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# USE SOCIAL NETWORK ANALYSIS TO IDENTIFY THE KNOWLEDGE-HOLE FROM LEARNING PORTFOLIOS STRUCTURES THROUGH WEB LOGS IN COGNITIVE APPRENTICESHIP AND GOAL-BASED WEB-BASED LEARNING SYSTEM

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# USE SOCIAL NETWORK ANALYSIS TO IDENTIFY THE KNOWLEDGE-HOLE FROM LEARNING PORTFOLIOS STRUCTURES THROUGH WEB LOGS IN COGNITIVE APPRENTICESHIP AND GOAL-BASED WEB-BASED LEARNING SYSTEM

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## **Abstract**

*This paper presented an in-progress research model to develop, design and test an innovated acculturated adaptive web-based learning systems which based on Vygotsky ' s zone of proximal development (ZPD) development theory. Based on ZPD related theories and researches, this research proposed to use cognitive apprenticeship instruction model as design guides to develop the activity functions to support acculturation ZPD instructions in MOODLE, a most popular open-source web-based learning system in the world. A support acculturation ZPD instruction adaptive system engine/mechanism, Heuristic Adaptive Learning Pattern (HALP), were also proposed in this paper. The major proposed designed adaptive function will base on the Blockmodeling method that used in social network analysis methodology which modelling the learner's learning portfolio and learning path.*

*Keywords: ZPD, Cognitive Apprenticeship, Social Network Analysis, Blockmodeling, Heuristic, Web-based Learning System.*

# 1 INTRODUCTION

Electronic course/web-based learning have been offered since 90's, the pervasive application of web technology (Hackbarth, 1997; Starr, 1997; Vasarhelyi & Graham, 1997; Windschitl & Andre, 1998). The capability of internet worldwide reach, the efficiency of material delivery by standard protocols, and the variety of deliver media through the web-based hypermedia and multimedia technology make the popularity. After decade's practising and development of web-based learning system, several researches had proposed the framework to utilize the power of computer technology not just uniformly delivering the same course material to all type of learners but also providing adaptive learning function to individual difference (Brusilovsky, Eklund, & Schwarz, 1998; Morss, 1999). There are the approaches of adapting the different presentations to the learner's knowledge or subject (De Bra & Calvi, 1998), or directing to different web links (Brusilovsky et al., 1998). According to the report (Brusilovsky, 2001), all most all the adaptive hypermedia educational systems are all web-based systems. Three levels of adaptations toward individual's difference were proposed. The first level is to organize the content completely and let the learner finds one's own learning path. The second level is to let the instruction design specific topic or path for specific learner. The third level is to provide adaptive guidance mechanism tailored to the target domain knowledge, goals, and tasks for the individual learner (Brusilovsky et al., 1998). The key question of exploiting adaptive web-based learning system is to determine which attributes should be used and worth the effort of modelling, and how to match different student's different learning style (Brusilovsky, 2001).

The purpose is to efficiently help the learners achieve the learning goals when the pedagogical procedures matching with individual characteristics (Federico, 2001). The learner's learning styles have been the focus to accommodate the function of adaptive web-based learning system (Ford & Chen, 2000; Magoulas, Papanikolaou, & Grigoriadou, 2003; McLoughlin, 1999; Papanikolaou, Grigoriadou, Kornilakis, & Magoulas, 2003; Papanikolaou et al., 2003; Specht M, 1997). Magoulas, et al. (2003), categorized adaptive web-based learning systems from four dimensions: the individual's characteristics, the level of system control, the level of system control, and adopted teaching/learning theory. The listed systems have several types of adopted teaching/learning theories from example-based, project-based, learner's learning style, and the presentation mechanism that matching with the learner's learning styles (Magoulas et al., 2003). However, from the summarized four system controls: adaptive navigation support, adaptive presentation, curriculum sequencing, and problem solving support, the adaptive learning system implementations are mostly focused on the end result of the learning outcomes: the knowledge level and goal, or the presentation for learning activities process. Smagorinsky (1995) criticized that using the focus of data collection to capture the learner's "ability" misrepresents the developmental process and the learner's relationship with the tools of mediation, the learning/instruction system or the environment.

Adaptive learning based on Vygotsky's development finding, the zone of proximal development (ZPD) (Lev Semonovich Vygotsky, 1987), considered that each person's learning potential is culturally shaped by one's social environment. Wertsch (1995) stated that the dependence on the genetic developmental method, the assumption of the social origins of consciousness, and the claim that mental processes are mediated by tools and signs are the three central framework of Vygotsky's theory. This viewpoint calls attention to sociocultural transformation, that constructing the environment as mediation tools to help learner internalize the ways of thinking through participating the culture world surrounded (Lave & Wenger, 1991). With this theoretical foundation, Tulviste's (Tulviste & Hall, 1991) principle of heterogeneity, an overlapping social networks environment can situate the learner with various types of problems to solve which allowing individuals to develop number of frameworks for thinking and take several directions simultaneously, provides the ground for adaptive learning. The system should enable the learners to be acculturated within the specific zones of proximal development that facilitating the learner's potential level (Lev S Vygotsky, 1978) to attain one's belief, ability, perspective, or skill.

Cognitive apprenticeship (Brown, Collins, & Newman, 1989), applied the principles of construction the context to from modelling of skills, coaching, articulation, reflection, exploration, increasing

complexity and increasing diversity of tasks, and global before local skills and understanding to implement the ZPD practising. This approach is depended on the identification of a meaningful social practice to the individual learner and retaining certain degree of authenticity. It is also proposed as “the legitimate participation” concept (Lave & Wenger, 1991). Based on these viewpoints, learning is a personal interpretation of the world through one’s internal structure. It is not possible to fully understand each individual’s schema and to design the individual learning context. Instead, this research is trying to facilitate and understand the learners’ internalization process through their interaction patterns with the system, the learning portfolio (Reckase, 1995). With the web-based learning system’s web logging feature for learning portfolio construction, the learner’s process and schema may be revealed (Chang, Chen, & Ou, 1998; Chen, Liu, Ou, & Liu, 2000; Niguidula, 1997).

It is the approach of this research, to design an adaptive web-based learning system framework that can adapt each individual learner’s different characteristics. To achieve such purpose, this research will propose a system design framework with cognitive apprenticeship and goal-based scenario (GBS) (Schank, Fano, Bell, & Jona, 1994) design principles to facilitate the learner’s legitimate participation. Then, the adaptation mechanism of this framework will focus on the learner’s participation process, learning portfolio to capture the learner’s participating and development path. Each individual’s learning portfolio will be analysed through social network analysis (SNA) method (Hanneman, 2000; Scott, 2002; Wasserman & Fraust, 1994) to construct the learning pattern. The learning pattern serves two purposes. The first, the patterns can be provided to the learner as the reflective learning system function for the learner to understand his/her participation and development status. Secondly, the learning pattern can be used by the teacher to facilitate scaffolding instructions.

It is the purpose of this research to propose the design framework and test the significant of the learning pattern construction through SNA methodology. The observation measurement of SNA variables are first constructed with cognitive apprenticeship and GBS principle. The portfolio web log of the system captures the participating process of the learners. These patterns then will be compared and tested the significance of the learner’s potential level indicators.

## **2 RELATED LITERATURE**

### **2.1 Cognitive Apprenticeship**

Brown, Collins, and Newman (Brown et al., 1989) used three examples to describe the successful practices of cognitive apprenticeship in instruction design, and propose a generalized framework as modelling, coaching, and fading for core method for designing a cognitive apprenticeship learning environment. The design framework is constructed with four sections; content, method, sequence, sociology. The content of cognitive apprenticeship learning is not only the domain knowledge, but also the heuristic strategies for practising the domain knowledge, the control strategies in deciding the proper process, and the learning strategies for the procedures of the acquisition of the domain knowledge. All of the knowledge, the explicit knowledge: domain knowledge, and tacit knowledge, should be incorporated into the practice of cognitive apprenticeship learning strategy design. The design of cognitive apprenticeship teaching constitutes with core methods of modelling, coaching, and scaffolding and fading and using articulation, reflection and exploration as the practising guidelines (Enkenberg, 2001; Järvelä, 1995; Liu, 1998; Tsai, 2002).

The key concept of cognitive apprenticeship framework that is adopted in this research is sequence. The framework uses sequence to emphasize the gradualness of complexity and diversity. The process of sequence also should follow the view of global before local skill to foster the learner cognitive and meta-cognitive comprehension. To achieve such complex design; the sociology principle is proposed to help integrating the culture of expert practice, intrinsic motivation, exploiting cooperation, and exploiting competition into the environment. By such principles, each learning activities have their indexes position in the sequence of learning environment. It is the foundation to allow the forming of learners’ conceptual map from their learning activity portfolio can be meaningfully appraised with the domain knowledge structure and the expert’s practice.

## **2.2 Goal-based scenario**

Goal-based scenario (GBS) instruction design computer-based framework was proposed by Schank, Fano, Bell, and Jona (Schank et al., 1994). GBS is set of structure that promotes learn-by-doing through a controlled environment with the content, set of targeted skills toward desire goals. It provides a micro-view of task oriented instruction architecture. The GBS instruction designer needs to devise the domain knowledge as their pedagogical objective of skills not content of topics which can be learned by working through a set of missions. The acquisition of the knowledge is by practising the set of skills through authentic activity to conquer the mission (Schank et al., 1994). It is derived from situated cognition that used situated instruction to facilitate comprehension, retention, recognition and transfer, which is origin of cognitive apprenticeship concept (Brown et al., 1989).

In providing an authentic context for practising skills, GBS structure layouts the process to guide the specification of constrains on task and environment for learner to extract the proper comprehension from the feature of situation. The first level of designed instruction in GBS is to define the characteristics of environment & its relationship to the goal to initiate the learner's cognitive state by crucial features of situation. Then, the tasks are organized to generate suitable goal and progress to develop the learner's appropriate expectations to create intrinsic motivation to learn. The designed tasks can have different levels of goal: the task achievement goals that are necessary to complete a task, the instructional goals that address issues go beyond the needs of the immediate tasks, and the knowledge-building goals that explicitly formed and addressed knowledge-building by relating new material to the acquired knowledge.

The learner's activities of practising were distinguished as early stage that is establishing encoded representation, further practice that is strengthened the connection among procedure and conceptual, and the eventually practice which showing more efficient and effortless performance to shift from declarative to procedural representation. By the designed GBS framework, the student's performances can be examined through the reach of goals or sub-goals, the acquisition of skills in the process of pursuing the goals, the reflection of appreciation to the role of the skills played in the practice context, the ability to execute plans to achieve a class of goals, and the application of acquired knowledge to new context as knowledge transferring. The GBS framework not only used as the guideline to facilitate the students to acquire the targeted knowledge, does it also provide the criteria as the evaluation principle to understand the each student's progress stages. The design criteria of GBS are naturally the index reference to observe in the student's learning activities as the concept of learning portfolio.

## **2.3 Learning Portfolio and Web Log**

Using the activities logs with the principles of cognitive apprenticeship and GBS framework to construct the learner's portfolio that have the pedagogical meanings indexed with each activity. The portfolio can be easily used as the indication of learning progress evaluation.

Portfolio concept had been used as individual's resource or capabilities, such as financial portfolio or artist's writing or working folders (Kneeshaw, 1992). The concept of using portfolio as the student's capabilities was proposed to replace placement test to provide more pervasive and accurate differentiation. Using portfolio model to understand student's capabilities and support classroom instruction were proposed and practice by several literatures (Burch, 1999; Niguidula, 1997; Reckase, 1995).

Portfolio defined by Meyer, Schuman & Angello (Meyer, Schuman, & Angello, 1990) as a purposeful collection of student work in a given areas to tell the story of the student's effort, learning progress, or achievements. For such purpose, the system designed to support portfolio management should help to collect the actual products of student's effort to determine the generalized skill and knowledge. Furthermore, to enable the verification of instruction effectiveness, the collected information should be able to associate with the result from classroom instruction.

## 2.4 Social Network Analysis

Social network analysis (SNA) focuses on using quantitative measurement to study the interaction among the members instead of individual analysis of the community. It has been developed and practice from social studies for decades. However, it had not been utilized in large network structure researches till recent years for the advance power of computer that enables the possibility of complex network relationship studies (Scott, 2002). With the implementation of the design, such technique can be applied to understand from the relationship of community members to the learning activity relationship among the designed scaffolding cognitive apprenticeship instruction design (Winne, 1994).

The basic components of SNA study is the node, as the source of action, and the connection, as the relationship developed among nodes. There has been several extensive studies and research for the definition of SNA (Scott, 2002). The key characteristics of SNA utilized in this research are summarized as follows (Wasserman & Faust, 1994):

- Establishing the community's network's structure, interaction, and the function of network as the measurement of the community. The relations among members are considered as resources, and the network is the pipeline of such resource transaction.
- The analysis can be cascaded to group form subgroup, triad, or dyad. The computer supported SNA capability allows an ego-centered, whole-network point of view, or both integrated analysis. When applying computer techniques into SNA, the measurement attention has been on the tie, relation, and range to establish the structure of the whole network and groups. The most used measurements for the tie are: distance, density, and frequency by the connected relation.
- Two types of ties, strong and weak were identified and recognized as the most influential result in sociology research form SNA method (Granovetter, 1973). The weak ties are the channel of information or knowledge (Luo, 2000). The strong ties are the affective character bonds (Krackhardt, 1992). The shifting of the ties from the dynamics interaction of the network may provide other valuable insides.
- Relation is the main focus of this research enabled by computer support was categorized in two types, group and network (Garton, Haythornthwaite, & Wellman, 1997; Wellman, 1996). Group has the characteristics of close relationship, small range, and low mobility, such as the project team in an organization. Network has lower density of member interaction, wider range, many varieties of relations, and high mobility. Relation is the channel of resources transaction. The function of the network can be categorized by the type of the resources transmitted, such as trust, suggestions...etc. The relation can be existed in single direction or dual directions.
- Range can be measured from the contact counts of each members, the connection with other type of network. The resources transmitted within or among networks also is the possible indicator, as well as the types of the resources among the networks (Garton et al., 1997; Wasserman & Faust, 1994). Social Network Analysis has been used widely by social scientists to investigate the dynamics of a social group. Focuses have been put on advice network, trust network, and communication network (Krackhardt & Hanson, 1993).
- Centrality measurement is adapted from mathematics graph theory to provide the measurement of the network and group relation status. Size, distance, density, closeness, and betweenness are the most used measurements. Centralization is the structure indicator for the network, group, and the individual node position status related to other nodes. Centrality can be measured form its degree, closeness and betweenness (Hanneman, 2000; Scott, 2002). Degree of centrality is the measure of point centrality by calculating the number of nodes the node is adjacent (Nieminen, 1974). It is also can be distinguished as in-degree and out-degree when there is directional relation among nodes (Knoke & Burt, 1983). Closeness is the measurement of global centrality in term of the "closeness" of all the nodes in the group or network by measuring the path distance (Freeman, 1979, 1980). Closeness can also be the indicator of power of the reference point by the distances to all other points (Hanneman, 2000). Betweenness specifies the node's status in the group and onto other nodes. The node's betweenness is the measurement that it plays the part of a "broker" or "gatekeeper" with the control power over other nodes in the network or the group (Freeman,

1979). Betweenness also used as the cutting point to identify the subgroups in the network (Tyler, Wilkinson, & Huberman, 2003).

- Sub-group is used to identify the subgroup in the network to provide valuable information for the understanding about the influential subgroup in the network and the characteristics and status of actor (node) among the subgroups and the whole network. “Structural holes” and “Bridges” (Burt, 1992) are the developed measurements. Subgroup can also be identified by the measurements of component, clique, k-plex, and k-cores.

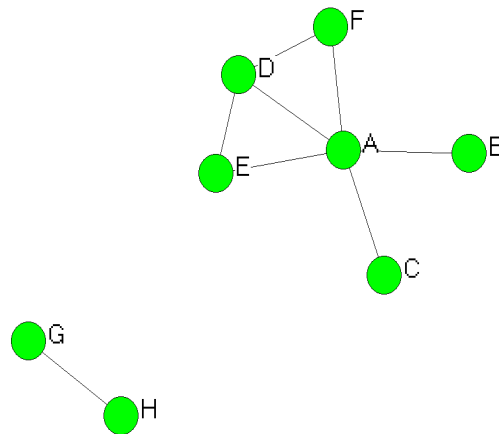


Figure 1. SNA subgroup example A

- A component is the all connected sub-graph. Any disconnected graph is identified as separated component. In Figure 1, there are two separated components. A clique is a sub-set of nodes that every possible pair of nodes is directly connected and the clique is not part of any other cliques, and it is usually formed at least with three nodes. In Figure 1, the subgroup of (A, D, E) is a clique of distance 1, and the subgroup of (A, B, C, D, E, F) is the clique of distance 2. A k-plex is a set of nodes that each node is adjacent to all except k of the other nodes. That is said that each node at least has N minus k connections to other nodes (Scott, 2002). In Figure 1, the subgroup of (A, D, E, F) is a 2-plex subgroup.

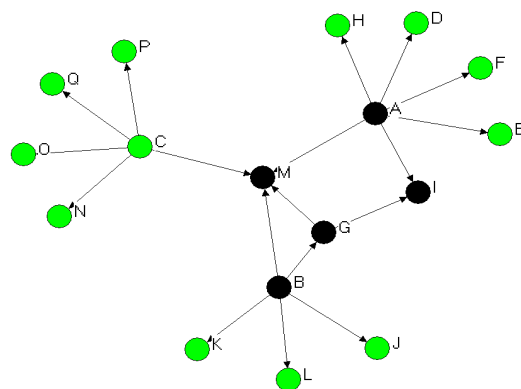
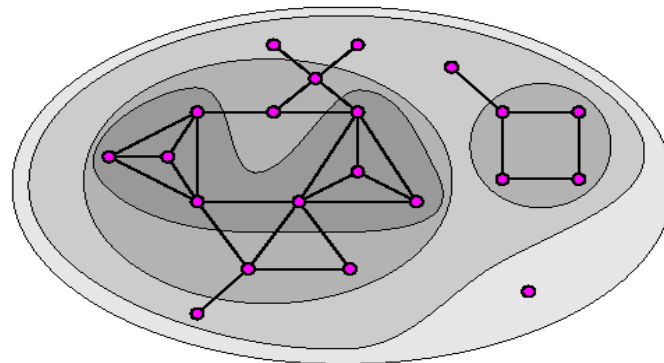


Figure 2. SNA subgroup example B

- K-core is used to identify the strong ties in a network or community (Swan, 2001). It is a maximal sub-graph that each node is adjacent to at least  $k$  other points. K-core was also proposed as an essential complement to the measurement of density which may not capture many features in the global network (Scott, 2002). In Figure 2, the subgroup of (A, I, G, B, M) is the 2-core group. It provides the comparison to the other subgroup in 1-cores (B, K, L, J) or (M, C, O, P, Q, N). Use the technique of “core collapse sequence” to understand the structure of the network (Seidam, 1983). The underlying structure illustrated through  $k$ -core subgroup measurement was used in this research as the indicator of abnormality in the context of internet auction. The example 0, 1, 2, 3- $k$ -core graph is illustrated in the Figure 3 that was adopted from V. Batagelj and M. Zaversnik’s



*Figure 3. K-core illustration of 0-core, 1-core, 2-core, and 3-core from V. Batagelj and M. Zaversnik (2003)*

work (Batagelj & Zaversnik, 2003). The outermost isolated node is the 0-core, to the inmost connected nodes as 3-core. The different depths of gray shade are used to illustrate the ranges.

Many other researches has been use the measurement of SNA to various of subjects that related to group, organization, and community, such as organization knowledge sharing (Tsai, 2002)(W. Tsai, 2002), organization structure and working relationship related to its information conveyance (Cross, & Parker, 2001), the study of agent system in internet communities toward trust building (Sabater & Sierra, 2002), and organizational subgroup structure identification through email log (Tyler et al., 2003).

### **3 PROPOSED DESIGN FRAMEWORK AND CONCLUSION**

#### **3.1 Conceptual Framework**

The instructions of proposed system will be designed with the 6 principles of cognitive apprenticeship: modelling, coaching, scaffolding, articulation, reflection, and exploration. Each web usage or activities of these instructions will be logged as the construction of the learner learning style. The style will include the time, length, frequency, related cognitive apprenticeship methods, related domain knowledge/concepts. Use SNA to turn the sliced web log become sequenced activity structures from nodes (domain knowledge/concepts, activities method), links (the sequence that connect to the node) for succession of activities method/cases. SNA’s measurement of structure indicators will be calculated to each learner’s structure of learning portfolio as comparison/statistical analysis to differ advanced learner from detained learner, compared/verified from regular academic achievement test. Using the SNA measurement and clustered learner’s structure to identify detained learner’s the structure difference (missing links). The concept of structure hole will be transferred as



knowledge hole and tested as the indication of learner's portfolio weakness for adapted instruction treatment.

### **3.2 System Design Framework**

There are several functional amendments to be constructed into Moodle system to format the knowledge map of the instruction target and the SNA indicators of the network structure of learning activities from each learner.

#### *3.2.1 Instruction material labels and weights:*

By using Moodle architecture, all learning material can be categorised as resources or activities. In this proposed model, all material will be further labelled with one or more of six cognitive apprenticeship methods: modelling, coaching, scaffolding, articulation, reflection, and exploration while they were presented in the courses. The instruction material will be labelled by using key-terms of the domain concepts as well as weights each concept for its complexity related to the learning subjects or the problem solving skills. The results of this process will be constructed as the knowledge map of the targeted subject. This function will be presented as an option when the material set up into the course unit. The method labels will be used to identify learner's activity node type in the learning path. The label and weight of the material will be used to denote as the size/weight of the learning node.

#### *3.2.2 Extract-Transfer-Load (ETL) of Web logs and Instruction Material*

ETL is the process to extracting transactional data, such as web access-log, into network structure data which will be stored as SQL database. Within Moodle system, it is designed to log each learner's learning activities. A background web service module will be developed to facilitate the process of converting two set of information. This first set of information is the knowledge map of the targeted domain knowledge. This will be extracted as the semantic web from the instruction material. The other process will extract the learner's access log into the network structure of learning path. Such network structure will be a two-mode network structure, one mode is nodded by the cognitive apprenticeship methods, and the other one is nodded by the related knowledge concepts. The path will be logged according to the time used in each material.

#### *3.2.3 SNA Indexes Construction and advise mechanism*

Based on the previous collected database, a Moodle filter will be developed to construct the knowledge map of the target subject and the learner's leaning path in this subject. This filter will also provide SNA indexes such as structure holes, k-core, centrality, closeness... etc., to utilize as the comparison among learners to identify the deficiency of any learning activities as well as categorize learning patterns. Those indexes will be used as the input of the advise mechanism to formulate the learner-customized learning resources advise which will be based on a heuristic data mining model. The outcome of this process will present a learning path or instruction material for each individual learner to the instructor or the learner according to the SNA indexes comparisons.

## **4 CONCLUSION**

In the paper, we propose a design framework to construct learner's learning pattern in web-based learning system, Moodle, through SNA methodology. Cognitive apprenticeship principle is the central of proposed system which based on Vygotsky's sociocultural view to provided a guided experience that acculturating the learners into authentic practice of social interaction and advancing the learner from novice to expert in a zone of proximal development (ZPD). The measurement of SNA indexes will be constructed with cognitive apprenticeship and GBS principle. The portfolio web log of the system captures the participating process of the learners. These patterns then will be compared and

tested the significance of the learner's potential level indicators as the mechanism of adaptive web-based learning system.

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