PROVIDING ADEQUATE INTERACTIONS IN ONLINE DISCUSSION FORUMS USING FEW TEACHING ASSISTANTS

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ABSTRACT
In order to encourage students to participate in online learning forums, prompt responses to their questions are essential. To answer students' online questions, teaching assistants are assigned to manage discussions and answer questions in online learning forums. To minimize the response time, many teaching assistants may be needed to interact with learners. We investigated the trade-off between the request-response time and the cost of labor for handling the requests since this has become a challenging and important issue for education managers. In this study, a queuing-based model is proposed to construct the relationship between response time and the human resource requirement in a learning forum. In addition, an experiment using students in a Computer Science Introduction course at a vocational high school was conducted to verify the model and determine the average number of assistants required so that the students' questions can be answered within an acceptable time interval, providing valuable information for managing online discussion forums for educational purposes. Finally, the participants' perceptions were investigated using a questionnaire revised from the Technology Acceptance Model (TAM) in order to identify whether feelings of the perception-of-usefulness and the perception-of-satisfaction during the response wait time showed significant differences when the number of teaching assistants was reduced. The results revealed no significant difference in learners' perceptions after reducing the number of teaching assistants. It confirms that using the model to predict the number of required teaching assistants is highly reliable, and effective in reducing labor costs without jeopardizing student satisfaction.
Keywords: queuing-based model, response time, human resource requirement, learning forum, technology acceptance model.

INTRODUCTION
The interaction between instructors and students is indispensable for online learning. Gates, Myhrvold, and Rinearson stated that the information superhighway (i.e. Internet) makes it easier to keep up with distant acquaintances by reducing the amount of time for socializing and interacting with distant people (Gates, Myhrvold, & Rinearson, 1995). With the advance of information and communication technologies (ICT), researchers have attempted to provide guidelines for technology-supported learning communities. Several studies have indicated that the facilities of learning communities are helpful to learners in sharing and constructing knowledge via online interactions (Lave & Wenger, 1991; Jonassen, Peck, & Wilson, 1999). The common component of those studies is participation that promotes students' active involvement in learning processes. In other words, the most important role of an online instructor is to ensure the participation of students online.

A network-based virtual community usually consists of participants who congregate due to common interests and exploration of certain issues (Palloff & Pratt, 1999). Researchers have indicated that regular discussions and sharing viewpoints are the certain characteristics of a sound learning community (Collison, Elbaum, Haavind, & Tinker, 2000). Among the various functions of online learning communities, online discussion forums (ODF), in which the learners only need to select a subject and interact with others by browsing and posting articles, may be the most popular (Hann, Glowacki-Dudka, & Conceicao-Runlee, 2000). An ODF for learning communities, sometimes called a *learning forum*, can provide students with open and equal discussion opportunities. ODF have also been recognized as being efficient and convenient by freeing learners from temporal and geographical constraints (Chen & Chiu, 2008; Schellens & Valcke, 2005; Wever, Schellens, Valcke, & Keer, 2006). In addition, online team interactions tend to draw out quiet team members who rarely speak up when sitting in a traditional classroom, providing shy students the opportunity to speak freely (Calongne, 2002). Hammond (2000) also stated that forums take advantage of the opportunities for informal and social exchange as well as those for sustained reflection afforded by the medium (Masters & Oberprieler, 2004). Among online learners, ODF have been recognized as the most frequently and conveniently used online learning activity (Garrison, Anderson, & Archer, 2003). In light of all this, an ODF can be viewed as one of the imperative conditions for online learning.

In order to ensure the success of an ODF, it is essential to institute forum regulations, such as the roles and responsibilities of learners, instructions for posting messages to proper categories/boards, the maximum number of words in a post, the type of content allowed, formats for attached files, and the deadline of a discussion topic (Palloff & Pratt, 1999). With regard to discussion activities, problem-solving strategy can be used to promote participation of a learning community. For instance, the problem solving activity with three steps was designed in the study (Hou, Sung, & Chang, 2009). First, the teachers provide lectures. The second step is the learners' writing project. Last is the Q&A discussion. Hou, Sung, & Chang (2009) also conclude that teachers should make timely interventions in an ODF in order to guide students and improve their critical-thinking skills using a problem-solving strategy. To ensure an ODF have fervent discussion, the conceptual model of intention to participate in ODF has become increasingly important (Yang, Li, Tan, & Teo, 2007).

Although learning forums seem to be helpful to learners, the improvement of learning performance depends on the degree of learners' participation and roles (Davies & Graff, 2005; Chang, Chen, & Wang, 2011). Moreover, online learners must efficiently manage their time in order to manage the load and quantity of online discussion happening around them. Although mobile technology can improve acceptability of ODF, Stratfold (1998) stated that time stress is the problem which most online learners are confronted with (Chang, 2010). At the same time, instructors also have time stress for providing prompt feedback in online discussions (Stratfold, 1998). Instructors are overloaded, with stress contributed to by the time constraints for responding to the frequent requests in the forums. Palloff and Pratt (1999) indicated that the key factor of success in performing an ODF is to respond to questions rapidly (Palloff & Pratt, 1999). Jonassen (1999) stated that the assistance and guidance of instructors has an impact on the success of learning communities. However, the working burden of instructors is not only heavy but also time-consuming (Kearsley, 2000). One of the difficulties and challenges in an ODF is how to keep learners participating in the discussion or query (Kearsley, 2000). Therefore, in order to solve the problem and not to leave any learner's question for too long without being replied to, the study applies Queuing Theory to determine the optimal number of teaching assistants needed for a learning forum.

As each assistant is only capable of answering a limited number of questions, the number of assistants needed is determined based on the number of questions submitted, which could be significantly different from day to day. In addition, to encourage students to participate in the learning forum and join the discussions, the unanswered questions need to be fewer and the average response time needs to be shorter; at the same time, the number of assistants should be as small as possible in consideration of the human resource costs. Therefore, it becomes a challenging issue to determine the number of assistants, taking all of these requirements into account. To cope with this problem, the first research problem is to find out the acceptable waiting time before a message is responded to. Although the acceptable time interval differs from person to person, the study tried to determine the response time interval that satisfied more than 60% of learners. The first research question of this study is:

1. Can the threshold of the response time be determined so that more than 80% learners can accept it in the forum?

   Then, the study used a queuing theory to model the interactive dynamic of a learning forum. A queuing method (M/M/4):(FCFS/∞/∞) was proposed to predict the balancing strategy so that there are assistants who can provide learners with adequate responses to prevent them from digressing before they lose their patience or interest in waiting for feedback, and even cease participating. Therefore, the second research question of this study is:
2. When few teaching assistants are allocated, do all questions get responses within acceptable time? The number of teaching assistants is determined by the queuing model.

   Finally, a learners' satisfaction survey was conducted to validate the queuing model. Hence, the last hypothesis of this study is:
3. Do few teaching assistants provide adequate interactions? In other words, there should be no significant difference of learners' perceived of usefulness and satisfaction after reducing the number of teaching assistants properly.

Table 1 outlines the relationships of the three issues in the study.

Table 1. Relationships among research problems, limitations, and solutions.

Problem	Limitation	Solution
Acceptable response time	More than 80% learners agree	Preliminary survey
Minimum teaching assistants	All responses within time constraint	Queuing theory
Adequate Interactions	Perceived of usefulness	Satisfaction survey

Acceptable Response Time Determination

An ODF provides quick and easy communication, but a learning forum is not a synchronous tool. Instead, learners can take their time before responding a message. Although learners can share ideas and experiences in a learning forum, they are encouraged to ponder on messages that are permanent, asynchronous, and enabling sustained reflection (Hammond, 2000). A forum is the bridge among three characteristics, which are personal experience, theoretical insight, and circumstances. One of the key factors to facilitate reflection in an learning forum is the role of the instructor or assistant (Seale & Cann, 2000), who is not only a respondent to the questions but also an encourager in the forum (Hew & Cheung, 2008; Tagg & Dickson, 1995). It is indicated that encouragement to students can be provided by delivering a continual facilitator presence. For example, rapid and subsequent response to students' questions or comments within an average of three days makes them feel highly respected and encouraged (Hew & Cheung, 2007; Tagg & Dickson, 1995). In addition, one of the most significant features of an ODF is to offer asynchronous distributed collaboration across geographic and international boundaries. Related studies have shown that people mainly focus on the roles of information seekers, information givers, evaluators, and encouragers (Chandler, 2001); furthermore, negotiation and coordination are vital to the success of any online collaboration. Schrire (2006) also found that the achievement of synergistic interaction in computer conferencing leads to deeper learning. The findings support social constructivist approaches to learning.

Many studies also used a learning forum for other major purposes instead of interaction. For instance, Chen and Chiu (2008) showed that teachers could use and manage online discussions at the message level to promote critical thinking, facilitate discussions of controversial topics, and reduce status effects. Schellens and Valcke (2005) also showed that students process information at high cognitive levels during online discussions. That is, online discussion can promote active and critical thinking because it allows more opportunities for students to prepare, reflect, think, and search for extra information before participating in the discussion (Chen & Chiu, 2008; Pena-Shaff & Nicholls, 2004). Although many investigators have explored how satisfied distance learners are with the feedback or support provided, a report by the British Council indicated that nearly two thirds of respondents (64%) were either dissatisfied or very dissatisfied (Sampson, 2003). That report indicates that to institute sufficient student support services for advice/counseling, tutoring, and assessment, feedback is a key issue to satisfying the needs of distance learners.

Ideally an instructor would not leave any question unanswered after a period of two weeks, (Mazzolini & Maddison, 2007), especially for an Inquiry Learning Forum (ILF), in which the role of the instructor or assistant is unlike that in a general online discussion forum. The intervention of instructors or assistants is essential in ILF, although the participation of instructors is not the only indicator of the quality of forum discussions (Mazzolini & Maddison, 2003). Moreover, assistants who frequently make prompt replies are usually recognized as being more enthusiastic and professional. If the assistant or the instructor does not respond rapidly to the questions submitted by the students, the number of students who are willing to discuss in the forum might be significantly reduced. Therefore, the role of an instructor or an assistant as a main facilitator in learning forums is very important if the construction of the forum aims at providing a problem-solving area for the students.

Previous study reported that rapid and subsequent response to students within an average of three days makes them feel highly respected and encouraged (Hew & Cheung, 2008). This study investigated the opinions of the participating students and also found that most of them felt that an acceptable waiting time is about two to three days, as shown in Figure 1. Although two days should be a better choice (81.84%), the threshold of the acceptable wait time in this study is set to 72 hours (i.e. 3 days). In Figure 1, it can be seen that at least 60% of the students can be satisfied when the threshold is reached. However, a waiting time of more than 72 hours may cause much dissatisfaction. In addition, the working time of an assistant, who is usually a graduate student, is four hours per week. The mean response time spent on each question is about half an hour. The viewpoint of the assistants was also investigated in this study, and it was found that dealing with a request or question takes an assistant half an hour on average. By taking these factors into consideration, the M/M/4 queuing model is employed to evaluate the balance between the number of assistants and the waiting time of requests submitted by the students. In other words, four teaching assistants were employed at the beginning. The queuing theory uses mathematical formula to simulate messages arriving at the queue (the learning forum), waiting in the queue (unanswered messages), and being served by the servers (teaching assistants) at the front of the queue. The queuing model and the equations will be explained in the following section.

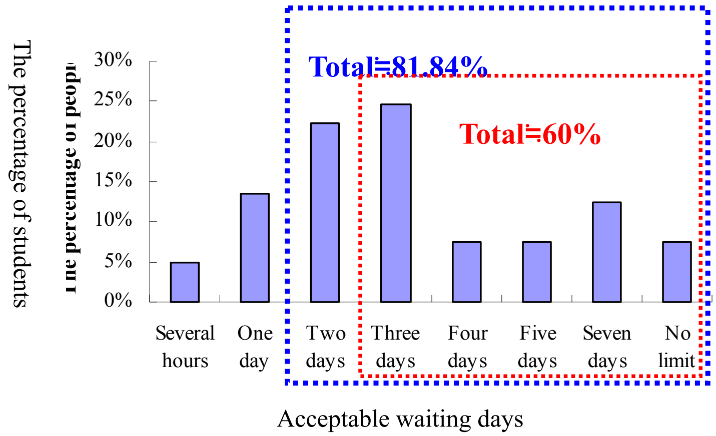

Figure 1. Acceptable wait time according to participants.

Queuing Theory Model for Teaching Assistant Allocation

For the purpose of facilitating students joining in the learning forum, the waiting time for responses to their requests should be as short as possible. Nevertheless, each assistant only works for a limited amount of time and is only capable of answering a limited number of questions. On the contrary, although having many assistants can solve the problem of answering questions, human resources and wages will be wasted. To cope with this problem, we propose a Queuing method which uses the balancing strategy. Queue Theory has been applied to solve various complex problems in the past. There have been many real-life examples of applying the Queuing method for management, such as department stores, passport control booths in airports, or other service systems (Itai, Rodeh, & Shachnai, 2002). For example, Itai, Rodeh, and Shachnai (2002) investigated the passport control problem of dynamic arrangement of the queues in a service system where each server can be in either an active or an inactive mode. In order to balance the load of the service system, the customers were assigned to the queues to minimize the maximum wait time of a customer in each active station. Due to the popularity of the Internet, Queuing Theory has been frequently applied to the task assignment problems in the distributed client/server environments (Squillante, Xia, & Zhang, 2002; Yin, Dai, Li, & Xi, 2007). For example, Son and Kim (2004) employed the Queuing method to determine the optimal number of servers for on-line request processing when multiple identical servers were provided, such that several criteria, including fast response time, high fault-tolerance, and continuous availability, were taken into consideration. In the following sections, the problem formulation and the approach to determining the optimal number of teaching assistants to meet the multiple requirements is proposed, and the experiment results of applying the innovative approach are presented.

The service discipline in this study is the FCFS (First Come First Served) scheme. The waiting model is one line and multiple servers in an infinite population, which is shown as (A/B/C): (FCFS/∞/∞), where A is the distribution of inter-arrival times, B is the distribution of service times, and C, which is finite in this study, represents the number of assistants who provide the service. A and B can be M (Markovian), D (Deterministic) or G (General). In this study, A and B are both Poisson distribution (i.e. Markovian arrival processes) because a number of messages posting to a learning forum in a fixed period of time occurs with a known average rate and independently of the time since the last message posted. Therefore, the queuing model is (M/M/4): (FCFS/∞/∞) assuming C is 4 (i.e. four teaching assistants). The number of requests or questions is conventionally infinite, which is represented as '∞'. In addition, it is assumed that the arrival times of the requests follow a Poisson distribution, and the service times are in Exponential distribution. Relevant parameters of this model are defined and interpreted in the following.

- λ (the mean of student request-submitting rate). When the mean of the submission rate is λ, the mean interval of arrival time is $1/\lambda$. That is, the greater the number of request submissions, the greater the parameter λ and the probability of submitting n requests. Therefore, while the number of request submissions in the system is n, the mean arrival rate of the requests is $\lambda_n = \lambda$. (n=0,1,…).

- μ (the mean service rate of the assistants). When the mean of the service rate of an assistant is μ (the number of times of providing service in an hour), the mean of the assistant's service time is $1/\mu$. While the number of request submissions in the system is n, the mean service rate of the assistants is μ_n. As the service time is in exponential distribution and n is infinite, we have $\mu_n = n*\mu$ (for n <c ,where c is the number of assistants) if the number of requests is smaller than the number of times service is provided by the assistants; otherwise, we have $\mu_n = c*\mu$ (for n □c) if the number of requests is larger than the number of times service is provided by the assistant and there are some requests which must wait. Symbol c represents the number of assistants, which means the most number of times service can be given at the same time. In this study, we have the following sequence: μ, 2μ, 3μ, 4μ, 4μ, 4μ, ...
- ρ (the utilization ratio). $\rho=\lambda/c\mu$, and the idle ratio is $(1-\rho)$. If $\rho>1$, the service is unstable; in other words, the number of assistants is not enough to handle all of the requests (the waiting probability is 100%). When ρ is convergence ($\rho<1$), the service is stable, and the service status can be calculated by applying the following formulas.

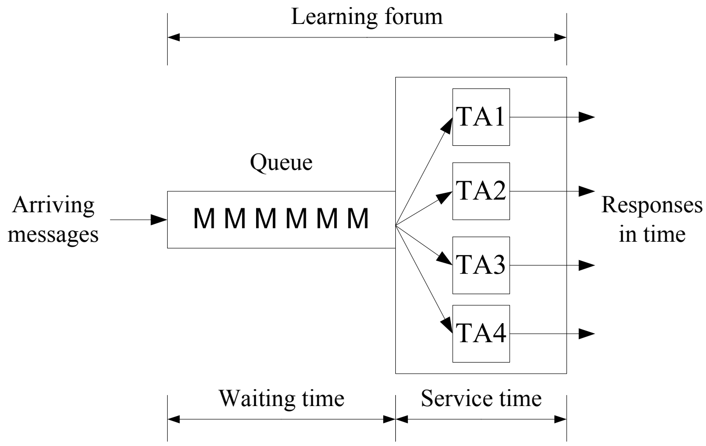

Figure 2. Interaction model of a learning forum on queuing theory.

Figure 2 illustrates the model of a learning forum based on the queuing theory. The model is restricted to two conditions. First is the FCFS discipline. Second is the service is stable (i.e. $\rho<1$). The expected response time, denoted as ET, is equal to expected waiting time (denoted as EW) plus service time ($1/\mu$). Hence, the evaluation function of the mean time that each request spends before getting feedback is

$$ET = EW + \frac{1}{\mu} \tag{1}$$

In other words, the ET of equation (1) should be less than 72 hours in this study. However, the expected waiting time of equation (1) depends on the expected number of requests in the waiting queue, denoted as L_q. If we can find L_q, the EW of equation (1) can be calculated by $EW = L_q/\lambda$. To model the L_q, the probability of n messages in the queue is first denoted as P_n. Then, the L_q can be represented as the following equation (2) based on the assumption of four teaching assistants (i.e. C is 4).

$$L_q = P_5 + 2*P_6 + 3*P_7 + 4*P_8 + 5*P_9 \ldots \tag{2}$$

There will be only one message in the waiting line when five messages were posted into the learning forum. Because there are four teaching assistants, the probability of P_1, P_2, P_3 and P_4 is zero. If a steady state exists, we obtain the following balance equations, including $\mu P_1 = \lambda P_0$, $2\mu P_2 = \lambda P_1$, $3\mu P_3 = \lambda P_2$ and so on. Equation (3) can be derived from equation (2) by substituting for those balance equations.

$$L_q = \frac{(\lambda/\mu)^c \rho}{c!(1-\rho)^2} P_0 \quad \text{, when } \rho<1 \text{ and n is infinite.} \tag{3}$$

Hence, the logical first step of the problem is to solve P_0 (i.e. the probability of no request submitted to the system). The derivations of equation (4) can be found in the book, Fundamentals of Queueing Theory (Gross & Harris, 1998).

$$P_0 = 1/\left(1+\sum_{n=1}^{c-1}\frac{C^n\ \rho^n}{n!}+\frac{C^c\rho^c}{C!(1-\rho)}\right), \text{ when n is infinite and } \sum_{n=0}^{\infty} P_n = 1.\ (M/M/C/\infty) \qquad (4)$$

Adequate Interaction Validation

To evaluate the performance of the Queuing model, an ODF for learning by asking in a vocational senior high school was employed in the Concepts of Computer Science course, and the data of the forum was analyzed by applying our innovative approach. The students attended three hours in a traditional classroom every week. After class, the students could ask questions in the learning forum. There were 40 vocational high school students participating in the learning forum. There were two experimental stages and the duration of each stage was four weeks. After each forum activity stage, the participant feelings of the learning forum, including the perception-of-usefulness and the perception-of-satisfaction with the response wait time were investigated using a questionnaire revised from TAM (Technology Acceptance Model). There were 3,042 records in the forum at the end of the eight weeks. One hundred and seventeen questions were asked and discussed.

The learning forum was implemented in a Moodle system shown as the right part of Figure 3. There were 94 questions with correct responses and, 23 questions with incomplete answers on the day the experiment ended. The system flow to respond in time is shown as the left part of Figure 3. After a student asked a question in the learning forum, the question would be pushed into the queue where it would wait for a teaching assistant or peer to respond to it. If a question was not responded to or solved, it would be pushed back into the queue again, depicted as two diamond symbols in Figure 3. The dotted lines connect the system flow with examples in system implementation to demonstrate the processes of the Queuing theory model. Among the replies, 18% were provided by other students (i.e. peers) in the forum, while 82% were given by the assistants. From the records of the system database, the mean of questions received per week was about 15 messages (i.e. posts) in the learning forum.

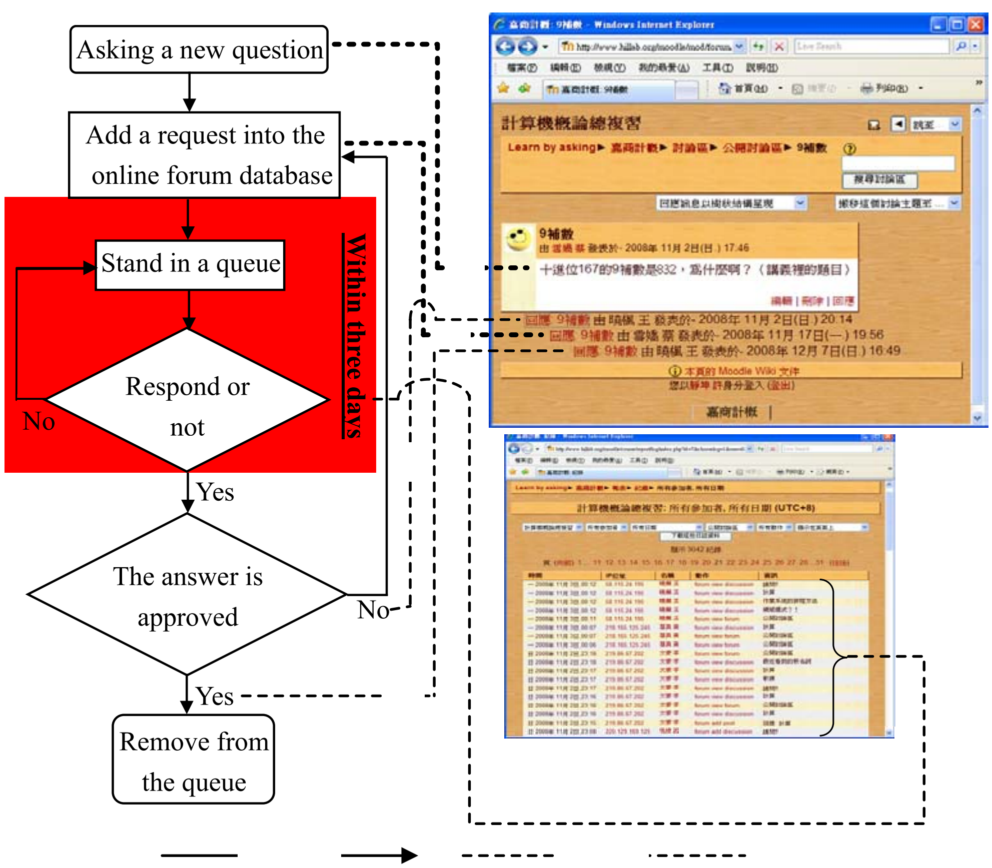

Figure 3. System flow and implementation to provide adequate interaction.

Use Queuing Model to Analyze Results

As an assistant serves 4 hours per week and the cost of an assistant is about thirty USD (one thousand New Taiwan dollars) per week, it is essential to appraise the statistics for a multi-serving of assistants by M/M/C because too many assistants will waste human resources, while too few assistants will affect the service quality in the learning forum. By employing Lingo (a simulation program), the parameters of the M/M/C model with an infinite population can be obtained, as shown in Table 2 where C represents the number of assistants, P_0 represents no message in the queue, EW represents expected waiting time, ET represents expected time, and L_q represents expected number of questions in the queue.

Table 2: The evaluation of response time by Queueing model (M/M/C) :(FCFS/∞/∞) for learning forum

C	P	P_0	EW	ET	L_q	Pwait= @PEB(arrival,servers)
1	Unstable	●	●	●	●	●
2	Stable	0.0322580	0.9072581	1.032258	15.48387	0.9072581
3	Stable	0.1322314	0.4030440	0.486377	2.52066	0.3873967
4	Stable	0.1492353	0.0085097	0.133509	2.00264	0.1446660

The anticipation results show that the mean expected response time in the M/M/3/∞ model is 3.404639 days (ET=0.486377 week) whereas the expected response time in the M/M/2/∞ model, which is 7.225806 days (ET=1.032258 week), is more than a week. Moreover, the expected waiting time in the M/M/2/∞ model, which is 6.3508067 days (EW=0.9072581 week), is more than the expected waiting time in the M/M/3/∞ model, which is 2.821308 days (EW=0.403044 week). The expected waiting time in the M/M/3/∞ model is just below our acceptable response time although its expected response time is a little bit higher than the threshold. Consequently, the result recommends that it would be better to hire three assistants because the expected waiting time of the requests is fewer than three days, which is acceptable. In fact, based on the Queueing theory prediction, the expected request wait time will be less than one day if there are four part-time teaching assistants.

From the viewpoint of educators, both the frequency and the quality of the interactions between instructors and students are important factors in learning forums. In order to ensure that the request channel is unobstructed and the wait time for replies is within a tolerable range, the Queuing approach was introduced in the experiment. When it is supposed that the number of requests is unlimited in Figure 4, the dotted lines are the cost of human resources, which increase as the working days and the number of people increase. In contrast, the object lines are the probability of the request wait time in the three situations, which decreases when the number of assistants increases. It can be seen that the determination of the number of assistants and the service quality is a trade-off. Furthermore, in practical applications, the factors for predicting the number of assistants and the expected request wait time can be much more complex. For example, different assistants who work in different time zones scales might give more diverse results.

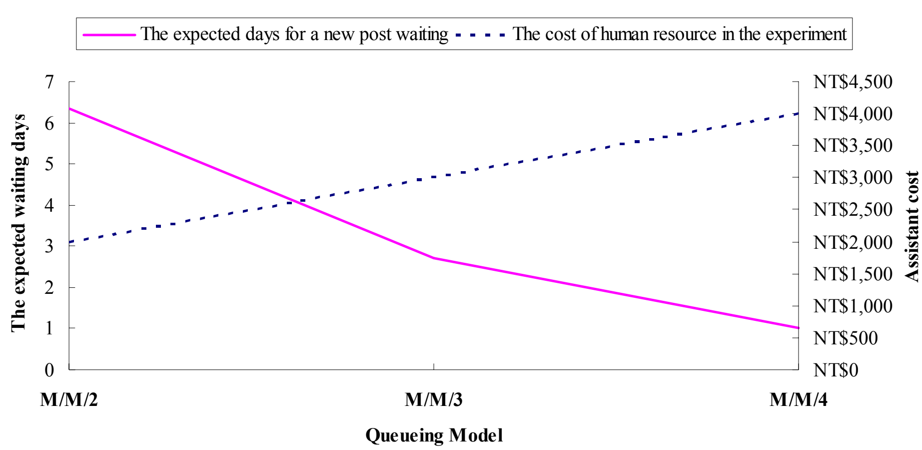

Figure 4. The relationship among number of assistants, waiting time, and cost-effectiveness.

Validate Prediction of Queuing Model by Survey

This study not only provided a place for students to ask any question about the concepts of computer science, but also hired assistants to answer the questions. Widanski (2003) recommended learning through asking questions. He said that the hours spent in the classroom are merely part of the real work of learning. His classroom research showed that good students ask more questions and learn more (Widanski, 2003). One of Widanski's basic assumptions is that all learners' questions got responses. It was found that most of the questions were solved by the assistants, but nearly 18% were discussed and solved by the students themselves. All of the topics were related to the concepts of computer science. In other words, the students did not use the forum to chat about other topics. The forum therefore achieved the goal of providing an assisted learning platform for asking questions outside the classroom. The main language used in the forum was Chinese.

Based on the queuing model, both of M/M/4 and M/M/3 can fit the research assumption that is to answer a response within three days. The practical issue of this study is whether learners can accept having fewer teaching assistants or not. To test the hypothesis, an experiment of measuring learners' acceptance was conducted. There were two experimental stages. In the first stage, four assistants were allocated to the forum during the first four weeks. In the second stage, three assistants were allocated, and every assistant served four hours a week during the two experimental stages. The question of interest was whether the forum contributions would become lower or whether the students would feel that they had to wait too long for responses as a result of the reduction in assistant numbers. There was an in-depth investigation after each experimental stage.

In order to ensure that applying the queuing model to allocate the number of assistants did not have obvious side effects, such as reducing the interest or satisfaction of the learners, the questionnaire that was revised from TAM was used to investigate the participants after each experimental stage. To ensure reliability of the tool, the fourth item in original TAM was deleted to make the Cronbach's alpha increase from 0.844 to 0.906. The internal consistency of the satisfying part can be accepted (Cronbach's alpha is 0.886). The items in the questionnaire use a 7-point Likert scale, where 1 = strongly disagree and 7 = strongly agree. The number of assistants in the second experimental stage was recommended by the predicted results of the Queuing approach. The number of assistants hired in the first stage was greater than the number of the prediction result. The number of valid questionnaires acquired in both experimental stages was 34. The participants in the first experimental stage were the same as those in the second experimental stage. It was found that there was no significant difference between the first stage and the second stage in terms of the perception-of-usefulness (0.096 > 0.05) and the perception-of-satisfaction (0.374 > 0.05) according to the paired-sample T tests, as shown in Table 3.

Table 3: The paired-samples T test after reducing the number of teaching assistants.

	Perceived-of-Usefulness		Sig.	Perceived-of-Satisfy		Sig.
	Mean	Std.	(2-tailed)	Mean	Std.	(2-tailed)
First experimental stage (4 teaching assistants)	4.79	0.862		4.41	1.365	
Second experimental stage (3 teaching assistants)	4.58	0.944	0.096	4.22	1.008	0.374
	Non-significance			Non-significance		

Accept hypothesis

CONCLUSIONS

The popularity of the Internet has encouraged educators to pay more attention to the behaviors and effects of learning communities in cyberspace. Many teachers or assistants use the Internet as a medium to interact with students, including answering requests or questions submitted by students online. An ODF is one of the most popular tools on the Internet for teachers and assistants to interact with students asynchronously. In recent years, an increasing number of teachers have been using learning forums in the courses they teach. Since the number of requests or questions submitted by students might be large, to promptly respond to the students, it would be necessary for teachers to hire an appropriate number of assistants to help them answer the students in a timely fashion. In this study, the Queuing approach was applied to determine the appropriate number of assistants needed, taking the number of requests and the cost of human resources into consideration. As part of our study an experiment on a vocational high school class was conducted to demonstrate our innovative approach. The results show that the assistant number predicted by the approach did satisfy the demands of the learners. For future research, we plan on considering more factors, including the different costs for hiring assistants with different backgrounds in different time zones, various arrival rates of requests in different time zones, and the difficulty of individual requests.

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