e-Learning. Moreover, they indicated such factor as an important factor which may effect, positively, on learner satisfaction. This factor includes variables: `I feel confident to' work with internet, download/upload my necessary files from the web, and googling the web, say respectively X_9, X_{10}, X_{11}.
- **In-time response from instructors, say F_4:** Soon et al. (2000) Arbaugh (2002), Chickring & Gamson (1987), Ryan et al. (1999), and Thurmond et al. (2002) are authors who pointed out in time response of instructors' may effect, negatively, on learner's satisfaction. This factor includes variable: `my instructor sends my comments, assignments, tests, etc on time,' say X_{12}.
- **Attitude toward of instructors?, say F_5:** Webster & Hackley (1997) and Piccoli et al. (2001) found out that, instructors' attitudes toward e-Learning or IT may influence, positively, on results of e-Learning. This factor includes variable: `compared to traditional course, how useful do you think your instructor has positive opinion about the course,' say X_{13}.
- **Course flexibility, say F_6:** Arbaugh (2000) refereed the e-learning's flexibility as the most attractive feature of an e-learning course. Moreover, he mentioned it as a factor may increase learner and instructor satisfaction. This factor includes variables: `taking the course in this manner' allow me to arrange my class work more effectively, have more advantage compare to the traditional manner, have less disadvantage compare to the traditional manner, and allow me to arrange my schedule more effectively, say respectively $X_{14}, \dots, X_{17}$.
- **Course's quality, say F_7:** Piccoli et al. (2001) emphasized quality of course content as an important attribute that leads students' satisfaction and consequently a successful outcome for an e-learning training system. This factor includes variable: conducting the course in this manner improved the course's quality, say X_{18}.
- **Technology quality, say F_8:** Technical attributes affect, positively, students' satisfaction (Webster & Hackley, 1997). This factor includes variables: `I feel the information technologies used in the course are easy to' use and obtain, say respectively X_{19}, X_{20}.
- **Internet quality, say F_9:** This factor includes variables: `I feel satisfied with' the speed on the Internet and the cost of the Internet, say respectively X_{21}, X_{22}.
- **Perceived usefulness, say F_{10}:** Chiu et al. (2005) defined perceived usefulness is ``the degree that a person believes using a particular system would enhance his/her job performance''. Also they pointed positive effect of such factor on learner satisfaction. This factor includes variable: `using this training system improves my performance in the course,' say X_{23}.
- **Perceived ease of use, say F_{11}:** Perceived ease of use is ``the degree that a person believes using a particular system would be free of effort'' (Davis, 1989). Such factor may impact, positively, on learner satisfaction. This factor includes variables: `I is easy for me to' become skillful at using the course's environment, get the course's requirement, say respectively X_{24}, X_{25}.
- **Diversity in assessment, say F_{12}:** Thurmond et al. (2002) stated that environmental variables such as diversity in assessment may influence on e-satisfaction. This factor includes variable: `This course offered a variety of ways to assess my learning (quizzes, assignments, midterms, etc,)' say X_{26}.

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http://www.cisjournal.org

- **Perceived interactions with others, say F_{13}:** Arbaugh (2000) and Piccoli et al. (2001) found out that the more learners perceive interaction with others may lead to a higher e-satisfaction. This factor includes variables: `This training system provides' a more conformable interaction with other students and instructor compare to the traditional training system and a more comfortable discussional environment compare to the traditional training system, say respectively X_{27}, X_{28}.

This article considered the course satisfaction as a latent variable (or factor) which contains variables: I am satisfied to take the course in this manner, I would glad to take another course in this manner, I was very satisfied with this course, and I would like to take all of my courses using this training system, say $X_{29}, ..., X_{32}$, respectively.
According to the above review of literature, the following theoretical framework, Figure 1, has been developed to indicate effect of 13 latent variables (or factors) $F_1, ..., F_{13}$, given the above.

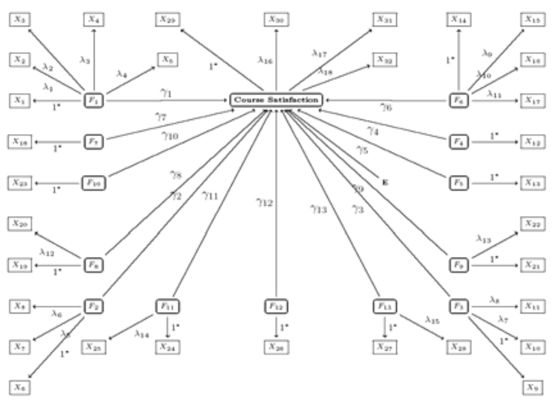

Figure 1: Theoretical framework of the course satisfaction.

In Figure 1, `E' represents error term of the structural equation modeling and $X_1, ..., X_{32}$ and $F_1, ..., F_{13}$, given the above. In structural equation modeling, traditionally, one of factor loadings for each latent variables is fixed by 1 (and indicated by 1^*) and other factor loadings are estimated. $\lambda_1, ..., \lambda_{18}$ indicate factor loadings which represent relationship among observed variables and latent variables and $\gamma_1, ..., \gamma_{13}$ are factor loadings which represent relationship among latent variables. Using $100\sqrt{1-E^2}\%$, one can estimate the percentage of data that described by the structural equation modeling model.

2-1 Measurement

To collect information, a questionnaire with 40 questions was designed. The questionnaire includes: **(i)** 32 variables $X_1, ..., X_{32}$, given above and **(ii)** 8 demographical questions. Reliability of self developed questions in the questionnaire measured by the Cronbach's Alpha with a pilot study size 15. The Cronbach's Alpha exceeded 0.89, which indicates acceptable reliability of the questionnaire.
A census study has been conducted to whole of students in the course t Shahid Behashti university in 2010. It leads to N=55 useful questionnaires.

2-2 Purpose and Objectives

The purpose of this study is to identify a number of factors that represent the relationship among sets of interrelated variables using structural equation modeling and to examine the contribution of each factors to the students' satisfaction. The main hypothesizes of this study were:

- H_0^1: The student's attitude towards e-learning does not influence on their the course satisfaction.
- H_0^2: The computer anxiety of students doesn't influence on their the course satisfaction.
- H_0^3: Learners' self-efficacy will not influence on their the course satisfaction.
- H_0^4: Students' satisfaction is not impacted by in-time response of instructors.
- H_0^5: Students' satisfaction is not influenced by instructor's attitude towards e-learning.
- H_0^6: Course flexibility does not impact on students' satisfaction.
- H_0^7: Quality of the course contents does not influence on students' satisfaction.
- H_0^8: Technology quality does not influence on students' satisfaction.
- H_0^9: Internet quality does not impact on students' satisfaction.
- H_0^{10}: Learners perceived usefulness of the e-Learning system will not influence on their satisfaction.
- H_0^{11}: Learner perceived ease of use of the e-Learning system will not influence on their satisfaction.
- H_0^{12}: Diversity in assessment will not impact on students' satisfaction.
- H_0^{13}: Learners perceived interaction with others will not influence on their satisfaction.

Relevant of such characters (or factors) to the course satisfactions has been explained in Section 2.

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3. METHODOLOGY

The Structural equation modeling is a well known technique which employs to estimate, analyze, and test models that specify relationships among (observed and latent) variables, say, theoretical framework. The term of ``latent variable models" refer to classes of hypothetical or theoretical variables (constructs) that cannot be observed directly, and treat observed variables as indicators of underlying constructs rather than perfectly measured representations of these same constructs. The structural equation modeling models are well recognized as the most important statistical method to establish an appropriate model to evaluate a series of simultaneous hypotheses about the impacts of latent variables and observed variables on the other variables (Shipley, 2000). Once a theoretical framework has been proposed, it can then be tested against empirical data. The relationships are described by parameters, say factor loadings, that indicate the magnitude of the effect (direct or indirect) that independent variables (either observed or latent) have on dependent variables (either observed or latent). By enabling the translation of hypothesized relationships into testable mathematical models.

The usual structural equation modeling employs the maximum likelihood (ML) method to estimate unknown parameters. It is well known that the statistical properties of the ML approach are asymptotic (Lehmann & Casella, 1998). Therefore, many of properties of the ML estimators have been oscillated for small sample size.

In the context of some basic structural equation modelings, many studies have been devoted to study the behaviors of the ML asymptotic properties with small sample sizes, see Lee (2007) for an excellent review. It was concluded by such researches that the properties of the statistics are not robust for small sample sizes, even for the multivariate normal distribution. The Bayesian approach to the structural equation modeling has ability: (**i**) to work properly for small sample size. Even small sample size, the posterior distributions of parameters and latent variables can be estimated by using a sufficiently large number of observations that are simulated from the posterior distribution of the unknown parameters through efficient tools in statistical computing such as the various Markov chain Monte Carlo (MCMC) methods (Lee, 2007); (**ii**) to utilize useful and prior information about the problem (which translated to a prior distribution) to achieve better results. For situations without accurate prior information, some type of non-informative prior distributions can be used. In these cases, the accuracy of the Bayesian estimates is close to that obtained from the classical structural equation modeling (Robert, 2001); (**iii**) to treat the discrete variables (such as the Likert and rating scales) as the hidden continuous normal distribution with a specified threshold (or cut point). Clearly, such approach provide a powerful tool to analyze the discrete variables rather than using spacial, but less powerful, statistical technique to do so (see Lee, 2007).

4. RESULTS

Table 1 Descriptive statistics for some variables in the target population.

			Percent of Level	
Variable	Mean	SD.	1	2
Computer usage (daily)/hour	4	2.811	—	—
Internet usage (daily)/hour	3.012	4.230	—	—
Gender	—	—	Female (65%)	Male (35%)
Major	—	—	Computer (40%)	Electronic (60%)
Having Laptop	—	—	Yes (56%)	No (44%)
Having an appropriate personal computer	—	—	Yes (93%)	No (7%)
Internet connection at home	—	—	Dial-up (61%)	ADSL (5%)
Internet connection at university	—	—	Wireless (60%)	Wire (30%)

As Table 1 shows: 65% of respondences are female; most of students have an appropriate PC to have an internet connection at home. Also, the above table respects the fact that the most of students have a comfortable internet connection at university.

To implement the Bayesian structural equation modeling analysis to test the above theoretical framework against collected data, a statistical package, named WinBUGS, has been used. WinBUGS is an open source and freely available software package, which can be used to implement Bayesian structural equation modeling analysis. WinBUGS combines the prior information (which summarizes in a prior distribution) with observation and derives a distribution for factor loadings. This approach to factor loading provides more information about factor loading compare to other classical structural equation modeling approaches. More precisely, one can estimate mean, variance, and credible interval for mean of factor loadings. Therefore, hypothesis $H_0: \lambda = 0$ reject in favor of hypothesis $H_1: \lambda \neq 0$, at significant level α, whenever zero falls in the $100(1-\alpha)$ credible interval of λ .

As explained above, all ordinal and observed variables in this research considered as normally distributed latent variables. Using such approach to ordinal and observed variables along with the Invert Gamma and the Invert Wishart priors, which commonly use with normal distribution (whenever no prior information is

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available), one can employ the WinBUGS software to test the theoretical framework given by Figure 1.

Analysis described below was run in WinBUGS for total of 100,000 iterations, which mostly, burn-in about 10,000 iterations. All model validation criteria such as MC-error (it should be considerably lower than variance for each estimated parameters), autocorrelation functions (it should be approached to zero exponentially for each estimated parameters), and kernel density (all estimated parameters have to be normally distributed) have been met by the model. To consist on briefness such validity criteria removed from the article.

Table 2 represents Bayesian estimation and 95% credible interval for factor loadings of theoretical framework presented by Figure 1.

Table 2: Bayesian estimation and 95% credible interval for factor loadings.

Factor loading	Estimation	95% CI	Factor loading	Estimation	95% CI
λ_1	1.081	[0.434, 1.728]	λ_{17}	0.999,	[0.369, 1.628]
λ_2	1.084	[0.432, 1.736]	λ_{18}	0.541	[0.054, 1.027]
λ_3	1.163	[0.481, 1.845]	γ_1	-0.975	[-1.692, -0.259]
λ_4	1.025	[0.395, 1.655]	γ_2	-0.879	[-1.615, -0.142]
λ_5	1.295	[0.626, 1.964]	γ_3	0.434	[0.262, 0.606]
λ_6	1.329	[0.640, 2.018]	γ_4	0.698	[0.331, 1.065]
λ_7	1.011	[0.380, 1.642]	γ_5	0.821	[0.081, 1.561]
λ_8	0.945	[0.347, 1.544]	γ_6	0.911	[0.220, 1.601]
λ_9	1.508	[0.738, 2.278]	γ_7	0.849	[0.048, 1.650]
λ_{10}	1.386	[0.728, 2.044]	γ_8	0.560	[0.172, 0.948]
λ_{11}	0.781	[0.267, 1.294]	γ_9	0.540	[0.371, 0.709]
λ_{12}	1.048	[0.398, 1.698]	γ_{10}	0.994	[0.219, 1.769]
λ_{13}	0.687	[0.161, 1.214]	γ_{11}	0.830	[0.063, 1.597]
λ_{14}	1.166	[0.455, 1.877]	γ_{12}	0.891	[0.105, 1.677]
λ_{15}	1.338	[0.647, 2.029]	γ_{13}	-0.228	[-0.338, -0.118]
λ_{16}	0.884	[0.193, 1.576]			

One can restate the above null hypothesis $H_0^i: \gamma_i = 0$ vs $H_1^i: \gamma_i \neq 0$, $i = 1, \ldots, 13.$ The new hypothesis will be rejected, at significant level $\alpha = 0.05,$ whenever zero falls into the 95% credible interval for $\gamma_i.$ Using this fact along with the 95% credible intervals, given by Table 2, one can conclude that all the above null hypotheses H_0^1 to H_0^{13}, at significant level $\alpha = 0.05,$ will be rejected. Now from the above observation, the theoretical framework, given by Fig 1, without any change will be confirmed. Moreover, from Table 2, one can conclude that: (**i**) Linear relationship among the course satisfaction, as an independent latent variable and other dependent latent variables can be stated as

$$\text{The course satisfaction} = -0.975F_1 - 0.879F_2 + 0.434F_3\ 0.698F_4 + 0.821F_5 + 0.911F_6 + 0.849F_7 + 0.560F_8 + 0.540F_9 + 0.994F_{10} + 0.830F_{11} + 0.891F_{12} - 0.228F_{13} + E,$$

Where error of the above model (i.e., E) is, at most, 0.15. Therefore, about 98.87% of data are described by the model; (**ii**) Perceived usefulness, i.e., $F_{10},$ and course flexibility, i.e., $F_6,$ provide more positive effect on the course satisfaction; (**iii**) Attitude toward e-learning, i.e., $F_1,$ computer anxiety, i.e., $F_2,$ and perceived interactions with others, i.e., $F_{13},$ provide negative effect on the course satisfaction. While, other factors provide positive impact; (**iv**) Taking the course in this manner have more advantage compare to the traditional manner, i.e., $X_{15},$ and taking the course in this manner have more have less disadvantage compare to the traditional manner, i.e., $X_{16},$ respectively, provide more positive and indirect impact on the course satisfaction; and (**v**) Working with computer makes me confused, i.e., $X_8,$ and working with computer makes me uncomfortable, i.e., $X_7,$ respectively, provide more negative and indirect impact on the course satisfaction.

5. Discussion and suggestions

From the Bayesian structural equation modeling, 13 factors are proven to have critical relationships with the course satisfaction. More precisely, (**i**) negative impact of Attitude toward e-learning, Computer anxiety, and Perceived interactions with others on the course satisfaction have been proven. These observation also confirmed by Arbaugh (2000, 2002), Piccoli et al. (2001) and Hong et al. (2002); (**ii**) positive impact of Self-efficacy, in-time response from instructors, Attitude toward of instructors, Course flexibility, Course's quality, Technology quality, Internet quality, Perceived usefulness, Perceived ease of use, and Diversity in assessment on the course satisfaction, which verified by Thurmond et al. (2002), Davis (1989), Chiu et al. (2005), Webster & Hackley (1997), Piccoli et al. (2001), among others.

The findings indicate that perceived usefulness provides the greatest positive and direct contribution (total effect) to learning satisfaction. Therefore, the hybrid training system should provide useful information promptly so that useful recommendations are rapidly disseminated or shared with those that need to know. Instructors and learners should promote and create the positive learning atmosphere within the context of the system. In addition, the system should have a user-friendly interface that includes some key functions to minimize user's efforts in learning.

Based upon our experience, we believe that: **(i)** The system should offer good content features with multimedia presentation and flexibility in learning activity; **(ii)** The system should provide an environment for social interaction and instructor should motivate positive interaction publicly; and **(iii)** The university administrators should provide resources to enhance students' computer self-efficacy.

It worth to mention that, this empirical research develops and validates model, given by Figure 1, for learning satisfaction in the hybrid training system context. But, our findings have several limitations that could be addressed in the future researches. First, our results were obtained from one single study that examined a particular hybrid training system and targeted some specific students in Iran. Thus, caution needs to be taken when generalizing our findings to other hybrid systems or students groups. In addition, the sample size used in this study is another limitation. A cross-cultural validation using a large sample gathered elsewhere is required for greater generalization of the proposed model.

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