The Efficacy of Knowledge Map in Object-oriented Software Training: ADO. Net Components

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ABSTRACT

An experimental study examined effects of knowledge map-based learning, a form of Computer Assisted Instruction (CAI), on assisting novice users in acquiring software knowledge and skills. Fifty five subjects participated in this experimental study. Two classes of students in a webpage development course were randomly chosen to receive different treatments. Twenty four students received the knowledge map-based training, while thirty one students received the traditional face-to-face training. Target software acquired by students in this study is ASP.NET. This study focuses on the data-access component ADO.NET (ActiveX Data Objects) of this target software. ADO.NET is a database access component and allows users to interact with database systems from browsers. A pre-test and post-test was administered to assess the effect of knowledge map-based learning on learning outcomes, with the traditional F2F training group as a controllable group. Results showed that students who receive the knowledge map-based training slightly outperformed those students who receive the traditional face-to-face training. Statistical evidences show that both training approaches are effective to help students acquire object-oriented software, such as ADO.NET, based on the mean scores of pre- and post-tests. Recommendations were made to instructor and practitioners to improve the efficacy of knowledge map-based training.

Keywords: *Training, Learning, ADO.NET, Database, Knowledge.*

INTRODUCTION

A knowledge map depicts the dependent relationships of knowledge objects. Many variations of the knowledge map are available to help improve decision-making, education, information retrieval and the management of virtual communities (Lin and Lin, 2001). Decision-making criteria are objects in a knowledge map. The knowledge map draws the relationship among decision-making criteria and calculates the probability of their occurrence in order to improve the efficiency of the decision-making process (Browne, Curley and Benson, 1997). The way that the map is constructed to map knowledge can also help learners improve the construction of their cognitive structure (Paolucci, 1998). (previous sentence is confusing) A knowledge map is also an information retrieval tool if documents are structured graphically (Sebastiani, 2002). A well-organized knowledge map is a sitemap that is easily navigable to the right sources of information for the user. This feature can help solve the exacerbating information overload problems.

Knowledge maps capitalize on the strength of visual/spatial display, which is considered a better delivery method than the traditional text presentation for some users (Briscoe and LaMaster, 1991). Knowledge maps also have relative advantages over some graphical search engines in improving the effectiveness, efficiency, and usefulness of the information search process (Chung, Chen, and Nunamaker Jr., 2005). Technological advances in the display of visual information further ease the creation of knowledge maps to improve cognitive effectiveness.

A sophisticated tool to create knowledge maps allows users to display spatial networks in multiple dimensions. The technological improvement has made knowledge maps a viable tool to facilitate both individual (Hall, Dansereu and Skaggs, 1992) and cooperative learning (Patterson, Dansereau and Newborn, 1992). Novice trainees who lack experience or knowledge on the studied subjects can also benefit significantly from the use of a knowledge map (Lambiotte and Dansereau, 1992).

Knowledge maps have been widely applied to both educational and organizational contexts. Many educational applications can help construct the knowledge map based on subject domains and their structures. Mindmapper (http://www.mindmapper.com) and Semiomap (http://www.semio.com) are two popular knowledge map applications that have been widely adopted in educational and organizational contexts, respectively.

Knowledge maps have not yet been readily applied in the context of software training. A study to investigate if the knowledge map can be assimilated as another computer assisted instruction (CAI) to improve the ability of users to acquire software skills and knowledge is interesting, applicable and relevant.

Computer Assisted Instruction (CAI)

Computer-Assisted Instruction (CAI) involves the use of the computer to assist with learning activities, including drill-and-practice, tutorial, simulation, game-based drills, and assessment. CAI has been assimilated in a wide variety of fields, such as sales training, medical education and forecasting, to improve the efficacy of training. CAI can supplement the use of the traditional F2F instruction or be used alone. The study of the performance of CAI instruction is mixed in different areas of studies (DeBord, Aruguete and Muhlig, 2005; Forsyth and Archer, 1997). In the field of information technology, there is no short supply of studies on CAI efficacy. Rather, the phenomenal growth of CAI tools (e.g. web-based learning, computer aided software design, video streaming and flash) has made the efficacy study on innovative CAI tools an invigorative work. This paper will examine knowledge maps as a CAI tool to assist novice users in acquiring software skills and knowledge.

CAI is an effective approach to help learners focus learning attention via an interactive user interface, reduce cognitive loads (Sweller, 1999), personalize learning experience (e.g. adaptive assessment) (Newby et al., 2000), and increase the chance to retain knowledge in the long-term memory (Najjar, 1998).

Because learners have different learning styles or learning preferences. it is necessary to consider these individual variances in this study. Three popular learning style inventories are Myers-Briggs Type Indicator, Kolb's Learning Style Inventory (LSI) and Wislock's learning modalities. Kolb (1984) asserts that individuals learn by progressing through (1) learning by observation, (2) learning by thinking, (3) learning by doing, and (4) learning by feeling. Similarly, Wislock (1993) stresses that a user has one of three learning preferences: (1) learning by seeing (visual), (2) learning by hearing (aural), and (3) learning by doing (kinesthetic). Because learning preferences have a strong influence on learning outcomes, learners taught in their preferred learning modalities or styles are more likely to perform better in learning tasks (Davis and Davis, 1990; Ramsden, 1988). Some learning styles are more applicable to a given learning context, whereas others are more applicable to another learning context. For instance, Kolb's Learning Style Inventory (LSI) has been widely adopted in the field of information technology. However, the knowledge map-based learning centers on the use of visualized maps. Therefore, Wislock's theory on visualized learning is more applicable to the purpose of this study.

Knowledge Map versus Concept Map

A wealth of information about the use of target software is available on the Internet (white paper, video demonstration, help desk, information portal). The exponential growth of information availability creates the information overload problem (Katz and Kahn, 1978), which makes the learning process become counterproductive. Information overload can lead to learning ineffectiveness, in addition to psychological, physical and social problems, such as aggression, apathy and depression (Kerka, 1997). Many information filtering technologies, such as IP filtering, information portal and advanced search engines, have emerged to help mitigate information overload problems. Visualized tools, such as concept mapping, mind maps, conceptual diagrams and visual metaphors, are also growing in their popularity to enhance motivation, attention, understanding and recall of students in the classroom setting (Eppler, 2006). The proliferation of these technologies illustrates the importance of information filtering and processing capability.

To promote effective learning, there are two ways to construct an information map to help users improve their learning: concept maps and knowledge maps. Concept maps arrange major concepts into a visual structure that shows the location of major concepts and the relationships between concepts. By helping users integrate the existing cognitive structures of learners with new concepts, and thus construct new knowledge (Novak, 1985), concept maps can enhance the meaningful and active learning process.. A concept map can be customized to represent the cognitive structure (schema and mental models) of users to ease the process of constructing new concepts. A learner is more likely to have the deep learning or better learning performance when he/she forms a cognitive structure (Bruner, 1966). Thus, concept maps can aid the brainstorming process and have been primarily used in idea creation.

The knowledge map, however, is an enhanced version of the concept map. A visualized technology that can improve learning effectiveness and potentially minimize information overload problems is the definition of a knowledge map. . These knowledge maps are tools to organize ideas, opinions, propositions, and the constitution of knowledge (Anderson, 1983) in a multi-level hierarchical structure to represent the mental models of a learner. The visualized approach to represent the structure of abstract knowledge of a learner allows an instructor to assess the learning performance of the learner (Laffey and Singer, 1997). Constructing learning in the knowledge map can help students externalize their knowledge in a visual format, which can lead to higher cognitive ability.

Concept and knowledge maps have commonalities in that they both use concept-like notes and labeled links between nodes (Chmeilewski, Dansereau & Moreland, 1998). However, nodes of knowledge maps contain more information than nodes of concept maps. Thus, the size of nodes is larger (Dansereau and Patterson, 1997). Concept maps are primarily hierarchical in nature, while knowledge maps are more flexible in structure (Lambiotte et al., 1989). A well-constructed knowledge map can help students recognize and recall course materials (McCagg and Dansereau, 1991) and build new knowledge based on the understanding of the studied course materials (Chmeilewski and Dansereau, 1988).

In addition, knowledge maps are an effective alternative to hypertext-based and list interfaces in assisting the learning process of users (Dansereau, 1990). Knowledge maps consist of networks of concepts, consisting of nodes (concepts) and links (relationships between concepts). Links can be non-, uni- or bi-directional to represent different categories of concepts and relationships, such as causal or temporal relationships. Knowledge maps are useful tools to (1) communicate complex ideas, (2) improve learning by constructing new knowledge based on the existing knowledge, and (3) assess understanding of studied subjects (Novak, 1991).

Some essential attributes are required for the construction of knowledge maps (Table 1). Different attributes and symbols are adopted to represent different relationships between knowledge objects, descriptive relationships, dynamic relationships and instructional relationships (Newbern and Dansereau, 1995).

The Relative Advantages of Knowledge Maps over the Traditional F2F Training

Knowledge maps are an effective communication medium to make the who, what and why of inter- and intra-organizational communication process explicit (Wexler, 2001). The information transparency feature can enhance the learning of an organization. In contrast, object-oriented programming is primarily composed of structure and behavior constructs (Armstrong, 2006). Major concepts of the structure construct are abstraction, class, encapsulation, inheritance and object. Each object has behaviors, such as messaging passing, method and polymorphism. Departments, divisions, business protocols, and business rules to an organization are as the constructs of objects and behaviors to the object-oriented programming. The proper application of knowledge maps could potentially minimize the number of objects required to show their behavior. This strength can help an individual learner acquire object-oriented programming skills and knowledge. (I have absolutely no idea what the previous paragraph is talking about so I can't help with it. It is very confusing, so it seems like it needs work)

Theoretical value beliefs, cognitive ability and personality together are potent predictors of object-oriented programming performance (Cegielski and Hall, 2006). Cognitive ability is the ability of a programmer to acquire, memorize, recall, combine, compare and use programming concepts and skills in the context of computer programming. Improving the cognitive ability of a programmer can help predict his/her programming performance (Evans and Simkin, 1989). Many deficiencies, such as semantic inconsistencies, vagueness and conflicting notations, have contributed to the learning difficulties of object-oriented programming concepts and skills, like Unified Modeling Language (UML) (Siau and Loo, 2006). The visual representation of the instances of concepts and concept relations can ease the acquisition of complex knowledge (Crampes et al., 2006). It is plausible that the representation of object-oriented components in visual forms via the knowledge mapping technique can potentially improve the cognitive ability of a programmer. In contrast, traditional step-by-step instruction presents the entire content of what is to be learned by the learner in the final form (Ausubel, 1963) and is a feature-focused approach (Bostrom et al., 1990). As such, this deductive approach does not allow users to experiment with the use of the acquired programming concepts and skills in the new context with the inductive approach (Taba, 1963). Learning object-oriented programming concepts and skills via the traditional approach have been a major barrier to most users (Morris, Speier and Hoffer, 1999). One major problem with today's learning of object-oriented programming skills is that no consensus has been built around the fundamental concepts of OO approach (Armstrong, 2006). No definitive object-oriented concepts have resulted in the ineffectiveness of the deductive learning approach.

Table 1: Essential Attributes of Knowledge Map

	Attributes	Symbols
Descriptive Relationships	(Characteristic)	C
	(Part)	P
	(Type)	T
Dynamic Relationships	(Influences)	I
	(Leads to)	L
	(Next)	H
Instructional Relationships	(Analogy)	A
	(Side remarks)	S
	(Example)	E

Source: D. Newbern and D.F. Dansereau (1995). Knowledge Maps for Knowledge Management. In Wiig, K.M. (eds.).Knowledge Management Methods. Texas: Schema Press. 1995.

Knowledge maps can assist users of the networks in understanding the flows of information and knowledge (Chan and Liebowitz, 2006). The visual representation of major object-oriented concepts can potentially help stride across the barrier of learning difficulties due to no definitive object-oriented concepts and the emergence of new concepts. Knowledge maps allow users to engage in inductive learning by experimenting with the behaviors of objects. Knowledge maps combine inductive and deductive learning approaches, and can increase the likelihood of improving the cognitive ability. Therefore, we believe that users receiving the knowledge map-based training approach can outperform those users receiving the traditional instruction method in the object-oriented programming skills. Users without prior object-oriented programming skills can also enhance their performance after receiving the knowledge map-based training method. Hypothesis 1 and 2 are constructed to test our beliefs based on the literature review.

Hypothesis 1: Subjects receiving knowledge map-based training approach can outperform those receiving the traditional F2F *training approach in acquiring object-oriented programming concepts.*

Hypothesis 2: Novice users can significantly enhance their performance in acquiring object-oriented programming concepts and skills after receiving knowledge map-based training approach.

RESEARCH METHODOLOGY

The purpose of this study is to investigate the efficacy of knowledge map on software learning. An experimental study with 55 subjects divided into two groups of training was conducted. Differences in learning outcomes are used to measure the influence of knowledge map approach on learning outcomes. Another avenue of research goal is to assess if learners can acquire their software knowledge and skills after receiving both the traditional F2F and knowledge map training methods.

ADO.NET is the target software in this study. It is important for students to internalize the knowledge and skills to use the software. Learning method is the independent variable. Learning outcomes is the dependent variable. Controllable variables include the attitude of the instructor and the influence of equipment. Motivations of students and instructors' teaching styles are also controlled to avoid their influence on learning outcomes.

Experimental Design

We randomly divide students into two groups, one group receiving the knowledge map training, and another group receiving the traditional F2F training. This randomization control can mitigate the self-selection bias of subjects. A pre-test was conducted to assess the degree of understandings of subjects about the tested topics. This research also assesses if the experience of users has any influences on learning outcomes. Subjects are college students taking the same courses. They have similar educational background. The demographics are relatively the same. The course content is identical except the way to represent course materials is different. ADO.NET is the main subject of this study. Two graduate assistants are instructors in this experimental study. Both assistants have similar educational backgrounds. They have the same undergraduate degree from the same university.

Seventy nine juniors who were taking a webpage development course were invited for the participation of this experimental study. After excluding the subjects who participated in this pre-test and post-test, there are fifty five valid samples. The researchers further divided these valid samples into two groups of subjects. Twenty four students participated in the knowledge map training, whereas thirty one students participated in the controllable group, the traditional training. All trainees had taken the prerequisite course of the webpage development course and acquired knowledge and skills on HTML, SQL, and VB.NET. Most users have basic concepts about webpage development and know how to write programming languages.

This research adopts experimental tools, such as pretest, post-test and course materials. Multiple choice questions and open-ended questions related to the studied subjects were used in the pre test. This arrangement is to filter students who are knowledgeable or experienced in the studied subjects from novice students. Post-test was administered immediately right after the training session. The purpose of this test is to understand the influence of different training methods on learning outcomes. Ten multiple choice questions on ASP.NET and ADO.NET were asked in the post-test. Subjects also need to fill out questionnaire. The internal validity and reliability of the questionnaire was assessed before being distributed to subjects. Questions 1, 3, 8, and 9 were deliberately worded in the way that the direct assessment of the influence of knowledge map training on learning outcomes can be conducted.

Operational Procedures

A computer lab of a private university is used to conduct the experiment. All users have their own machine to participate in the experiment. There are no resource constraints during the execution of this study. Software tools used in this study are Microsoft Powerpoint, Microsoft Word, Microsoft SQL Server 2000, Microsoft Access and IIS. Hardware equipments used in this study are projector, screen, PC or laptop.

The whole experiment lasts for three hours in total for experimental and controllable groups, respectively. The pretest lasts for an hour. The training session lasts for an hour. Students can take a break and practice for 25 minutes before participating in the post-test for forty minutes. Table 2 and 3 show the experimental design model and operational procedures.

Knowledge maps can assist users of the networks in understanding the flows of information and knowledge (Chan and Liebowitz, 2006). The visual representation of major object-oriented concepts can potentially help stride across the barrier of learning difficulties due to no definitive object-oriented concepts and the emergence of new concepts. efs based on the literature review.

Course Materials

Course materials cover two major topics on (1) connecting to database, and (2) display of data formats via ADO.NET. Subjects who participated in the pre-test were not qualified to

Table 2: Experimental Design Model

Group	Pretest	Training Session	Post-test
Knowledge Map (Experimental Group)	O_1	X_1	O_2
Traditional CAI (Controllable Group)	O_1	X_1	O_2

Note: (1) X is the experimental treatments
(2) O1 is the pre-test
(3) O2 is the post-test

Table 3: Operational Procedures

	Experimental Group	Controllable Group
Pre-test	60 minutes	
Training	**Instructor A** Course materials: Knowledge map as the major training method. Microsoft MS Word is a supplementary document to display the execution results. Duration: 50 minutes	**Instructor B** Course materials: Microsoft Power Point as the major training method and display the execution results. Duration: 50 minutes
Practice & Break	All subjects move to another lab where computers are installed with VB.NET Duration: 25 minutes	All subjects move to another lab where computers are installed with VB.NET Duration: 25 minutes
Post-Test	The post-test is conducted immediately after the practice & break. Duration: 40 minutes	The post-test is conducted immediately after the practice & break. Duration: 40 minutes
Equipment	Hardware: Desktop, projector and screen Software: IIS、SQL Server	Hardware: Desktop, projector and screen Software: IIS、SQL Server
	2000、Access、powerpoint	2000、Access、powerpoint

participate in the post-test because these participants are from the same population. The administration of the pretest allows us to:

- Examine the easiness of the survey tools
- Validate the appropriateness of wording
- Judge the flow of experiment and the schedule allocations
- The comprehensiveness of instruction or manual
- The appropriateness of questionnaire

The authors create different nodes and use them to deliver a knowledge map (Figure 1). The triangle represents the "prerequisite knowledge," which has successive relationships with other main nodes (topics). On the right of the main topic are the explanations of this main topic. Thus, the main note and the explanation note have "clarification or notification" correlation. This main note branches out into two sub-notes. Both sub-notes have similar attributes or content. Therefore, these two sub-notes have "similarity" or "analogy" relationships. In addition, these two sub notes must go through the note of "Communication with DB." Therefore, the note has relationship with those two sub-notes. The note attached to the sub-note is an "example note," which provides explanations of the predecessor note. The "class" note contains attributes of its predecessors. Therefore, these two notes have the "attribute" relationship. Since these two "class" notes have influences on the "mandatory procedure" and "access and display of data" note, these two notes have the "influence" relationship. Finally, the "mandatory procedure" note can lead to differences in "access and display of data." Therefore, these two notes have the "influence" relationship.

ASP.NET is a broad topic. We narrow the learning subject to the ADO.NET component. ADO.NET is the main topic, which is related to the connectivity with database. However, before learning this subject, prerequisite knowledge on HTML (HyperText Markup Language), Script Language (VBScript, JavaScript, VB.NET), SQL (Structured Query Language) and XML (extensible Markup Language). Students can begin learning ADO.NET knowledge after having the prerequisite knowledge. The main topic is comprised of two main parts: The first part is SQL Server 7.0 or newer version, such as SQL Server 7.0, SQL Server 2000. The second part is non SQL Server 7.0, such as Oracle and Microsoft Access. It takes four processes to interact with database:

- Connect to database
- SQL Command
- Execute SQL Command before executing database
- Close connection with database

After completing those four processes, the users need to display the data extracted from database. There are a few methods to do so, including DataSet, DataTable, DataRelation, DataView, DataList and DataGrid. However, in order to "connect to database" and "display data," two methods are needed:

- 1st Method: System.Data, System.Data.SqlClient, Sql Connect, SqlCommand, SqlDataReader, and Sql Data Adapter
- 2nd Method: System.Data, System.Data.OleDb, Ole DbConnect, OleDbCommand, OleDbDataReader, and OleDbDataAdapter.

The knowledge map interface used in this experiment was constructed using a proprietary knowledge mapping tools software package developed by Tamkang University. This software extends the use of knowledge maps beyond knowledge representation, to serve as the browsing interface to the ADO.NET knowledge body. The knowledge map-based browser is the interface to different components of ADO.NET body knowledge. Each knowledge object provide access to complementary or auxiliary information to explain the studied subjects in the form of screenshots and text explanations, or to other knowledge maps (external links) that expand on the subject. The knowledge map is arranged in the hyperlink form so that users can navigate all knowledge objects. Figures 2 to 9 are screenshots of all knowledge notes when uses navigate to them.

Representation of Knowledge Map Notes

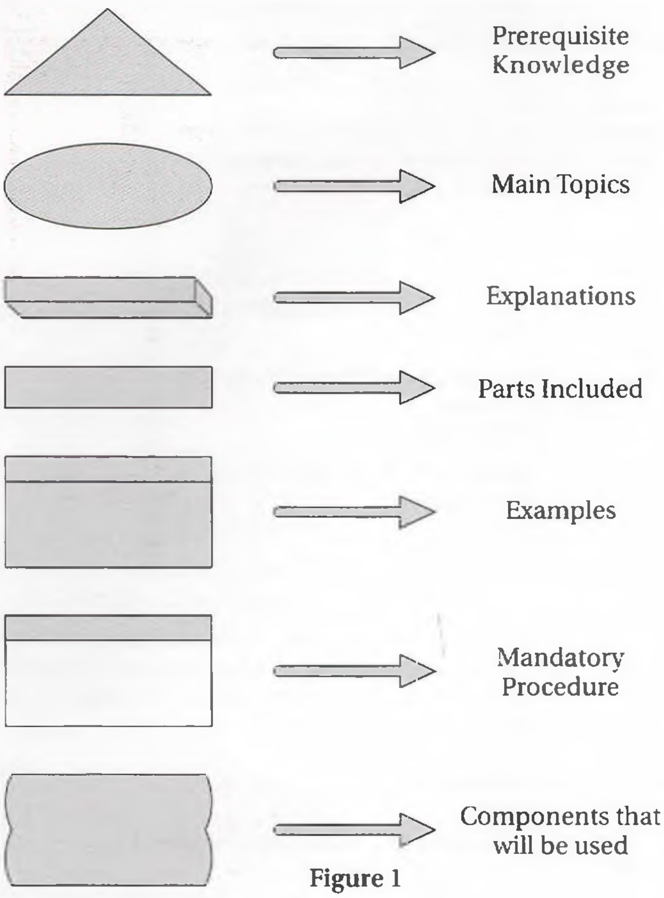

Figure 1

Screenshots

1. Move mouse to the "prerequisite" note (Figure 2)

Prerequisite Note

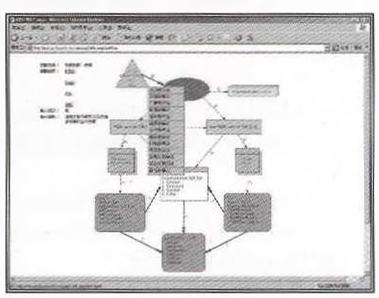

Figure 2

2. The screen appears after moving mouse to the "main topic" node. The knowledge map will dim so that nodes can stand out (Figure 3)

Main Topic

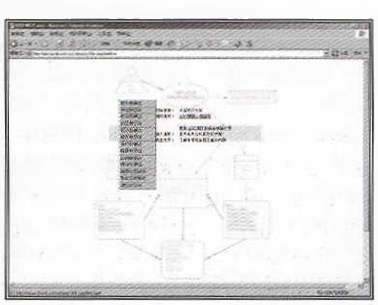

Figure 3

3. This screen appears after moving mouse to the "notification" node (Figure 4)

Notification

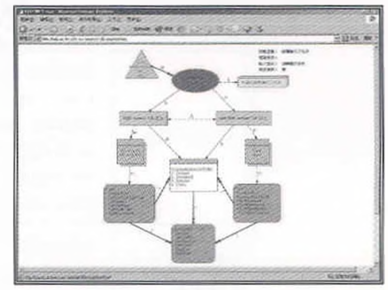

Figure 4

4. This screen appears after moving mouse to the "SQL Server 7.0" node (Figure 5)

"SQL Server 7.0 and Later Version" node

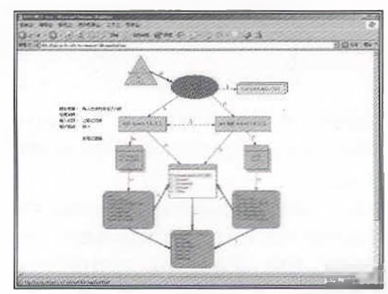

Figure 5

5. This screen appears after moving mouse to the "example" node of "SQL Server 7.0" (Figure 6

"Not SQL Server 7.0 and Later Version"

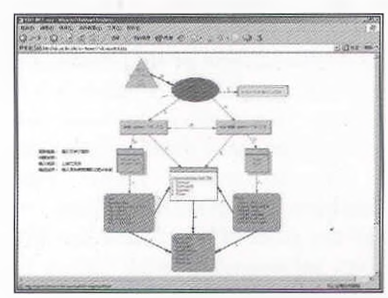

Figure 6

6. This screen appears after moving mouse to the "mandatory procedure" node. Knowledge map become dim so that the hierarchical structure of nodes stands out (Figure 7)

"Mandatory Structure" Node

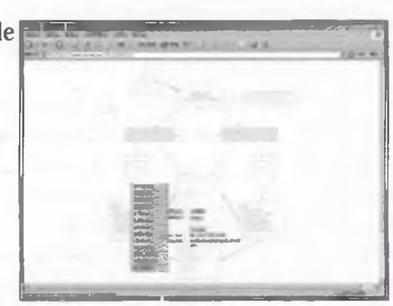

Figure 7

7. This screen appears after moving mouse to the "class" node of SQL Server 7.0 (Figure 8)

"Class" Node

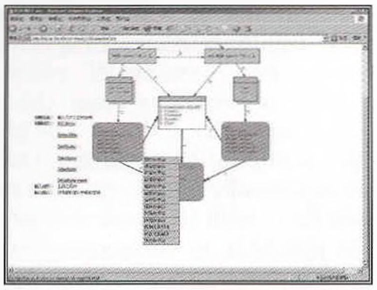

Figure 8

8. This screen appears after moving mouse to the "data searching and display" node (Figure 9).

"Data Searching and Display" Node

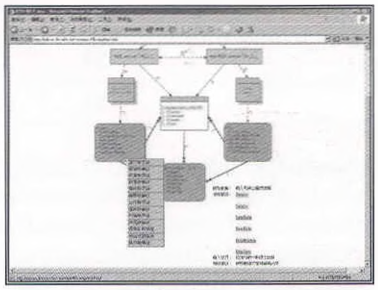

Figure 9

DATA ANALYSIS

SPSS 11.0 for MS Windows is used to analyze the collected data. Statistical analysis methods adopted in this study include Cronbach α and T test. Questionnaires were analyzed with its reliability with the Cronbach α. Cronbach's alpha is an indicator for the reliability of a set of items (or variables) used to measure a single undimensional latent construct. The authors designate the cut-off coefficient of reliability (or consistency) to include or exclude items of the questionnaire at Cronbach's alpha 0.66. Cronbach's alpha values for questionnaires used in the pre- and post-tests are 0.66 and 0.73, respectively. Their standardized item alpha values are 0.70 and 0.73, which shows that average inter-correlation among the items are larger than the designated coefficient of reliability. Both Cronbach's alpha values have medium to high reliability.

Table 4: Mean Scores and Standard Deviations

	Team	N	Mean	Std. Deviation	Std. Error Mean
SUM	1	24	126.67	40.611	8.290
	2	31	124.16	44.337	7.963

Note: 1. Experimental group; 2. Controllable group

Validity analysis is also conducted to assess the content, face and construct validity. The prerequisite knowledge of the main topic ADO.NET can be divided into three categories: HTML, VB.NET and SQL. Students' scores in these three categories of topics are summed up. The t-test is used to assess whether the mean scores of experimental and controllable groups in these prerequisite knowledge are statistically different from each other. A risk level (alpha level) is predetermined at 0.05.

The mean score is relatively the same for both groups. The p-values are 0.897 and 0.896 with (1) equal variances assumed, and (2) equal variances not assumed, respectively (Table 4). Both p-values are substantially higher than the pre-determined alpha value (Table 5). This indicates that these two groups are homogeneous and are not statistically different from each other.

Table 5: t-test on Two Groups

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Sig. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
SUM	Equal variances assumed	.0 00	.992	.129	53	.897	1.51	11.626	-21.814	24.824
	Equal variances not assumed			.131	51.447	.896	1.51	11.495	-21.567	24.578

Pre-test questions also include questions directly related to ADO.NET. Another t-test was conducted to assess the group differences in the ability to answer these pre-test questions (excluding those pre-requisite questions). The mean score is 19.17 for the experimental group and 19.35 for the controllable group. The mean score is also relatively the same for both groups (Table 6). The p-values are 0.974 and 0.974 with (1) equal variances assumed, and (2) equal variances not assumed, respectively (Table 7). Both p-values are substantially higher than the pre-determined alpha value. This indicates that these two groups are homogeneous and are not statistically different from each other. The influence of prerequisite knowledge is minimum.

Table 6: Mean Scores Excluding Pre-requisite Knowledge

	Team	N	Mean	Std. Deviation	Std. Error Mean
Pre-ADO	1	24	19.17	19.982	4.079
	2	31	19.35	22.201	3.987

The indifference in personal background and prerequisite knowledge allows us to have a better control of learning approach and investigate its influence on learning outcomes. Table 8 shows the mean scores of experimental (57.92) and controllable groups (50.97) after receiving their respective training. The group of subjects receiving knowledge map-based training performs better than that receiving the traditional F2F training. However, it is unclear if the marginal advantage of knowledge map-based training over F2F training is statistically significant. A t-test was conducted to assess the mean difference between these two groups. The p-values are 0.317 and 0.315 with (1) equal variances assumed, and (2) equal variances not assumed, respectively. P-values are improved (p=0.897 to p=0.317), in comparison with the pre-test (Table 9). However, p values are still not statistically significantly. This indicates that the experimental group of subjects, who receive knowledge map-based training, has similar performance to the controllable group of subjects. Thus, Hypothesis 1 is not supported.

Table 7: t-test (Excluding Pre-Knowledge)

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Sig. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pre ADO	Equal variances assumed	.228	.635	-.033	53	.974	-.19	5.782	-11.736	11.409
	Equal variances not assumed			-.033	51.740	.974	-.19	5.704	-11.636	11.259

Table 8: Mean Scores of Knowledge Map-Based Training vs. F2F Training

	Team	N	Mean	Std. Deviation	Std. Error Mean
Pre-ADO	1	24	57.92	24.844	5.071
	2	31	50.97	25.607	4.599

A further investigation on the performance of subjects in pre- and post-tests shows that both groups have improved their understanding and skills of ADO.NET after the training. The mean scores of experimental group are improved from 19.17 to 57.92, whereas those of controllable group are improved from 19.35 to 50.97 (Table 10). The improved performance of both groups is statistically significant (p=0.000<0.05) (Table 11). Thus, Hypothesis 2 is supported. A closer examination shows that post-test scores of the experimental group (57.92) are slightly higher than controllable group (50.97). This score difference is not statistically supported. Thus, Hypothesis 1 is not supported.

Table 9: t-test Analysis Results

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Sig. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
After ADO	Equal variances assumed	.111	.741	1.011	53	.317	6.95	6.873	-6.836	20.734
	Equal variances not assumed			1.015	50.304	.315	6.95	6.846	-6.800	20.698

Table 10: Pre- and Post-Test Scores

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-Test	19.17	24	19.982	4.079
Experimental	Post-Test	57.92	24	24.844	5.071
Pair 2	Pre-Test	19.35	31	22.201	3.987
Controllable	Post-Test	50.97	31	25.607	4.599

There are three methods to assess the efficacy of knowledge map in the learning context (Ruiz-Primo and Schavelson, 1996):

- Assess a student's knowledge map nodes: propositions, hierarchy and links (Novak and Gowin, 1984)
- Compare a student's knowledge map with criterion map (e.g. closeness index) (Acton, Johnson and Goldsmith, 1994)
- Compare a student's generated knowledge map with a criterion map.

Table 11: t-test

		Paired Differences					t	dt	Sig.(2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre-ADO vs. Post-ADO	-38.75	18.489	3.774	-46.56	-30.94	-10.267	23	.000
Pair 2	Pre-ADO vs. Post-ADO	-31.61	21.617	3.883	-39.54	-23.68	-8.142	30	.000

Questions 1, 3, 8, and 9 were designed deliberately to understand if knowledge map-based training has a direct and immediate effect on learning outcomes. For instance, Question 9 is "Which is the baseline software to decide if ADO.NET needs to include SQL Server or OLEDB?" (a) SQL Server 7.0, (b) SQL Server 2000, (c) SQL Server 6.5, and (4) Access. Users can directly relate this question to the "Notification" node of knowledge map. This allows us to assess the degree of alignment between a student's cognitive structure and knowledge map. Table 12 shows that experimental group scores higher than the controllable groups in four out of these six questions. Among these four questions, three of them are higher than 10 percent. This indicates that knowledge-based mapping is higher than F2F training. Sample sizes of these two groups are different and may have influence on learning outcomes. The z-test was conducted to standardize the deviations of mean scores in these questions due to sample size.

Table 12: The Percentage of Subjects Who Answer Questions Right in Post-test Questions

	Post-Test Questions				Number of Subjects
	1	3	8	9	
Experimental Group (% of subjects who answer questions right)	71%	83%	79%	75%	24
Controllable Group (% of subjects who answer questions right)	52%	55%	68%	68%	31
Experimental – Controllable Group	19%	28%	11%	7%	

All Z values have a 95% confidence level with the cut-off point at 5% alpha value. Table 6 shows that all six questions have a more than 1.96 standard deviations above and below the mean. Z-values are 10.65, -3.27, 16.51, 6.80, 4.23 and -11.43 (Table 13). They are all greater than the standard deviation of 1.96. This indicates that thee six z values are very significantly. Among these six questions, four questions are positively significant.

Table 13: Z-Test

	Post-Test Questions				Number of Subjects
	1	3	8	9	
Experimental Group (% of subjects who answer questions right)	71%	83%	79%	75%	24
Controllable Group (% of subjects who answer questions right)	52%	55%	68%	68%	31
Z Values	10.65	16.51	6.80	4.23	

IMPLICATIONS

This experimental study compares the performance of subjects receiving the knowledge map-based and the traditional inductive training. Our findings confirm that the knowledge map-based training approach is effective to help users acquire object-oriented programming concepts and skills. Novice users without prior training can enhance their learning via the knowledge map-based training. Their scores increase from

19.17 to 57.92 points. Although subjects receiving the traditional instruction methods also enhance their learning (score increase from 19.35 to 50.97 points), their improvement is not as substantial as that of those subjects receiving knowledge map-based training approach. However, we do not find any statistical evidences on the score difference between the experimental and controllable groups. This indicates that knowledge maps and traditional F2F approach are equally effective at improving the ability of users to acquire object-oriented programming skills and knowledge.

The acquisition of ADO.NET concepts relies on the understanding of users about not only the object-oriented, but also database and web components. Within the object-oriented concepts and skills include more subcomponents, such as event-driven diagram, procedural diagram, MSDN skills, integrated development environment and object-oriented diagram (Ritzhaupt and Zucker, 2006). Although we screen out users based on prior learning experience in ADO.NET, this control does not help screen out other complementary components. It is nearly impossible to incorporate all these important concepts into an hour of experimental session in order to enhance the learning process. Subjects receiving treatments in this study are college students without years of programming experiences. Subjects with varying procedural programming experience in C++, Java or Visual Basic may also enhance or hinder the acquisition of object-oriented programming concepts and skills (Siau and Loo, 2006). Future research may want to replicate this study with more subjects, different object-oriented software or over time, to understand if any statistical differences between these two training approaches can be captured.

CONCLUSION

The major areas of applications of knowledge maps include knowledge discovery, learning effectiveness, social network analysis, and web searching. This study focuses on investigating the relative efficacy of knowledge maps in helping novice users acquire object-oriented knowledge and skills, in relation to the traditional F2F training approach.

For many novice users, object-oriented programming knowledge and skills are hard to learn due to their evolving, non-standardized, and innumerous concepts, constructs and behaviors. For some experienced users, object-oriented programming differs greatly from procedural programming and that has created confusion and hindered learning effectiveness. The traditional F2F approach heavily relies on the deductive approach that primarily focuses on learning concepts and features. Learning object-oriented programming concepts before knowing how to put them in practice is a time-consuming and laborious process. Many novice users have found the process of learning object-oriented programming a frustration, and an ineffectiveness process. Our study affirms our speculation that knowledge maps are an effective medium to enhance the learning of object-oriented programming concepts and skills via knowledge maps. Subjects receiving this visualized training approach can outperform those receiving the traditional inductive approach. Knowledge maps are an effective alternative to ease the process of acquiring object-oriented programming concepts and skills. Practitioners and academia alike can develop better object-oriented programming courses based on the knowledge maps.

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