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AN INNOVATIVE KNOWLEDGE MANAGEMENT LEARNING CYCLE BY LEGO NXT FOR SCIENCE EDUCATION

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Abstract. *The competition for knowledge creation and imparting learning has become more and more intense. In this competitive environment, teachers have to manage their imparting knowledge not only by maintaining quality and creativeness, but also by increasing interaction with their students. Learning-oriented concepts can give teachers a competitive edge for sustainable development. The key to maintaining the knowledge management learning cycle (KMLC) with students is based on a stable sharing system, effective management, expertise participation, social relationship assets, etc. The purpose of this study is to examine the correlation among the antecedents of information education using Lego NXT intelligent robots. Valid questionnaires are received and the research model was tested. The relationships assumed in the conceptual model were analyzed. The findings show a significant positive effect for learning intention and performance.*
Keywords: Science education, Lego NXT, Knowledge management learning cycle (KMLC), Artificial intelligence, Learning intention

1. **Introduction.** Information education is supported by web-based information technology, which represents the combination of information technology (IT) and professional community. Information education can be facilitated through utilization of such things as the cloud technology, Lego NXT system, micro-robot contest, artificial intelligence and neural networks. An efficient and effective education system usually provides convenient capacity for instructors. This study aims to explore the performance of an integrated curriculum consisting of human resource assets, technical assets, complementary assets and relationship assets offered to students. The teaching content is designed to incorporate informal education resources focusing on science learning, specifically by the integration of a series of Lego NXT intelligent bricks. The goal is to help students to flexibly use the knowledge they have learned, go beyond the limits of their learning areas and learn to apply their knowledge in their daily lives.

2. **Theoretical Background.** Resource based theory and social capital theory are utilized in the present research model.

2.1. **Resource based theory.** Resource based theory (RBT) proposed by Barney in 1991 has received attention from many researchers. It originated in the management and industrial organization literature and briefly states that firms deploy their resources in an effort to gain a sustainable competitive advantage over their competitors (Barney, 1991). This model begins with the assumption that firm resources are heterogeneous and immobile. To have this potential, a firm resource must have four attributes: first, the resource must be valuable in the situation it is to be used. Firm resources can only be a source of competitive advantage or sustained competitive advantage when they are valuable (Barney, 1991; Bloodgood and Salisbury 2001). Valuable resources can take a variety of forms, including some overlooked by the narrower conceptions of core competence and capabilities. They can be physical, like manufacturing facilities, or they may be intangible, such as brand names or technological know-how; the valuable resource may even be an organizational capability embedded in a company's routines, processes, and culture. Second, the resource must be rare. Resources that are held by one or only a few firms enable those firms to do things their competitors cannot. This enables the firm or firms to gain an advantage over their competitors at least temporarily (Bloodgood and Salisbury 2001). Third, the resource must be inimitable. Inimitability is the extent to which a given competence cannot be copied and is analogous to the concept of structural differences, at least to the extent to which it may enhance competitive advantage (Bloodgood and Salisbury 2001). The resource is difficult to acquire due to the ambiguous link between the capability and the achieved sustained competitive advantage, or because it is socially complex. Fourth, the resource must be non-substitutable. Resources that are non-substitutable enable a firm to sustain an advantage by preventing competitors from accomplishing the same thing using a different set of resources (Bloodgood and Salisbury 2001). Recently, many IS researchers have treated IT capability as a strategic asset and striven to examine its effect on organizational performance (Bhattacherjee, 2001). Therefore, RBT is adequate to explain the IT-related issues.

2.2. **Social capital theory.** Social capital may be defined as those resources inherent in social relations which facilitate collective action. Social capital resources include trust, norms, and networks of association representing any group which gathers consistently for a common purpose. A norm of a culture high in social capital is reciprocity, which encourages bargaining, compromise and pluralistic politics. Another norm is belief in the equality of citizens, which encourages the formation of cross-cutting groups. Through interaction with others in this social network, individuals are able to build unique social relationships such as friendships, norms, beliefs and respect. The accumulation of these relationships can be viewed as a form of public wealthy for each individual in the system. Resource creation is a continuous process of dynamic interactions, which emphasizes social interactions for exchanging information, collaborating, and initiating spontaneous interactions. Nahapiet and Ghoshal (1998) defined social capital as having three distinct dimensions: structural (the overall pattern of connections between actors), relational (the kind of personal relationship people have developed with each other through a history of interactions) and cognitive (those resources providing shared representation, interpretations and systems of meaning among parties). The structural dimension concerns the properties of the network as a whole and refers to the overall pattern of connections among individuals which in turn indicates who people reach for social resources and how they reach them. From the perspective of the structural dimension, there is a strong belief that social capital benefits from the presence or absence of ties between actors and it benefits from the increased efficiency available for information diffusion. The relational dimension relates to the features of personal relationships. These include trust, trustworthiness,

norms of reciprocity and sanctions, obligations and expectations, identity and identification (Nahapiet and Ghoshal, 1998). The third cluster of attributes can be described as the cognitive dimension and refers to shared language, codes, and shared narratives within the organization. These language symbols can be applied in electronic networks helping people share their knowledge and mental schema with others, reduce obstacles to communication and reach a consensus. Among the most key facets of the cognitive dimension are shared vision and shared language (Nahapiet and Ghoshal, 1998).

3. **Knowledge Creation.** A variety of sets of knowledge management (KM) processes have been developed to effectively manage internal and external knowledge effectively, and guide the way for effective knowledge management (Gold et al., 2001). Alavi and Leidner (2001) suggested that there are four such processes, creation, storage/retrieval, transfer and application. Bloodgood and Salisbury (2001) considered three processes, creation, transfer and protection. Gold et al. (2001) proposed four processes, acquisition, conversion, application and protection. Two types of knowledge have been defined in prior studies, explicit and tacit (Polanyi, 1964, 1967; Nonaka, 1994). Explicit knowledge can be expressed in numbers, words, or images which are easily shared formally and systematically in certain codified forms, such as hard data, codified procedures, specifications, scientific formulae and manuals (Nonaka and Takeuchi, 1995). Essentially, explicit knowledge is defined as knowing "that" or knowing about practice. Tacit knowledge, on the other hand, is "knowing how". Tacit knowledge includes insights, personal belief, perspective and values, intuition, and hunches, which are often built by experience and thus difficult to formalize, articulate or share (Connell et al., 2003). The sharing of explicit knowledge is a rather common procedure, i.e., sharing reports, financial budgets and policies. However, tacit knowledge needs to be transferred into explicit knowledge during the knowledge creation process. Nonaka (1994, 1995) and Nonaka et al. (1996) suggested four cycles for knowledge transfer as seen in Figure 1. Socialization, sharing tacit knowledge through face-to-face communication, is the acquisition of knowledge through social interactions, such as observation, imitation and practice. A typical example of this category of knowledge transfer is an apprenticeship. Through the process of field observation, an apprentice learns skill and develops his own technique. Externalization, converting tacit knowledge into explicit knowledge, represents the implementation of an acquired implicit knowledge into specified instructions. This transfer is followed mechanically and transparently. The concepts, embedded with combined tacit knowledge, are developed to enable efficient communication. In the process of codification, for example, procedures depicted by an expert explicitly describe the actions of a master or expert. Therefore, a superior product can be implemented using these procedures. Combination is the transfer of various elements of explicit knowledge to be compiled and manufactured into a new piece of knowledge. Building an instructional prototype that retrieves information from a number of sources is an example of this process. Internalization is the transfer of explicit knowledge into tacit knowledge. An explicitly detailed source becomes part of the individual's knowledge base (e.g., mental model). Furthermore, an instruction manual describing this knowledge can be turned into an asset for the organization. These four categories are included in the schematic representation of the SECI model of Figure 2, which represents Nonaka's socialization, externalization, combination, internalization procedures hereafter. Knowledge generation is a continuous process. The process involves the dynamic interaction between explicit and tacit knowledge. The four modes of knowledge conversion interact in the spiral of knowledge creation. The spiral, as shown in Figure 2, becomes larger in scale as it moves upward through organizational levels, and can trigger new spirals of knowledge creation (Nonaka et al., 1996, 2000). Knowledge creation is

seen as a vital component in KM, being a strategic weapon to sustain an organization's competitive advantage in the global market (Lee and Cole, 2003).

In order to better understand the knowledge creation process, this study employs the theory of knowledge creation advocated by Nonaka (1994), which has been considered a useful model for explaining the knowledge creation process and has been widely accepted in prior studies (e.g., Chou anf He, 2004; Lee and Choi, 2002; Lee and Choi 2003). Based on Nonaka's theory, knowledge creation involves the continual interplay and conversion between tacit and explicit knowledge (Alavi and Leidner 2001; Nonaka 1994). In fact, Nonaka's SECI model includes not only knowledge creation, but also knowledge transfer (Lee and Choi 2003). Moreover, this model seems to assume that created knowledge will be used effectively (Gold et al., 2001).

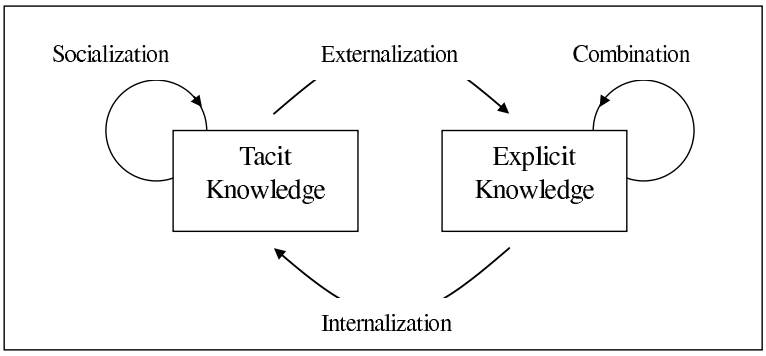

FIGURE 1. Schematic representation of the tacit-explicit knowledge cycle (Nonaka, 1995)

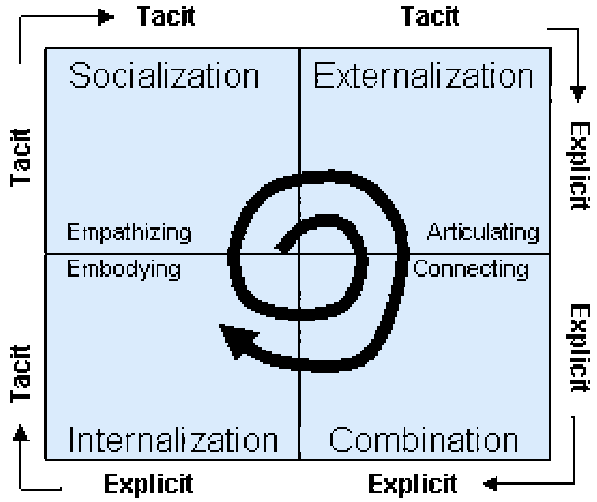

FIGURE 2. The SECI process (Nonaka et al., 2000)

4. **Measurement Results.** The technology acceptance model (TAM) contains two particular constructs: perceived usefulness and perceived ease of use. These two factors are the primary drivers for acceptance of technology (Davis 1989). Perceived usefulness is defined as "the degree to which a person believes that using a particular system would enhance his/her job performance", and perceived ease of use is defined as "the degree to which a person believes that using a particular system would be free of physical and

mental effort" (Davis, 1989). Furthermore, perceived usefulness and perceived ease of use both affect a person's attitude toward using the learning system and these attitudes toward using the learning system determine behavioral intentions (Li et al., 2009; Murata and Ozawa, 2010; Mi et al., 2010; Ito et al., 2010; Shih et al., 2010, 2011, 2012). TAM has been extensively applied in user acceptance research for various types of technologies. For example, Lee and Tsai (2010) examined people's usage intentions of an online game facility. Park, Roman, Lee et al. (2009) explored the factors that influence behavioral intention to use a digital library.

Learning satisfaction is one of the most influential attributes for the medical service industry. Donabedian (1996) indicated that learning satisfaction is an important effect indicator to evaluate medical service quality. In relation to this issue, Hansagi et al. (1992) proposed that learning satisfaction is a key indicator in the choice of medical service provider. Furthermore, learning satisfaction can help hospitals changing the medical process so as to satisfy more users (Abramowitz, 1987).

From previous studies, we realize that expectation, perception and medical care experience are important factors that influence learning satisfaction. Medical service providers need to understand learning expectations and try to satisfy them. To achieve this goal, learning satisfaction can be used as a tool to evaluate medical service quality. Mahon (1996) notes medical service quality can be told from learning satisfaction. The study intends to understand how important learning satisfaction is for medical service quality. Therefore, learning satisfaction was applied to evaluate medical service quality of a hospital in this research. The population for the study was in southern Taiwan. Meanwhile, the average of item scores for each factor was used as measures in the path model, as shown in Figure 3. In this study, we developed a research model based on review of literature. We conducted a survey of learning intention to test the hypotheses related to the research model. There has been increasing interest in computer-aided learning and its applications in recent years, such as in the fields of intelligent robots, artificial intelligence and Lego NXT brick (Chen 2007, 2009, 2010, 2011, 2012; Yu et al., 2011; Lee et al., 2010).

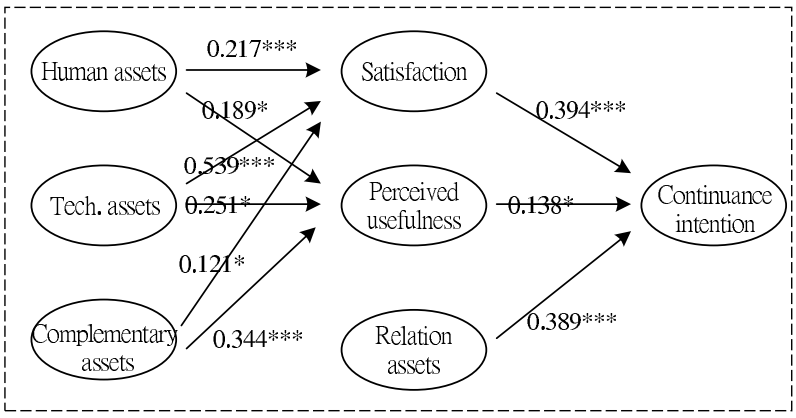

FIGURE 3. Final model with all significant relationships

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

5. **Conclusion.** This study investigated the antecedents of information technology (IT) and professional community by using extended Resource-Based Theory (Extend RBT). The Lego NXT intelligent bricks could be designed in the learning cycle for Science Education. The causal paths specified in the research model were all supported in the full sample. This study investigates whether teaching competitiveness was the cause of the

development of human resource assets, technology assets, complementary assets and relationship assets. Community assets could be defined as consisting of the aforementioned assets. Moreover, satisfaction, perceived usefulness and relation assets were found to be significantly associated with learning intention. This study proposed the integration of resource-based theory and social capital theory to investigate the assets of professional information and the influence of satisfaction and continued learning intention. The results investigated the effects of four assets, relationship assets, technology assets, complementary assets and human resource assets, on the learning intension. This study uses statistical tools and integrates resource-base theory with social capital theory.

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