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Detecting Users' Online Knowledge Sharing Behavioral Patterns in a Knowledge Management System: Using Sequential Analysis to Explore Online Knowledge Construction Process of an Online Teacher Community

Huei-Tse Hou [1+], Kuo-En Chang [2] and Yao-Ting Sung[3]

[1] Department of Information Management, Ching-Yun University

[2] Graduate Institute of Information and Computer Education, National Taiwan Normal University

[3] Department of Educational Psychology and Counseling, National Taiwan Normal University

Abstract. Promoting knowledge sharing behaviors of online community members is a crucial issue for knowledge management(KM) systems, and detecting of users' knowledge sharing behavioral patterns will be able to find out the limitations instantly during their knowledge sharing process and provide a good reference for KM system to provide intelligent guidance to the process instantly. This research adopted the sequential analysis calculation, which can individually examine whether the sequential relationship between each knowledge sharing behavior has been achieved significantly, aiming to infer the knowledge construction behavioral patterns of online communities through analysis of actual behaviors. This research conducted an empirical observation and analyzed online knowledge sharing of a teacher community in Taiwan. The study detected the teachers' sequential knowledge construction patterns and also proposed further suggestions for online intelligent KM systems according to the analysis method and the patterns we found out.

Keywords: knowledge management, knowledge sharing, behavioural pattern detecting, sequential analysis.

1. Introduction

1.1. Promoting knowledge sharing in online instructional KM systems

Promoting knowledge sharing behaviours of online community members is a crucial issue for knowledge management systems. Recently, many studies have discussed the issues of knowledge sharing, which focuses on the process of knowledge-interaction among community members. This includes the exploration of the "internalization" and "externalization" of knowledge [1]. Organizations or communities can come up with various knowledge sharing strategies in order to achieve knowledge transition, innovation, and re-use among members [2] [3]. Moreover, the strategies may be applied in a KM system to promote the social knowledge construction of an online community. Many studies on knowledge sharing have discussed the factors that motivate members to share knowledge [4] [5], most of them discussing knowledge sharing in commercial organizations by questionnaires-survey or case observations; technologies have also been proposed to assist knowledge sharing [6] [7].

There have been few recent studies on educational knowledge sharing, and knowledge sharing behavior may differ from one organization type to another [8] [9] [4]. Previous studies have also demonstrated that teachers' knowledge sharing in community is limited [10] [11]. Therefore, the topic of how to better use technology to facilitate interactions in an instructional KM system for teachers deserves to be explored. In instructional KM systems, the knowledge of teachers is always shared via online discussions. Since the design of online discussion mechanism has a strong influence on the quality of discussions[12] [13] In order

+ Corresponding author. Tel.: +886-920014266; fax: +886-3-2841149.
E-mail address: hthou@cyu.edu.tw

to promote knowledge interaction in educational KM systems, detecting online knowledge sharing discussion patterns/limitations of online teacher communities is crucial. The detected patterns may be provided for important references for designing/revising the knowledge sharing strategies and providing intelligent feedbacks instantly for teachers in KM systems.

1.2. Applying lag sequential calculation to detect online knowledge sharing patterns

For detecting behavioural patterns of knowledge sharing in KM systems, we applied Lag Sequential Analysis calculation [14], which allows us to better detecting the sequential patterns in students' online discussions as it lets us accurately examine whether the sequential relationship between any two discussion behaviors is statistically significant. Some previous studies have already applied this method [15] [16] [17] [18] [19] [20]. Just as in a quantitative content analysis, behavioural coding schemes are required. The following five procedures of sequential analysis are then carried out [24] to infer the patterns.

- Calculate the frequency transition matrix: The frequencies of transitions between codes are calculated to form a frequency matrix.
- Calculate the sequential transition conditional probability matrix: Based on the above matrix, we calculate the conditional probability of inter-code transitions to generate a conditional probability matrix.
- Calculate the expected-value matrix: Based on the above sequential frequency matrix, we calculate the expected-values of inter-code transitions to form an expected-value matrix.
- Calculate Adjusted Residuals Table: Based on the Z-score values yielded from the above three matrices, we examine whether the continuity of each sequence has reached the level of significance. A Z-value greater than +1.96 indicates yes ($p<0.05$).
- Draw the behavioral transition graph: The sequences in the Z-score matrixes that are significant are extracted to make a correlation graph, in which each coded behavior is a node and the arrow represents its connection directions. The thickness of the arrow heads represents the strength of significance. Z-score values are provided for further analysis.

Since sequential analysis is more inferential in terms of analyzing knowledge-interaction behaviors, we in this study tried to apply it to detect teachers' knowledge sharing discussion behavioral patterns in an online instructional KM system, and also proposed further suggestions for online intelligent KM systems according to the analysis method and the patterns we found out.

2. Method

2.1. Participants

We hosted workshops in Taiwan in 2006. The topic of the workshops was "how to apply ICT on teaching in an e-Learning/KM system." The participants in this study were 495 teachers from locations around Taiwan who teach at elementary or secondary schools.

2.2. Research Tool: Online Instructional KM System

We used WIDE-KM (Web-based Instructional Design Environment with Knowledge Management tool) [19] [21], which offers teacher an online teaching and knowledge management environment. Based on the two main theory- instructional design and knowledge management, WIDE-KM provides e-Learning related functions and tools for teacher's usage in teaching and sharing. The system developed 26 sub-modules, and each module has its own functions in order to reach the goal of creating an e-Learning environment for teacher's online instruction and knowledge management. We used one of the communicate module: "Q&A forum" of WIDE-KM as the tool for this study, which allows teachers to conduct Q&A and share of their pedagogic knowledge.

2.3. Procedure

The content of discussions by the teachers who participated from June to September, 2006, was then coded by the IAM coding scheme [22], which is divided into five phases (see Table 1); each phase represents a type of knowledge construction in the discussion content. This coding scheme had been commonly applied in the analysis of online discussion [23] [15] [18] [19], which enhances the validity of content analysis [24]. There was no any intervention from teacher-trainers during the entire discussion process.

2.4. Data Coding

The KM system was equipped with a coding module for teacher trainers to code each discussion message according the IAM scheme. Observation took place from June to September, totaling three months, and 133 topics were posted. We randomly picked out 61 topics (near half the topics) for another coder's analysis. The inter-rater Kappa reliability of the coding reaches statistically significant (Kappa=0.422, p<0.01), and the coded data were put through sequential analysis.

3. Results

A total of 133 topics and 706 C-codes were obtained in accordance with the IAM coding scheme. We calculated the frequency of each behavioural category immediately following another behavioral category, as shown in Table 2. C4 and C5 did not appear in the discussions. This shows that it is hard to achieve the C4 and C5 phases of knowledge construction, as seen in other research conducted according to Gunawardena, Lowe & Anderson's (1997) coding system [22] [15] .

To detect the sequential patterns, we then conducted a lag sequential analysis on the data. Results were organized into Table 3, and a behavioural transfer diagram deduced (as shown in Fig. 1).

Table 1: Gunawardena, Lowe, and Anderson's Interaction Analysis Model (IAM)

Code	Phase	Operation
C1	Sharing / comparing of information	Statement of observation or opinion; statement of agreement between participants
C2	Discovery and exploration of dissonance or inconsistency among participants	Identifying areas of disagreement; asking and answering questions to clarify disagreement
C3	Negotiation of meaning/co-construction of knowledge	Negotiating meanings of terms and negotiation of the relative weight to be used for various agreement
C4	Testing and modification of proposed synthesis or co-construction	Testing the proposed new knowledge against existing cognitive schema, personal experience or other sources
C5	Agreement statement(s)/application of newly constructed meaning	Summarizing agreement and meta-cognitive statements that show new knowledge construction
C6	Others	Discussions irrelevant to knowledge construction

Table 2: Frequency Transition Table

	C1	C2	C3	C6
C1	451	21	44	2
C2	14	4	0	0
C3	33	1	0	1
C6	0	0	0	2

Table 3: Adjusted Residuals Table (Z-Scores)

	C1	C2	C3	C6
C1	0.39	-5.38	6.98*	-12.35
C2	-0.43	3.64*	-1.21	-0.41
C3	0.50	-0.50	-1.75	1.34
C6	-1.32	-0.30	-0.39	15.06*

*p < .05

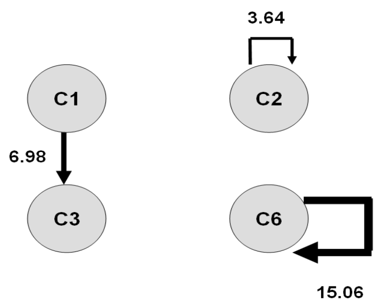

Fig. 1: Behavioural transfer diagram.

Fig.1 presents all sequences in Table 3 that reached a level of significance. Data shown in Table 2 and Fig. 1 show the behavioural patterns that occurred during online discussions.

The sequences that reached significance during online discussions are C1->C3, C2->C2 and C6->C6. The sequences C1->C3 and C2->C2 show that during the discussion, the continuation of teachers' knowledge-construction in C2 was significant. This indicates that teachers tend to provide different perspectives and ideas, and that when teachers internalize others' discussions, they sometimes provide opposing views, questions, or different perspectives, and continue to switch between these tendencies as they externalize the ideas. C1->C3 shows that although C3 was limited, the teachers would often continue to engage in deeper analyses or explorations of knowledge content after sharing information (C1->C3). C1->C3 and C2->C2 indicate that a step-by-step behavioural pattern is observable to a certain extent in teachers' discussions. However, we also found that although C6 (discussion irrelevant to the main topic) was very rare; C6->C6 reached the level of significance. This shows that once one off-topic message occurs in teachers' discussions, it becomes more likely for such messages to continue.

4. Discussion and Conclusions

The purpose of this study was to try to use sequential analysis to detect the knowledge sharing behavioral patterns displayed by teachers during their online discussion activities in a KM system. From the results obtained from the sequential analysis, the patterns of C1->C1, C2->C2 and C6->C6 tell us that the continuity of discussions and knowledge-analysis was high, and the C2->C2 pattern shows that the teachers continued to propose different perspectives in order to deepen discussions. However, irrelevant discussions were continued even though they were very rare (C6->C6) and it is hard to achieve the C4 and C5 phases of knowledge construction. The overall detected patterns did showed the status and limitations of knowledge sharing in an online teacher community. Community members' discussions may lack depth because members are unable to fully internalize discussions that already exist and so cannot connect all the discussions. Sporadic knowledge lacked topics that effectively integrate or connect them, possibly because fewer people participated in older discussions, and some discussions were actually stopped [25] ,or the continued irrelevant discussions happened (C6->C6) [18].

Finally, we provide some suggestions for applying the sequential analysis to promote the knowledge construction in an instructional KM system. If the intelligent agent embedded in a KM system could apply the sequential analysis calculation to detect the teachers' recent knowledge sharing behavioral patterns and determine feedbacks instantly, it may promote in-depth knowledge sharing in an instructional KM system. For example, the agents may detect the knowledge sharing patterns, indentify the limitations and the crucial keywords of recent discussions, then use data-mining to gather similar previous discussion contents, and show them via pop up hyperlink lists for references, then cross-discussions between different topics may also be generated, the depth of discussions may increase to C3, C4 phases and new topics or new knowledge may be constructed (C5 phase). In the future, we will develop the abovementioned agents for the instructional KM system and conduct more empirical observations to examine the performance.

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