

Enhancing virtual learning team performance: A leadership perspective

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Abstract. Debate abounds over whether the virtual team is an effective substitute for the traditional F2F team and can sustain itself. Drawing upon literature on leadership, trust, computer-mediated communication, and teams, we propose a theoretical model of online learning team effectiveness. A quasi-experiment was conducted to empirically test the impact of trust, trust propensity, leadership effectiveness, and communication frequency on virtual learning team satisfaction and performance. The results of PLS support the majority of our hypotheses. Trust serves a mediating role in the relationship between leadership effectiveness and team satisfaction and performance. Theoretical and managerial implications are discussed at the end of the paper.

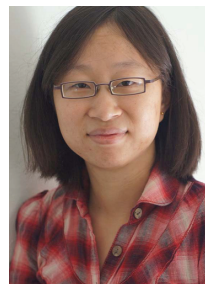
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Virtual team learning is becoming a prevalent practice in business and academics. Perhaps the most intriguing and productive benefit of virtual team learning is its value in promoting peer-to-peer interactive communication. Unlike the traditional team, virtual learning team is not constrained with geophysical distance. As a result, a team member can be exposed to a wider range of perspectives from other members in the virtual team than in the traditional team.

The proliferation of Web 2.0 technology (e.g., Google Doc., Facebook, Twitter, Instant Messenger, Weblog, Wiki) further eases the socialization and communication process. Many learners begin applying the Web 2.0 technology to facilitate their learning process and open themselves to diverse participation. However, diverse participation without proper coordination can lead to chaotic and ineffective learning. A cursory observation of the general use of Web 2.0 technology shows that not every media attracts equal attention, and not every user of each media expends the same efforts in enriching the content. Simply having virtual learning team members adopt the social media does not guarantee that learning effectiveness can be achieved. This observation causes one to wonder what it takes to successfully manage a virtual learning team.

In this paper, we attempt to investigate how a leader's effectiveness can influence the effectiveness of a virtual learning team. In addition, the relationships between trust, trust propensity, and communication frequency

are examined and their impact on virtual learning team effectiveness are assessed.

1. Virtual learning teams and leadership

Virtual teams operate across spatial and time difference via electronic means [59]. They are formed according to tasks, membership and roles [14]. The virtual form has many advantages over collocated teams in which team members are physically located together, such as the flexibility of team coordination and reorganization, reduction of travel budget, frequency of communication, and fast responses to customers' needs [33].

Virtual teams formed in an e-learning program have a definite set of tasks to complete within a predetermined length of time. The instructor is a project manager who approves or disapproves the project outcomes delivered by the virtual learning team. Team members can alternate roles as either a project manager or a team member. Despite the difficulty of establishing social goods (e.g., trust) and aggregating the disparate interest of virtual team members, virtual teams designed for learning purposes often have clearly stated educational goals, such as the deadline of assignments, course materials to study, and exams to take. "The best predictor of a virtual team's success is in the clarity of its purpose and the participatory processes by which the group achieves it" [30]. As such, it is plausible that it is easier to establish a virtual community in the higher education than in a business context.

2. Learning effectiveness of virtual team

Like any e-learning technology, virtual learning teams also need to address the desired pedagogical goals [13]. Effective learning models include the traditional classroom, constructivism, and collaborativism [12]. The focus of traditional classroom learning is the dispersion of information, rather than information processing. Its primary weakness is the lack of an active learning process [11]. Experiential exercises are effective approaches in improving communication skills, building self-confidence and motivating knowledge-sharing among team members in the traditional classroom [52]. Constructivism focuses on the knowledge construction process and is an inductive approach to improve knowledge transfer effectiveness of a learner. Collaborativism differs from the other two

learning models in that it exposes students to diversified ideas and provides a more realistic learning context [13]. Potential benefits are the improvement of shared understanding, communication and listening skills, and participation.

Collaborative knowledge creation and sharing activities have been evident in a wide range of forms, such as the vertical organizational integration in a supply chain to reduce uncertainty and improve transactional efficiency [43], virtual laboratory and professional virtual communities, and online learning communities. In the online learning community, collaborative learning is an active learning approach to advance one's knowledge and to solve class problems in a collaborative fashion [38].

Team-based learning in a cooperative mode is more effective than learning in an individual or a competitive manner to improve a student's (1) higher-level reasoning skills, (2) new ideas and procedural innovation, (3) critical thinking skills, (4) more creative responses [13], and (5) a higher motivation to learn [12]. The instructor is a coach who facilitates the learning process. Students need to actively engage themselves in the team-based learning process to succeed in collaborative learning, discovery learning and high order reasoning [47]. However, it is more challenging to have effective collaborative learning in a virtual space than in a physical space.

Interpersonal relationships in a virtual team are more fragile because of a lower degree of internal communications and cohesiveness and the absence of contextual factors such as social cues and social presence. Based on group formation and process theory, interpersonal contexts are a prerequisite to the formation of virtual teams [41]. A lack of social context may result in doubt, distrust and suspicion among team members, which inhibits the operation of the virtual team. The fast fluidity of team formation can also potentially weaken the cohesiveness of virtual team [4].

The satisfaction or dissatisfaction of team members in a virtual learning team is attributed to intrinsic and external factors [55]. Motivation-hygiene theory [22] asserts that job satisfaction is more related to intrinsic factors (recognition, achievement and responsibility), whereas job dissatisfaction is more closely related to external factors (e.g., salary and work conditions). Many studies of e-learning also validate this proposition. Intrinsic factors, such as computer self-efficacy of learners [6], degree of engagement into online activities [31], and a strong sense of community [1], can help improve satisfaction of e-learners. In contrast,

external factors, such as poor course design and instruction quality [35] and ease of use of e-learning systems [20], can result in attrition of and complaints about e-learning programs. Improving external factors, such as the social presence factor of e-learning systems (adding video feature to the audio-based lecturing) [20], and the usability of e-learning systems [60] did not significantly improve the satisfaction level of e-learners.

This finding leads to speculation that improving the internal management process of an online learning community via leadership is a potentially effective approach to improving satisfaction levels of members. It is a challenge to ensure that team members participate and support the online learning activities, given that they are affected by uncontrollable extraneous factors that are not directly related to learning tasks [14] throughout the course. Team governance is an issue that has been underestimated. In particular, the lack of effective leadership is one key inhibitor of virtual team success. Without this important factor, accomplishing the predetermined learning goals in a virtual team may be difficult.

3. Leadership effectiveness

There are three established theories in leadership effectiveness: trait theory, contingency theory and behavioral complexity theory. Trait theory assumes that a leader is "born, not made". An organization is more likely to succeed when led by individuals with leadership traits. The complexity of internal and external environments has rendered the viewpoints less valid in virtual teams, where the missing social/context cues [62] caused by technological incapability can potentially undermine strong leadership traits, such as charisma and social status.

Contingency theory emphasizes the degree of fitness between leadership roles and external environment. Leadership roles can be classified into task- vs. relationship-based leaderships based on the least preferred co-worker (LPC) instrument [23]. Task-centered leaders emphasize task accomplishments and achievements of subordinates, while relationship-centered leaders emphasize interpersonal relationships between coworkers and their emotional needs. This bipolar view oversimplifies the behavioral complexity of leadership roles and may overlook innumerable social contingencies in the virtual environment, such as the use of anonymity to sidestep conflict interests and malicious attack of others to gain popularity.

Behavioral complexity theories assume that a leader needs to possess multiple roles to succeed in a rapidly changing environment [48]. These theories further identify the number of behavioral repertoires an effective leader needs in order to succeed in a complex environment. Paradox and contradiction are common phenomena in a complex environment. A leader needs to have the ability to deal with them by playing competing or contradictory roles, if necessary, to move the entire team toward the accomplishment of team goals. Under this view, the contingencies of leadership in the virtual team can be analyzed more appropriately. We focus our attention on this theory and its connections to leadership effectiveness in the virtual environment.

Leadership effectiveness is defined as the effective utilization of limited resource to achieve objectives [3]. Extant literature investigates leadership effectiveness from various perspectives and dimensions, which is summarized in Table 1. The relevance of these variables varies with the research objectives and could have very different results in different situations.

The rapid advance in information systems enables a greater overall integration of technical, human and organizational systems than the traditional environment [2]. Therefore, measures of leadership effectiveness in the virtual environment also need to incorporate multiple dimensions. A review of leadership literature reveals that there are at least four approaches to measure leadership effectiveness: (1) objective versus perceptual measures, (2) acceptance versus rejection of the leader, (3) individual versus group performance measures, and (4) productivity versus satisfaction.

4. Research design

The theoretical framework is shown in Fig. 1.

4.1. Predictors of team trust

Social exchange theory discusses interpersonal exchange of intangible social costs and benefits [28]. Reciprocation among individuals is not recorded explicitly in the social exchange process [8], hence the success of the social exchange process relies on the beliefs of exchange partners [44]. Team members need to have a strong belief – trust – at the outset of the team formation in order to accelerate the social exchange process.

An individual's trust orientation or propensity to trust is a stable personality trait – that is, the willingness to trust others [49]. This orientation can directly or indirectly affect the degree one trusts [57, 58]. Team members' actual contributions to the team project are fundamental to the success of a virtual team project. A stronger orientation or propensity to trust can lead to actual trust. It is important to incorporate the trust factor into the design of a virtual team [25]. Hypothesis H1 states that the propensity to trust can directly affect the degree of actual trust. Specifically,

H1: The higher a team member's propensity to trust others, the higher degree of team trust a virtual community member perceives.

A leader is essential in executing and monitoring a project and dealing with roadblocks [14]. In the field of

Table 1
A review of leadership effectiveness dimensions

Researchers	Dimensions of leadership effectiveness
Reddin (1970)	Achieve objectives.
House (1971)	Motives of subordinates, job satisfaction and popularity of a leader
Vroom & Yetton (1973)	Decision quality and popularity of a leader
Fildler (1974)	Objective measurement of team performance; that is, levels of objective being achieved. For instance: productivity and job performance
Dansereau, Graen & Haga (1975)	Job performance, satisfaction and turnover rate
O'Reilly & Roberts (1978)	Performance, satisfaction and organizational commitment
Hersey & Blanchard (1982)	Matching leadership styles with the degree of sophistication of subordinates
Hunt & Osborn (1982)	Actual job performance and satisfaction levels related to results
Hoy & Miskel (1987)	Reputation of a leader, accomplishment of organizational objectives, satisfaction of team members
Yukl (2002)	The degree of objective accomplishment by the leader's team or organization
	Attitudes of subordinates toward their leader
	Perceived performance for the contribution of a leader to his team viewed by outsiders (third party) or subordinates

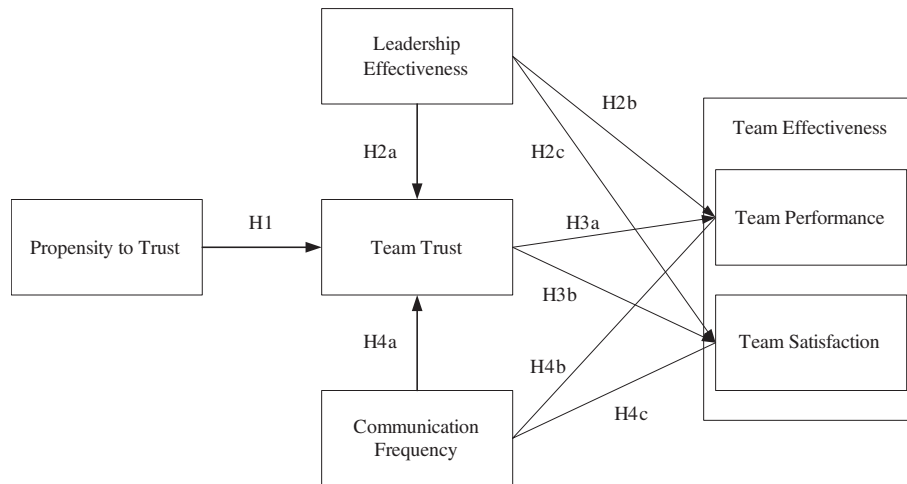


Fig. 1. Proposed theoretical framework.

organizational dynamics, leadership is one of the critical success factors for team cooperation [29, 50, 58, 61]. Virtual teams differ from F2F teams primarily in that a team leader heavily depends on information systems to lead and communicate with team members, as well as to disseminate and transfer information. IT as a primary communication channel can potentially undermine the capability of a leader to exercise his/her leadership in the virtual team [3].

A leader is a “relationship mediator”. An effective leadership strategy is to build relationships among team members and encourage understanding and caring for one another. This strategy can help improve the overall degree of trust [36]. Positive leadership can help build trust quickly and continuously maintain trust relationships [13]. This leads to H2a:

H2a: The higher leadership effectiveness a virtual learning team member perceives, the higher degree of trust she or he has.

A team needs to proactively engage in an effective communication process to build trust, such as providing relevant information and timely feedback [57]. Communication is one of the most important tasks for the success of a team project. The Project Management Institute asserts that a project manager spends about 98% of his/her time on verbal and nonverbal communications. Trust is the direct output of communication [33]. Hence, we propose,

H4a: The more frequently team members communicate with each other, the higher degree of trust a virtual learning team member has.

4.2. Predictors of team effectiveness

Team effectiveness is about whether a team can successfully achieve its predefined goals. Two major measures for the success of team performance include performance and attitudinal indicators. A performance indicator is concerned with the percentage of goals being achieved, while an attitudinal indicator is concerned with the team relationship [15, 36]. The former indicator can be further measured subjectively [18, 36] or objectively [15] – if the project goals (scheduling, scope, budget, quality) stated at the beginning of a project have been achieved. The latter indicator can be assessed by the satisfaction measurements in cooperation, team, team members, job [15], results [40] and the decision making process [53]. Literature on leadership and team effectiveness indicates that leadership effectiveness can help predict team effectiveness in both performance and satisfaction levels [25, 42].

H2b: The higher leadership effectiveness a virtual team perceives, the higher team performance a virtual learning team achieves.

H2c: The higher leadership effectiveness a virtual team perceives, the higher team satisfaction a virtual learning team has.

Trust is an important factor for the success of a virtual team. As important as the team goals, trust is the emotional link that connects members of a virtual team [30]. Despite this, it is easier to engender mistrust interference in the virtual team because of dissimilar backgrounds of team members and the lack

of social contexts. Many studies [57, 58] have found evidence supporting their argument on the importance trust among team members has on the success of a virtual team. Respected leaders need to earn trust from their team members in addition to possessing superior knowledge and power [21]. Trust is an efficient mechanism to improve communication efficiency and team cohesiveness.

A seminal study about the critical success factor of virtual teams at IBM, Sun Microsystems and Motorola found that trust is the prerequisite to the success of virtual teams [30]. The physical distance among team members [39] and the necessity of building trust at the outset of virtual team formation further substantiate the importance of trust issues in virtual teams. To succeed in a virtual team, a higher level of trust needs to be established at the beginning and ending periods of a project implementation [57]. In the early stages of project implementation, trust can be improved by (1) active social exchanges, (2) communications conveying enthusiasm, (3) the ability to cope with technical and task uncertainty, and (4) initiative among members [34]. Trust can be improved in the latter stage by having (1) equitable, regular and predictable communication, (2) substantive and timely response, (3) strong leadership, and (4) message transitions from procedural to task focus. Trust is a multidimensional construct comprised of cognitive (competence) and affective (emotional connections) elements [34]. Affective elements of trust are more important than cognitive elements in a fragile environment like virtual teams [9]. Virtual teams must quickly form trust [9]. Relative importance of the cognitive versus affective aspects of trust is contingent upon the type of social relationship, situation, and system [34]. A virtual learning team that nurtures trust throughout the team operation process will naturally lead to higher team effectiveness than virtual teams in other forms.

H3a: The higher trust a virtual learning team member perceives, the higher team performance a virtual learning team achieves.

H3b: The higher trust a virtual learning team member perceives, the higher team satisfaction a virtual learning team has.

We believe that critical success factors for a virtual team are not much different from a traditional team. Teams in both forms need a clear purpose [26], measurable goals, smaller team size of 3–12 people [30], establishment of team norms or operating guidelines [46], effective communication and decision making

skills and processes [19], and team interactions [37]. Virtual teams primarily differ from F2F teams in their heavy reliance on information communication and technology (ICT) media as a link between people and the purpose for communication [30]. Four dimensions determine the degree of digitalization for a virtual team: geography, time, organization and culture [29]. The higher one of these four dimensions, the higher degree a virtual team needs to rely on the support of ICT. ICT links can be either synchronous or asynchronous tools to perform interpersonal communications, collaboration and coordination [39]. Synchronous ICT tools vary with the dimensions of social presence and information richness, and can be classified as text-, audio- and video-conferencing systems. Asynchronous ICT tools include e-mail, discussion forms, bulletin boards, workflow, scheduling and other PM applications. Regardless of the communication channels, the more frequently virtual learning team members communicate with one another, the more likely they are to exchange information and learn from one another. As a result, team members can increase their learning effectiveness.

H4b: The more frequently team members communicate with each other, the higher performance a virtual learning team achieves.

H4c: The more frequently team members communicate with each other, the higher satisfaction a virtual learning team has.

5. Research method and procedure

5.1. Procedure

We conducted a quasi-experimental study to examine the relationships among the proposed theoretical constructs – team trust, team effectiveness and their predictors. Data collected were used to test the proposed theoretical framework and hypotheses. One hundred and seventy-eight undergraduates enrolled in an online MIS course of a private university in Taiwan participated in this experiment. These subjects were randomly grouped into fourteen virtual learning teams. Each team was comprised of twelve to thirteen subjects.

Instructors met with students online throughout the semester. Five mediated-communication channels were made available to students to support their team-based learning activities. F2F meetings were conducted only three times. The first F2F meeting was for the instructor to demonstrate and train participants to use

the adopted e-learning system. The instructor deliberately created a virtual meeting room for each team on the e-learning system. The meeting room was private and only accessible to members of the same team. The instructor e-mailed all participants and directed them to a message announced on the system's bulletin board. This first announcement detailed the operational process of virtual learning that students needed to follow in this course:

- Step 1. Subjects needed to find their virtual learning team and team members from a list of names. Each member needed to log on to the meeting room and post a message to introduce himself/herself to others.
- Step 2. Team members needed to choose a team leader by themselves. The election process forced the interaction among members and can help connect the team members.
- Step 3. Five online communication channels—MSN, e-mail, online synchronous and asynchronous meeting rooms, and messenger—were open to the use of each team. Each team and its members reserved the flexibility to use these channels at their convenience.
- Step 4. The chosen leader did not need to write reports. The leader's responsibility was to lead the team, advise members in composing the team's report, and direct team members to places or people where correct information can be located and problems can be solved. Team members needed to deliver the projects without leading the project.
- Step 5. Team members needed to work with each other for six weeks. To mitigate the potential influence of the scope and the difficulty of different cases, all cases studied were chosen from the website <http://digitalenterprise.org/cases/index.html>. Cases posted on the website include America Online, Classmates, Ofoto, Dell Computer, etc. Instructor randomly assigned a case to a virtual team. Each case includes at least two questions. Supporting materials are also provided for virtual team discussion. For instance, questions about America Online were: (1) What factors help explain AOL's ascendancy to the largest online subscription service? and (2) What is the strategy behind AOL's merger with Time Warner? Why did it fail? Question about Classmates were: (1) How does Classmates make money? (2) How do the membership tiers differ? and (3) What explains the success of Classmates in converting members into

paying subscribers where others have failed? The deliverable of the team effort was a team report on a chosen case. This report needed to include five sections in the following order: (1) introduction of the chosen case, (2) Q&A, (3) case analysis and findings, (4) location of a local e-business as the second case, and (5) search for relevant materials and proposal of a new e-business topic for in-depth analysis. Guidelines were provided for students to write the first three sections, whereas the other two sections had no guidelines for students to follow.

5.2. *Assessment*

Team members evaluated the effectiveness of their leader, and in turn the leader evaluated the contribution of team members to the team project. The mutual evaluation process is designed to motivate the team towards accomplishing team goals. To facilitate the communication process among team members, five communication channels were made available to them: messenger, E-mail, online synchronous meeting room, online asynchronous meeting room, and chat room. MSN is a many-to-many communication medium that allows the transfer of image, video and files. Users can create pseudonyms to interact with others for entertaining and learning purposes, while still retaining privacy. This medium is the most popular tool among users in this study. E-mail is an online asynchronous communication medium that allows the transfer of text and voice. Users can compose, forward, reply and receive e-mails. A private online synchronous meeting room was assigned to each virtual learning team. All participants can view only the discussion threads in their meeting room, to avoid the influence of other team members. Only the instructor and researchers can oversee all meeting rooms. In addition to posting messages, users can upload files, send e-mail and discuss with each other asynchronously. The team has flexibility to customize its meeting rooms for its members. Naming the team is impersonal and in the numerical order. The chat room has the voting features. The instructor can store video-based course materials in the chat room. Team members can write messages for asynchronous communication. The chat room also allows users to leave messages and create user directories. Unlike an asynchronous meeting room, this chat room is open to the public. Most participants had not adopted the use of chat room. Instructor collected the usage information captured by all communication channels other than e-mail and used it to track the team activities and to stop

Table 2
Operational schedule of the experiment

Week	Schedule	Main team activities
1	2004/10/7~10/14	1. Announcement of randomly grouped teams and guideline to prepare a report 2. Team members self-elect their leader
2–6	2004/10/15~11/18	November 8 is the deadline for the submission of term report and communication history
	2004/11/19	End the six-week team project by having members fill out the questionnaire

Table 3
Descriptive statistics

Construct	No. of items (before PCF)	No. of items (after PCF)	Mean	S.D.	Cronbach's α
Leadership effectiveness	5	5	3.83	0.71	0.95
Satisfaction	3	3	3.85	0.67	0.90
Trust	6	2	3.75	0.69	0.81
Trust propensity	4	3	3.55	0.52	0.77
Performance	1	NA	76.84	7.64	NA
Communication frequency (Synchronized)	1	NA	63.19	22.56	NA
Communication frequency (Non-synchronized)	1	NA	26.50	13.90	NA

malicious team activities, if necessary. The operational schedule is shown in Table 2.

5.3. Measurement

The measure of leadership effectiveness is adapted from a leadership study [61]. Team members assessed their virtual team leader's (1) performance, (2) managerial success, and (3) overall managerial effectiveness. Team trust is assessed with [57] measurement. A member's propensity to trust is measured with the instrument of a study on virtual team trust [54]. Communication frequency was calculated by (1) adding the number of posted messages and articles and dividing by the number of team members to obtain the frequency of asynchronous communication among team members; and (2) adding the number of participants who joined the MSN discussions and dividing by the number of team members. This study did not control and collect information about the use of e-mails.

Team effectiveness is measured by team learning performance and satisfaction of team members. To measure learning performance, the instructor and his teaching assistant assessed the quality of the team reports for a final grade. The grades were determined based on the rigors, creativity and formatting of reports.

The final grade was in three ranking orders: high (above 85 points), middle (84–75 points) and low (below 74 points). Team satisfaction was based on the assessment of subjects' emotions and future prospects for their virtual team with an instrument from a group and organization study [17]. All items of these instruments are on a five-point Likert scale.

6. Results

The psychometric properties of the measurement instruments were assessed with regard to reliability (internal consistency), discriminant validity and convergent validity (construct validity). Table 3 shows the descriptive statistics of major variables and Cronbach's α . Four items of trust and one item of trust propensity were deleted because of their low loadings on their corresponding constructs after factor analysis. The average leadership effectiveness, satisfaction, trust, and trust propensity are above average (mean > 3). All constructs measured by multiple items exhibit a α value higher than the acceptable level $\alpha = 0.7$. Overall, the reliability of the measurement scales is reasonably good. Table 4 provides the rotated loadings of principal components factor analysis. The results indicate that indicators load

Table 4
Factor analysis

	LDE	TRU	PRO	SAT
LDE1	0.885	0.082	0.193	0.163
LDE2	0.878	0.209	0.143	0.150
LDE3	0.900	0.116	0.160	0.168
LDE4	0.862	0.071	0.037	0.253
LDE5	0.855	0.030	0.069	0.344
TRU1	0.089	0.891	0.105	0.229
TRU2	0.186	0.804	0.230	0.262
PRO1	0.087	0.015	0.834	0.080
PRO2	0.068	0.200	0.757	0.216
PRO3	0.266	0.224	0.753	0.250
SAT1	0.288	0.175	0.195	0.761
SAT2	0.263	0.240	0.212	0.844
SAT3	0.315	0.015	0.230	0.804

LDE: Leadership effectiveness; TRU: Trust; PRO: Propensity to Trust; SAT: Satisfaction; Total Variance Explained: 81.2%.

more strongly on their corresponding construct (>0.70) than on other factors in the model (<0.40). Table 5 shows the correlations among constructs, Fornell consistency, and the average variance extracted (AVE). To assess discriminant validity, AVE should be larger than the correlations between constructs, i.e., the off-diagonal elements in Table 5 [5, 63]. All constructs meet this requirement. Similar to Cronbach's α , composite reliability is a measure of internal consistency. Unlike Cronbach's α , the composite reliability accounts for the actual loadings used to construct the factor score, and thus is a better measure of internal consistency. All composite reliability values (for constructs measured by multiple items) are greater than 0.80, indicating a good internal consistency.

Common method variance is a potential threat to internal validity, particularly in research using surveys to collect responses in a single setting. A factor analysis was performed to test for the potential of common method variance in the data set. According to Harman's one-factor test, the threat of common method bias is high if a single factor can account for a majority of covariance in the independent and dependent variables [45]. Our factor analysis did not detect a single factor explaining a majority of the covariance, so common method variance should not be a serious problem. Furthermore, data on team learning performance and communication frequency were not collected from survey respondents. Instructors evaluated team performance. And the e-learning system captures information

about communication frequency. Hence, common variance bias should not be a concern for this study.

6.1. Hypotheses testing

Structural equation model (SEM) needs to have a minimum of 15 cases or subjects per measured variable [32]. This study collects data from 178 subjects, which satisfied the required sample size. We use PLS Graph Version 3.00 to test the structural equation model (SEM). Bootstrapping was applied to evaluate the statistical significance of path coefficients [63]. Re-sampling technique establishes confidence intervals based not on assumptions such as multivariate normal distributions but on repeated samples from the researcher's own data. Thus, the normality of the survey data will not influence the PLS results. As shown in Fig. 2, exogenous variables explain considerable proportions of the variance—the R^2 for the endogenous variables ranges from 0.24 to 0.49. Examining path coefficients reveals that seven hypotheses are supported. Trust is significantly associated with team satisfaction and performance (H3a and H3b). Leadership effectiveness is strongly linked to satisfaction, performance, and trust (H2a, H2b, H2c). Communication frequency is only related to team performance but not any other constructs proposed. And finally, trust propensity is a strong predictor of trust (path coefficient = 0.38)

Next, we test the mediating effect of trust. Three conditions are essential to justify the existence of a mediation effect [51]. First, there should be a strong relationship between the independent and dependent variables. Second, independent variables have to predict the mediating variable, and the mediating variable has to predict the dependent variables. Finally, the path between the independent variables and dependent variables should decrease when the mediating variable is added.

Hence, to test the mediating role of trust, two additional structural equation models were run. One is a fully mediated model (with no direct link between independent variables and the dependent variables), and the other is a model without mediating variable (trust). Table 6 shows the PLS path coefficients of the two additional models. There are direct links between leadership effectiveness and team performance and satisfaction, between communication frequency and team performance, between trust and team performance and satisfaction, and between leadership effectiveness and trust.

Table 5
Correlation table with reliability and AVE

	Composite reliability	Leadership effectiveness	Satisfaction	Trust propensity	GRADE	Com. Fre (s)	Com. Fre (n)	Trust
Leadership effectiveness	0.963	0.839						
Satisfaction	0.936	0.569(**)	0.830					
Trust propensity	0.867	0.363(**)	0.558(**)	0.686				
GRADE	NA	0.303(**)	0.202(*)	0.167	NA			
Com. Fre (s)	NA	0.004	−0.065	−0.104	0.419(**)	NA		
Com. Fre (n)	NA	0.166	0.011	0.190(*)	0.271(**)	−0.056	NA	
Trust	0.912	0.333(**)	0.559(**)	0.469(**)	0.287(**)	−0.017	0.062	0.838

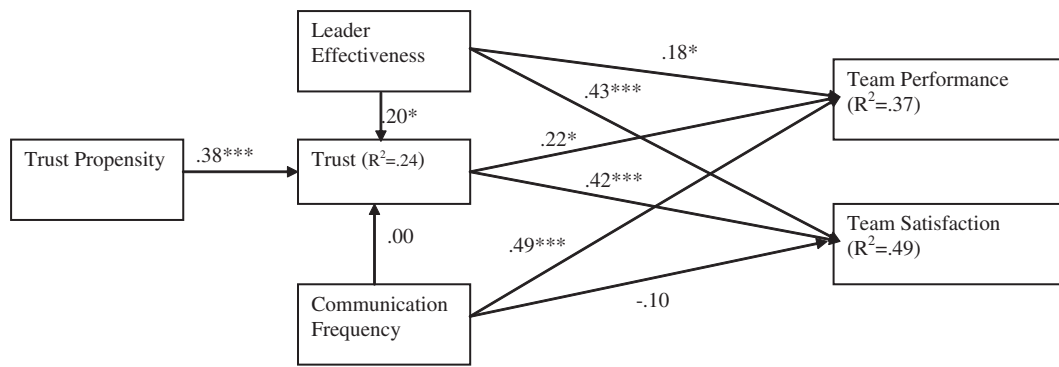


Fig. 2. PLS results *denotes significance at the $p < 0.05$ level; **denotes significance at the $p < 0.01$ level; *** denotes significance at the $p < 0.001$ level.

Table 6
Path coefficients of PLS (Test for mediating effects)

Dependent variable	(1)		(2)		
	Model with direct links and without mediator		Model without direct links and with mediator		
	Team performance	Team satisfaction	Team performance	Team satisfaction	Trust
Leadership effectiveness	0.26**	0.58**			0.21*
Communication frequency	0.46**	−0.10			−0.05
Trust			0.29**	0.56**	

*denotes significance at the $p < 0.05$ level; **denotes significance at the $p < 0.01$ level.

However, overall, the direct paths between leadership effectiveness and the dependent variables decrease when trust is added as a mediator (from 0.26 and 0.58 to 0.18 and 0.43). Hence, according to Baron and Kenny [51], trust is in fact mediating the relationship between leadership effectiveness and team performance and satisfaction. Trust does not mediate the relationship between communication frequency and team effectiveness though, because of a lack of direct link between communication frequency and trust.

7. Discussion

PLS results provide strong support for seven proposed hypotheses with the exception of hypotheses H4a and H4c. The support of H1 is consistent with a previous research [58] that an individual's propensity to trust others will directly influence the actual trust. Cultural backgrounds, experiences and personality traits can influence an individual's inclination, disposition or propensity to trust others [49]. The instructor

randomly grouped members into a virtual learning team without matching their social contexts. Without having the shared social context, our evidence shows that an individual is very likely to rely on his/her propensity to trust others at the beginning of a virtual learning team formation. Hypotheses H2a shows that leadership effectiveness is another influential factor for the trust building among team members.

However, when team members do not know one another and are not physically co-located, the higher communication frequency does not help close the psychological distance. H4a is not supported and no relationship was found between communication frequency and trust. This finding is contradictory to the importance of repeated interactions for the development of trust in the F2F context [34].

Trust is another form of psychological contract that is created through the expectations of reciprocal obligations between teammates [16]. Communication frequency alone may not be sufficient for the formation of the trusting behavior in the virtual learning context. It may be more important to examine the quality of each discussion, the duration, and the intensity of each discussion, rather than the quantity (communication frequency). This argument is particularly germane to virtual learning teams, because team members are more likely to engage in continuous and frequent interaction to avoid reneging and incongruence-based incidents before the project deadline [7, 24]. As such, a virtual learning team tends to create a higher level of trust among team members in the latter stage of team activities. This has entailed the incapability of communication frequency to create high levels of trust throughout the team formation process.

Trust and both dimensions of team effectiveness are positively correlated, indicating the important role of team trust in virtual learning group performance and team member attitude. H3a and H3b are supported. Previous researches on group performance and satisfaction in a face-to-face setting has proven the critical role of trust in team success and healthy team dynamics [15]. Our study confirms and extends those findings to virtual learning teams. As expected, leadership effectiveness has a strong impact on team effectiveness. H2b and H2c are supported. A closer examination shows that leadership effectiveness has a stronger impact on team satisfaction (path=0.43) than on team performance (path=0.18). Conflicts and disagreements among team members are often shown in the latter stage of virtual learning activities. A leader in the virtual learning team is more likely to focus on coordinating team

members to harmonize internal and external relationships, as well as mitigate their conflicts and crisis for most of time. A virtual learning team leader can wait until the latter stage of the team project to shift to task-oriented leadership. The dyadic dynamics of leadership roles are unique features to the virtual learning team and need to be fully considered during the formation process.

Unexpectedly, communication frequency is related to team performance but not to satisfaction. H4b is supported; whereas H4c is rejected. It is possible that in the context of online learning tasks, group communication and coordination is essential to obtaining a good performance (i.e., grade), but not necessarily higher satisfaction. Groups interacting via computer-mediated communication may experience more conflict and disagreement. Because fewer social and context cues can be efficiently communicated through mediated communication, it is also more difficult to resolve any conflicts and disagreements. Hence, the relationship between the frequencies of mediated communication and team satisfaction is unclear and worth further investigation. Table 7 summarizes the results of our hypotheses testing.

8. Implications and limitations

There are some noteworthy limitations that imply interesting and fruitful further research. First, team performance and dynamics may be highly task-dependent. As shown in the appendix, only a few tasks were used to evaluate team performance. The results of study may not be generalized to other types of tasks. In addition, our results may not be duplicated when other online learning software is used. There are many applications available in the market today, and even more being developed. Different e-learning software may provide different levels of support for communication and collaboration. To summarize, further investigation with other tasks and e-learning software is necessary to develop more robust and generalizable findings.

Second, because of the cross-sectional design of this study, no causation can be determined. The significant paths between constructs can only be interpreted as correlation, and the causal inferences are solely based on theoretical argumentation. Further studies employing longitudinal or controlled experimental design may provide even more convincing evidence of the critical roles of leadership effectiveness, trust, and communication frequency. Finally, team performance was

Table 7
Summary of hypotheses testing results

Hypothesis	Results		
	Supported	Not supported	t-Statistic of path coefficient
H1: The higher a team member's propensity to trust others, the higher degree of team trust a virtual community member perceives	X		4.93
H2a: The higher leadership effectiveness a virtual learning team perceives, the higher degree of trust a virtual learning team has	X		2.28
H2b: The higher leadership effectiveness a virtual team perceives, the higher team performance a virtual learning team achieves	X		2.38
H2c: The higher leadership effectiveness a virtual team perceives, the higher team satisfaction a virtual learning team has	X		5.03
H3a: The higher trust a virtual learning team member perceives, the higher team performance a virtual learning team achieves	X		2.91
H3b: The higher trust a virtual learning team member perceives, the higher team satisfaction a virtual learning team has	X		6.32
H4a: The more frequently team members communicate with each other, the higher degree of trust a virtual learning team has		X	0.02
H4b: The more frequently team members communicate with each other, the higher performance a virtual learning team achieves	X		6.00
H4c: The more frequently team members communicate with each other, the higher satisfaction a virtual learning team has		X	1.62

evaluated by single instructors and may be biased or inaccurate.

Online learning is becoming an important educational tool. However, the factors that may influence the success of virtual learning team have not been studied extensively. Whether the factors that impact the effectiveness of traditional face-to-face will also play critical roles in online learning has yet to be determined. Our study has several contributions to the research literature.

First, our experiment confirms that leadership effectiveness plays the same important role in online learning. Even though online team leaders cannot lead the team in a traditional face-to-face manner, their importance in coordinating group effort and promoting team trust is still a stronger predictor of team efficiency. When formed into the same team, team members hold different views and use different approaches to solve problems. The incompatibility between different forms of system thinking has been a major barrier to effective organizational learning [56], and organizational efficiency. This finding emphasizes the importance of assigning effective leaders to remove the potential incompatibility of team members, and improve team performance via effective coordination and trust-cultivating efforts.

Second, we found that communication quantity is not sufficient to improve virtual team satisfaction. Though communication frequency is linked to performance, to improve satisfaction, other ways to measure communication quality instead of quantity need to be adopted in the future to investigate the role of communication in virtual team effectiveness.

Finally, the significant direct and mediating roles of trust in virtual team effectiveness are tested in this study. Although trust is widely agreed upon as a critical predictor of face-to-face team efficiency, its role in the virtual learning team has not yet been explored extensively. Our research represents one of the first to study trust in an online-learning team.

This research also has important practical implications. Managers and educational professionals who would like to improve the efficiency of virtual teams can gain some insight from our theoretical framework. To improve team performance, practitioners can consider assigning effective team leaders, encouraging online communication (both quantity and quality), and promoting interpersonal trust between team members. Effective online communication and trust are part of integration and coordination efforts that a leader in human service organizations (e.g., higher educational

institutes) should emphasize [27]. These practitioners can also provide trainings and workshops to improve the leadership effectiveness of assigned or elected team leaders.

9. Conclusion

An effective virtual learning team needs to address both a team's learning performance and satisfaction level. Leadership effectiveness, trust, and communication frequency can potentially have direct impacts on the effectiveness of a virtual learning team. This study proposes a comprehensive framework to investigate the relationship among these factors. PLS structural equation model is used to test the collected data and analyze the hypothesized relationship. We find that trust is an influential factor in improving the effectiveness of virtual teams. To cultivate the trust of team members, it is important to assess their trust propensity. We explored the mediating effect of trust and confirmed its critical impact on team effectiveness. We also find that communication frequency does not have a relationship with trust and team satisfaction. However, communication can significantly improve team performance. Leadership effectiveness has a direct influence on the improvement of trust and team effectiveness.

This study integrates the theories of leaderships and virtual teams into the e-learning context. Like other forms of virtual teams, a virtual learning team relies heavily on the support of information communication systems and is susceptible to the use of such systems. It is often argued that communication frequency is one indicator of the successful use of e-learning systems to improve team effectiveness. This study disputes the argument that this indicator is not an effective one to predict team effectiveness. Other factors in virtual team communication, such as the degree of interactiveness, social presence, and the quality of communication need further investigation.

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