

# Technology Diffusion Through Social Networks: An Example of Technology Integrated Instruction

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**Abstract.** Many studies investigate IT integrated instruction adoption by discussing enablers and constraints. They suggest that school policies, infrastructures, and learning resources are critical for effectively implementing IT integrated instruction. However, few of the research explore the diffusion patterns of IT integrated instruction in educational organizations based on social network perspective. This study conducts a case study where an IT integrated instruction application is successfully diffused among teachers via social interactions. In this study, we seek answers of two research questions: (1) What kind of social networks are relevant to IT diffusion? And (2) How these social networks influence IT diffusion? Using social network analysis, this study examines the correlation between authority, consultation and affective networks and IT diffusion pattern. Our findings suggest that the authority, consultation, and affective networks are positively correlated to the IT diffusion. This study further illustrates and compares the characteristics of social networks and IT diffusion diagram. Our findings provide organizations a way to make good use of social networks for diffusing IT.

**Keywords:** Social network · IT diffusion pattern · IT integrated instruction

## 1 Introduction

With rapid development of information technology (IT), many educational organizations consider integrating IT into instructions with an expectation of improving education quality. IT integrated instruction refers to an instructional method that using IT to present learning materials and to design instructional activities [19]. The previous studies suggest that school policies, infrastructures, learning resources are critical for IT integrated instruction adoption [21]. In addition, peer support in organization and interpersonal interactions are also the important factors [20].

Most of previous studies investigate the adoption of IT integrated instruction by discussing enablers and constraints. Few of them explore the pattern that IT integrated instruction diffuses within educational organizations. In addition, IT integrated instruction, as an example of innovation, can be diffused through social interactions [16]. This study explores

the relationship between IT diffusion and social network. We identify three kinds of social network in organization and examine their correlations to IT diffusion pattern. We seek the answers for two research questions: (1) Which social networks are relevant to IT diffusion? (2) How these social networks influence IT diffusion? Our research is anchored on a case study of IT integrated instruction in an elementary school. In that case, the IT integrated instruction was effectively diffused among teachers without formal manipulations. Most teachers in the school displayed interactive electronic books with computer and projector as the way of IT integrated instruction for delivering instructions. This case provides us a good observation target to explore how IT can be diffused by social networks. We applied a social network analysis to explore the factors of IT diffusion in an organization. Specifically, we analyzed the correlation between teacher's authority, consultation and affective networks and IT diffusion pattern.

## 2 Literatures

### 2.1 IT Integrated Instruction

IT integrated instruction is an instructional method that integrating information technologies into the design of instructional processes and activities [19]. This instructional method can enhance learning because it enriches learning contents with multimedia and improves the interaction between students and learning materials [11]. The focus of IT integrated instruction is not only on using IT in classroom, but also on effectively applying IT features to design corresponding instructional activities, so as to enhance students' learning processes [11, 23]. This instructional method improves traditional instruction by providing richer learning material presentation, enhancing teacher-student interactions, and bringing much of creativity of instruction.

Although educational organizations promote IT integrated instruction with many advantages, it needs instructors accept and adopt such instructional method for realizing these advantages. The previous studies conclude the barriers of IT integrated instruction, including the lack of resources and support (i.e., funding, staff, and IT equipments), the unsupported norm, a lot of effort and stress on developing learning materials, and the insufficient computer literacy of using IT into instruction [13, 20, 27].

### 2.2 Theoretical Gap

Existing studies investigate IT integrated instruction by discussing the difficulties of implementation, including resources, IT infrastructure, instructor's IT literacy, and organizational norms. These studies contribute by proposing critical factors on facilitating the adoption of IT integrated instruction. However, they rarely discuss how IT is to be diffused within an organization, as well as by which channels it can be diffused. In the limited investigations, research suggests the importance of social interactions. For example, Wu and Wu [27] propose that IT integrated instruction diffuses through not only administrative policies, but also through the interpersonal exchanges and sharing among organization members. And Shih [20] suggests a significance of peer support.

These studies bring a implication that the interpersonal interactions embedded in working context can be important to the diffusion of IT.

The interpersonal connections are known as social networks which help individuals exchange information with group members [17, 18]. Interpersonal relationship in organizations is suggested to be a considerable influence on individual behaviors formation and change [7, 15]. Social network perspective provides a lens to understand IT adoption within organizations [22]. This perspective enables a creative solution of IT adoption by taking advantage of the existing interpersonal networks within an organization. Thus, this study applies the social network perspective to examine the relationships between the IT diffusion and social networks in an organization.

### 2.3 Social Network Perspective

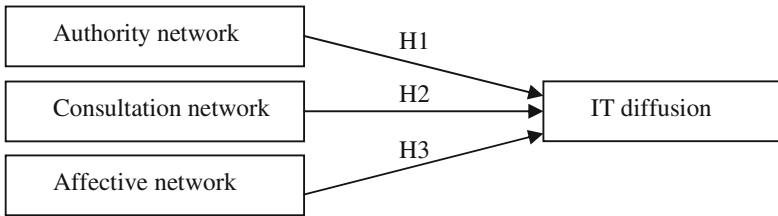
Social network refers to the network of relationship that people connect with each other through a certain social interactions within an organization or group [18]. Social network perspective conceptualizes a social structure as a pattern of the embedded resources, opportunities, social supports and constraints that an actor can receive affording by her network position [22]. By analyzing social structures to study management and organizational behaviors, social network has been wildly applied by studies in various fields [4, 7, 15, 18, 22].

Social network perspective explains performance and outcomes by the actor's position in social network [2]. An actor's position in social networks indicates the embedded social interactions and exchanges for enhancing or constraining access to valued resources, such as work advice and strategic information, as well as social supports [6, 14, 22]. A social network is usually represented by a graph formed of numerous 'nodes' and 'ties', where a node refers to an individual actor and a tie indicates the relationship among two actors [6, 9, 10, 26]. As ties typically involved different kinds of resource exchanges [1, 22], we focus on three typical ties (i.e. social relationships) within an organization. Social relationships in an organization can include formal authority relationships (such as superiors and subordinates, peers, and colleagues), consultation relationships (such as obtaining help, and advising others), and affective networks formed by friendships and trust [25].

Many studies examine network centrality to capture social exchanges within a social network. Network centrality is defined as 'the extent of an actor's involvement in assistance exchanges with others' [22, p. 375]. Three types network centrality are identified, including degree centrality, closeness centrality, and betweenness centrality [8, 24]. Degree centrality measures the direct linkage of an individual for examining her control scope within networks. An individual with higher degree centrality connects to more actors and has greater influence within the social network. The closeness centrality determines the extent of closeness between an individual and others. An individual with higher closeness centrality is closer to others, and is able to acquire information quickly. Betweenness centrality presents the extent of mediation that the interactions among members must be introduced by an individual actor. An individual with higher betweenness centrality is more critical to disseminate information across groups within a social network [6].

### 3 Hypotheses Development

We develop a research framework for studying the relationship between three social networks and IT diffusion pattern (Fig. 1). Three typical social networks in organization were identified by previous studies, including authority, consultation and affective networks [1, 22, 25]. The complexity of integrating IT into instruction poses the need to support teachers in overcoming knowledge and emotional barriers of IT features and instructional design. In an organization, such a support can be brought by authority (i.e. the formal report system), informal information exchange (i.e. consultation), and friendship (i.e. affective support) among the organizational members.



**Fig. 1.** Conceptual framework

**Authority Network.** Authority network refers to a social relationship formed by formal report system in an organization. In authority network, an actor interacts with her supervisor (or subordinates) and colleagues according to job position, rather than interpersonal relationship. When an actor interacts with others by authority, she can acquire the support of formal resources and information, and makes IT diffuse thereafter. Thus, we proposed the hypothesis H1.

*H1: Authority network is positively influence IT diffusion.*

**Consultation Network.** The deployment of an innovation (such as IT integrated instruction) usually create challenges as the organizational members have to learn technology features and interfaces, as well as to cope with new work processes [5]. Therefore, the individuals may pose substantial learning requirements [3, 22]. Learning how to integrate IT into instruction includes knowledge transfer across teachers with different levels of skills. It is easier for transferring knowledge among people with similar training, background and job characteristics. It implies that a teacher can benefit from consulting others for obtaining help or giving advices, and makes IT diffuse thereafter. Thus, we propose the hypothesis H2.

*H2: Consultation network is positively influence IT diffusion.*

**Affective Network.** When learning about a new innovation, an individual is also suffered from mentally fatigue and frustration [12, 22]. The affective network that build based on friendship and trust plays an important role for providing social support. An individual who highly involved in affective networks usually receives more emotional

support and resources, with which they can cope with mentally fatigue and frustration of using IT into instructional activities. Thus, we propose the hypothesis H3.

*H3: Affective network is positively influence IT diffusion.*

## 4 Research Design

This study conducted a case study to examine the relationship between social networks and IT diffusion. Based on theoretical sampling, this study selected an IT diffusion case in a Taiwanese elementary school as the research site because of two reasons. Firstly, this case presented the corresponding phenomenon that this study wanted to discuss. In this case, the IT was diffused among most organizational members via social interactions, rather than formal administration. Secondly, the social interactions among elementary teachers school were very intensive. The teachers usually worked together for developing instructions of each subject-matter in grade fragments. Meetings, special interest groups, and workshops were formed for teaching works. The adjacency of both classroom locations and office seats would increase the potential social interactions among teachers in terms of observation, consultation, and friendship. Such the complexity of social interactions also increased the potential of research exploration.

### 4.1 Case Background

Alpha was an elementary school located at a small town in the middle Taiwan. Established for more than fifty years, at the research time, Alpha ran a G1–G6 program by forty-one classes with 1300 students. There were sixty-eight teachers, including forty-two main classroom teachers and twenty-six academic teachers. Among the teachers, 90 % of them were with IT literacy of using computer and applications.

In 2009, Alpha's teachers volunteering adopted a new way of IT integrated instruction by displaying electronic books with a projector for teaching students. In 2012, more than half of the teachers had adopted such an instructional method. In Alpha, this was the first time that teachers used IT into daily instructional activities without formal regulation. Before this success, Alpha experienced a failure on introducing interactive whiteboard (IWB) in 2007. Although the school administrated several tutorials for teaching teachers IWB features and set a reward system for encouraging IWB use, but that project was terminated in the sixth months after implementation. Most of the teachers kept distance from using IWB. When comparing the two IT implementations, two observations were found. First, the teachers adopted an IT that had simple technological features (i.e. e-book with projector) but they rejected an advanced one (i.e. IWB). Second, IT implementation failed when there were formal manipulations via policy, but it succeeded under informal social interactions. Those observations posted the question on how IT would be diffused via interpersonal social networks without formal administrations.

## 4.2 Data Collection

Data collection in this study was through questionnaires responded by individual teachers in Alpha. The questionnaires contained six questions for drawing the IT diffusion, authority, obtaining help, advising, friendship, and trust networks, respectively. For each of the six questions, the subjects noted three organizational members who were best fulfilled the description of the questions. For example, the question of ‘authority’ required the subjects to indicate three people who they formally interacted with frequently for completing task. For another example, the response of ‘obtaining help’ should be three people who the subject frequently consulted with for solving problems. To verify the content validity, the questions were reviewed by three instructors who served for elementary schools for clarifying the appropriateness of description and meaning. All teachers in Alpha were candidates of filling the questionnaire in order to construct social network models as real as possible. As eight teachers refused to respond, we acquired a total of 60 responses for the following analysis.

## 4.3 Data Analysis

For the data analysis, this study used UCINET to construct and to analyze the correlations among social networks. For each of six questions, researchers compiled the 60 responses into a  $60 \times 60$  matrix and illustrated the correspondent social network diagram via UCINET illustrating tools. Then, as consultation and affective were second-order constructs, a CFA was used for versifying the reliability and validity. Next, principle component analysis was applied to generate the scores of consultation and affection matrices. Finally, a MRQAP (Multiple Regression Quadratic Assignment Procedure) regression was applied to estimate the correlations between authority, consultation, affective networks and IT diffusion network, respectively.

MRQAP was a regression analysis for matrices. MRQAP estimated the regression coefficients of a dependent matrix with several independent matrices with particular explanatory power. The calculation was in two steps. Firstly, a conventional regression analysis between the independent and the dependent matrices was carried out. Applying OLS (ordinary least squares) for calculating regression coefficient, MRQAP calculation procedure used  $N(N-1)$  observations in the matrices as the basis. After calculating the actual observation, secondly, a randomly permutation on the rows and columns in the matrices, then another OLS calculation was carry out to obtain another regression coefficients (i.e.  $\beta$  values). After repeated permutation and OLS calculations, a distribution of  $\beta$  values could be obtained. A comparison of the  $\beta$  values in the distribution with the  $\beta$  value obtained from actual observation was then carried out. If the possibility that  $\beta$  value after permutation was bigger or equal to the actual observed  $\beta$  value was lower than 5 %, it meant the actual observed  $\beta$  value has reached the 0.05 significance level.

## 5 Research Findings

### 5.1 Reliability and Validity

Since both of consultation and affective networks included two questions, we examined reliability and validity of these two constructs. The reliability was tested by Cronbach's  $\alpha$ ; and the greater value indicated the greater reliability. The Cronbach's  $\alpha$  for the two constructs were all greater than 0.7, indicating a satisfied reliability (Table 1). The validity was tested by a CFA for checking whether the obtaining help and advising converged into a factor while friendship and trust converged into another. The results of Table 1 showed that obtaining help and advising converged to a factor (i.e. consultation network). And friendship and trust converged to another factor (i.e. affective network).

**Table 1.** Factor loadings and Cronbach's  $\alpha$

Items	Consultation network (Cronbach's $\alpha = .905$ )	Affective network (Cronbach's $\alpha = .856$ )
1. Obtaining help	.962	.116
2. Advising	.787	.507
3. Friendship	.237	.910
4. Trust	.207	.928

Since both of Consultation and Affective networks were composited by two variables, we calculated the values of two  $60 \times 60$  matrices according to the factor loadings of Principle Component Analysis. The two  $60 \times 60$  matrixes, each of which represented consultation network and affective network were used for following analysis.

### 5.2 Hypotheses Tests

This study used UCINET VI software with a MRQAP analysis for estimating the correlations between the authority, consultation, affective network, and IT diffusion, respectively. Each of the networks was represented by a  $60 \times 60$  matrix according to the responses of the corresponding question. In MRQAP analysis, IT diffusion pattern was the dependent variable, whereas authority, consultation and affective networks were the independent variables. Table 2 showed the result of regression coefficients of MRQAP analysis.

**Table 2.** Regreesion coefficients

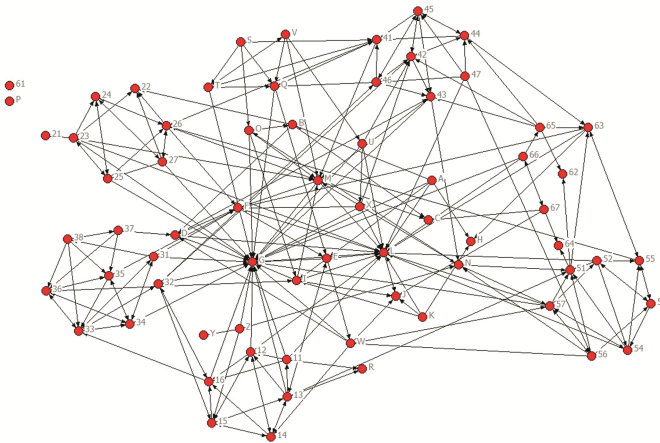
Independent matrix	$\beta$	Standardized $\beta$	$p$ value
Authority network	0.407	0.393	0.001***
Consultation network	0.284	0.298	0.001***
Affective network	0.060	0.062	0.001***

Note: Dependent matrix: IT diffusion pattern, \* $p < 0.1$  \*\* $p < 0.01$  \*\*\* $p < 0.001$ ,  $R^2 = 0.446$ ; Adj  $R^2 = 0.446$ .

In Table 2, all the three constructs were significantly correlated to the IT diffusion pattern, indicating supports on the hypotheses H1, H2 and H3. Authority, consultation and affective networks explained the IT diffusion pattern well ( $R^2 = 0.446$ ). These results indicated that the IT diffusion was significantly correlated to the teachers' authority, consultation and affective social networks. Among the three networks, the authority network was the most important predictor ( $\beta = 0.393$ ), followed by the consultation network ( $\beta = 0.298$ ), and then the affective network ( $\beta = 0.062$ ). That was, in this case, the IT was diffused mainly through authority and consultation networks. Although affective network had significant influence, its importance was much less than the other two.

## 6 Discussions

This study examined the influences of authority, consultation and affective network on IT diffusion. Taking an example of IT diffusion in an elementary school, our findings showed the three social networks were significant on IT diffusion. The IT diffusion pattern was presented in Fig. 2. In Fig. 2, some clusters of IT diffusion, such as IT1 (11, 12, 13, 14, 16), IT2 (23, 24, 25, 26, 27), IT3 (31, 33, 34, 35, 38), IT4 (41, 42, 44, 45, 46), and IT5 (51, 52, 54, 57, L), could be identified. It also identified some key persons for the IT diffusion, such as G (standardized in-degree centrality = 38.806), L (26.866), F (11.940), M (11.940), and 42 (10.448). Among them, G and L were current and former IT chief. That showed that the IT specialists played an important role on IT diffusion. In addition, E (standardized betweenness centrality = 21.307), 16 (17.296), F (16.467), 13 (15.707), 32 (13.663) had higher betweenness centrality, indicating that they played as important hubs for bringing IT across subgroups.

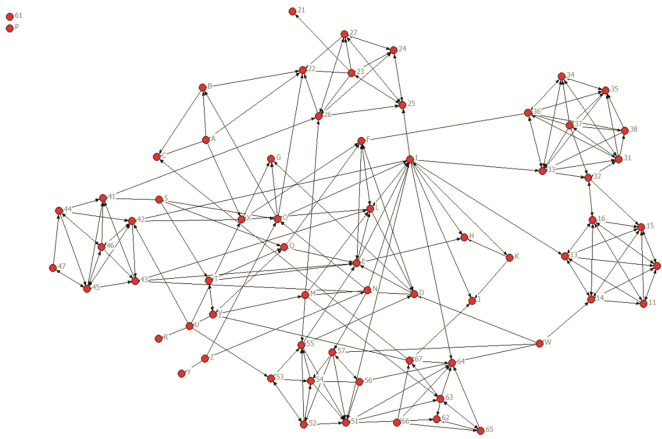


**Fig. 2.** IT diffusion pattern

**Authority Network.** Authority Network were proved by this study as the most important construct to IT diffusion. Figure 3 presented the authority network in Alpha. The authority network demonstrated the formal interaction based on job position and report



system. In Fig. 3, the teachers who served in the same grade fragment had a lot of exchanges and formed several clusters in this diagram. A small group analyze identified six clusters in this network diagram, including A1 (11, 12, 13, 14, 15, 16), A2 (22, 23, 24, 25, 26, 27), A3 (31, 32, 33, 34, 35, 37), A4 (41, 42, 44, 45, 46), A5 (51, 52, 53, 54, 55, 57), and A6 (62, 63, 64, 65, 67). The members of these clusters were teachers in the same grade fragment (i.e. G1–G6). This phenomenon presented the way teachers work in an elementary school. In an elementary school, instructions and activities were usually run based on grade fragment level. For a semester, each grade fragment identified particular instructional themes and activities for each subject-matter. Teachers in grade fragments conducted extensive interactions for coordinating the instructional plan execution.



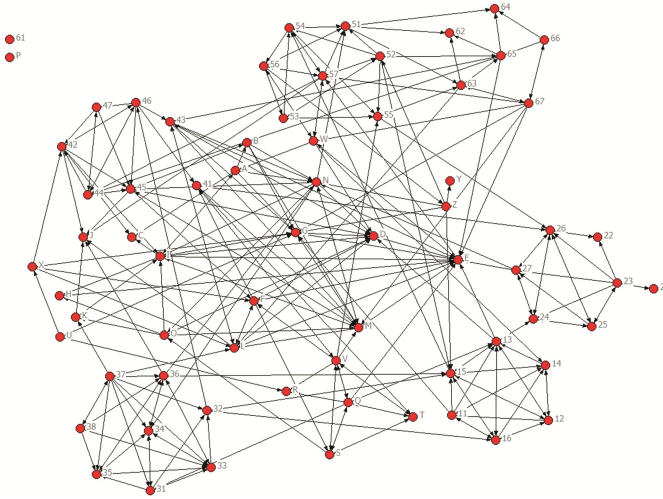
**Fig. 3.** Authority network

We found three overlaps when we compared the authority network with IT diffusion pattern. These overlaps were A1 (which overlapped IT1), A2 (which overlapped IT2), A3 (which overlapped IT3), A4 (which overlapped IT4), and A5 (which overlapped IT5). These evidences showed that the IT was diffused within grade fragments, especially in G1, G2, G3, G4, and G5.

The key actors with higher network centrality in authority network were 33 (standardized in-degree centrality = 10.448), E (8.955), F (8.955), 51 (8.955). Among them, E and F were also identified as key actors on IT diffusion network. Since E and F served for the Office of Academic Affairs, indicating that the staff in Office of Academic Affairs who had lots of interactions with teachers were also critical for such IT diffusion.

**Consultation Network.** The consultation network was also significant on IT diffusion. Excepting interactions based on authority, information exchange for problem solving was a critical path of IT diffusion. Such information exchanges could be obtaining help and advising others. Figure 4 presented the consultation network. In Fig. 4, six clusters could be identified, including C1 (11, 12, 13, 14, 15, 16), C2 (23, 24, 25, 26), C3 (31, 32, 33, 34, 37), C4 (42, 44, 45, 46, 47), C5 (51, 52, 53, 54, 56), and C6 (A, B, G, I, M, N). Most of the

group members were teachers served in the same grade fragment, but C6 was a group formed by academic teachers.



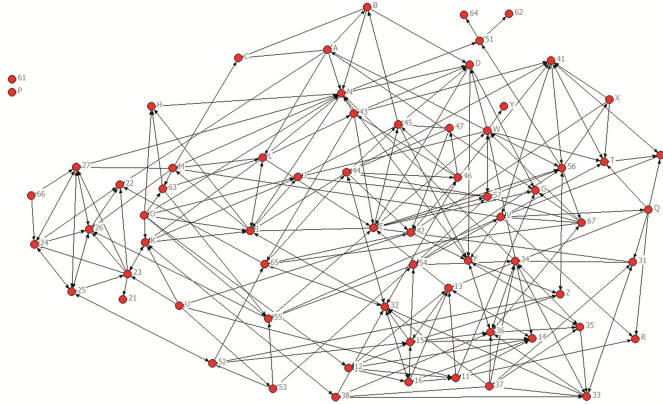
**Fig. 4.** Consultation network

The consultation network overlapped IT diffusion pattern on five clusters, they were C1, C2, C3 C4, and C5. This showed that IT was diffused along with the consultations (either obtaining help or advising) within grade fragments. It occurred especially in the grade fragments G1, G2, G3, G4, and G5.

In addition, the key actors with higher centrality in the consultation network were G (standardized in-degree centrality = 17.9100), E (14.925), D (13.433), 15 (11.940), and M (11.940). Among them, G had highest degree centrality in IT diffusion network as well. As G served as the IT chief in school, it was not surprised that he provided lots of consultation for IT use.

Furthermore, E presented the highest betweenness centrality in both consultation network (standardized betweenness centrality = 15.262) and IT diffusion network. These indicated that E not only assistant others but also an important referee. Acted as a hub, E helped the IT diffused across clusters when he provided consultations to teachers.

**Affective Network.** Figure 5 presented the affective network. The K-plex analysis indicated no significant clusters within this diagram. It meant that affective interaction among the teachers in Alpha didn't restrict to authority and work consultation. The actors with higher degree centrality was 32 (standardized in-degree centrality = 11.940), 36 (11.940), N (10.448), E (10.448), and I (10.448). Among them, only 32 had been identified as the hub (with higher betweenness centrality) in the IT diffusion diagram.



**Fig. 5.** Affective network

## 7 Conclusion

This study investigates the correlation between social networks and IT diffusion pattern. The results suggest that authority, consultation and affective network are significantly correlated with IT diffusion. These findings can bring three implications.

First, the authority network is effective for IT diffusion. For elementary teachers, the grade fragments formed based on authority is the critical channel for IT diffusion. Within grade fragment, the teachers need to interact with others closely for accomplishing the designed instruction plan and activities. Teachers hold meetings within grade fragment frequently, and these meetings increase the opportunities for teachers to share experiences on using IT into instruction. Besides meetings, the classrooms of the same grade fragment are usually located in the adjacent area. This arrangement makes it easy to discuss, share and demonstrate how to use IT for instruction. As a result, teacher's authority network promotes close interactions, especially within grade fragment, and becomes an important enabler of IT diffusion.

Second, professional consultations in organization play a key role of IT diffusion. The diffusion of IT is also facilitated through the consultation network in organization. When teachers are confused with work problems, they usually seek advice within grade fragment. The consultants who are senior and experienced might introduce IT as the solutions for solving their colleagues' problems on instruction. These advices are often convincing and persuasive because the consultants are in the same situation of organizational environment, have similar work conditions and resources limitations. Consultants not only support teachers instantly but also act as the learning partner on using IT for instruction. Experience sharing and support providing from consultants reduce teachers' sense of uncertainty and anxiety of adopting IT, and therefore makes IT diffusion.

Third, the affective network provides hubs for IT diffusing across grade fragments. The friendship and trust network among teachers facilitated the transfer of IT relevant information to the colleagues in different grade fragments.

This study has academic and practical contributions. For the academy, this study illustrates and explains how social network may influence IT diffusion. Our findings remind organizations to make good use of social networks for diffusing IT. Authority, consultation and affective network in organization are effective and critical channels for diffusing IT. For practice, organizations can take three ways to facilitate IT diffusion through social networks: (1) Strengthen the interactions of authority network in order to increase the opportunities of information exchanging and sharing; (2) Pay attention to the members who are often consulted by others. They can be the consultants and supporters who make other individuals to adopt IT; (3) Use affective network to encourage teachers to share their experiences and reflections on using IT, and provide the information to the teachers who do not use IT for instruction.

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