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Students' Intentions and Achievements in Using Open and Closed Network Resources for Web-based Problem Solving

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Abstract: Owing to the popularity of computers and computer networks, fostering the web-based problem-solving ability of students has become an important educational objective in recent years. This study attempts to compare the effects of using closed and open network resources on students' intentions and learning effectiveness with regards to web-based problem-solving activities. An experiment was conducted by situating students from a senior high school computer course in web-based learning environments with different network resources to find the answers to several questions about "structured programming design". The experimental results show that the low-achievement students who learned in both the open-resource network and closed-resource network made remarkable progress. However, the high-achievement students who learned in the closed-resource network had significantly better performance than those who learned in the open-resource network. In addition, the learning task completion ratio and the difficulties the students encountered were recorded and analyzed, and the perceptions of the students regarding their engagement in the learning activity are compared and discussed.

Keywords: Information searching, problem-based-learning, open network inquiry, closed network inquiry

1. Background and Motivation

Problem-based learning has been recognized as being an important and challenging educational issue in the past decades [1, 6, 14]. Nowadays, most of the information needed for solving problems can be obtained by searching the Internet via search engines, or digital libraries via the online information-searching interface. While searching for information to solve problems, the students need to express their intentions as keywords, evaluate the correctness and relevancy of the searched data or information, extract the proper content portions or statements, and organize the extracted content for solving the problems [4, 5]. Previous studies have shown the positive effects of using online technologies to support problem-based learning [12, 13, 20]. Researchers have further suggested that the provision of web-based problem-solving instructions has the potential to enhance and sustain the problem-solving skills of the learners [8, 20].

There are two kinds of web-based problem-solving environments: the first is the Internet, which provides an open but ill-organized environment for obtaining resources [2, 3, 18]; the other is digital libraries, which provide a closed and well-organized resource for problem solving [2]. From the Internet, students can search for universal data and complete their learning tasks via the search engines. On the other hand, the content of a digital library is usually relevant to some specific topic; moreover, its data are categorized and presented in

a unified format. The content on the Internet changes at almost every moment, while that in a digital library is updated periodically. The amount of data on the Internet is too large to count, whereas that in a digital library is limited.

Recently, many web-based problem-solving activities have been conducted using such open or closed network resources. For example, the students at the Department of Primary School Mathematics Teaching in Anadolu University Education Faculty took part in an experimental online problem based learning course [15]. In addition, a newly established polytechnic in Singapore employed problem-based learning to support its curricular implementation in view of the utility of the Internet as an informational repository [9]. In Taiwan, a web-based problem-solving activity for Taiwanese history was conducted by providing the learners with a digital library [2]; moreover, some activities concerning social science courses were carried out in a learning environment with search engines [7]. Among the web-based problem-solving environments, Meta-Analyzer, a freeware which combines the functions of search engines and e-portfolio management, has been successfully applied to many studies in various application domains [17].

Although the two web-based problem-solving strategies have been applied to many learning activities in the past decade, few studies have attempted to compare the effects of applying these two different approaches to the learning performance of students. During the web-based problem-solving activity, the students' attitudes, search strategies, computer use experience, and prior knowledge related to the problems could significantly affect their learning performance [11]. Consequently, this study aims to investigate and compare the effects of using the two approaches on students' learning attitudes, behaviors and performance from various aspects. An experiment has been conducted on the "structured programming" unit of a computer course in a senior high school in Taiwan.

Three research issues are investigated in the study. First, will the students' attitudes towards the Internet, their Internet self-efficacy, and their information commitments affect their web-based problem-solving outcomes in different information-searching environments? Second, will different information-searching environments affect the learning achievements of the students after participating in the web-based problem-solving activity? Third, what are the students' degrees of acceptance (usefulness, ease of use, satisfaction, and perceptions) of the information-searching environments after participating in the web-based problem-solving activity? The research questions abovementioned will be explored in the study.

2. Method

The theme was not taught using traditional teacher-centered explanations, but rather, the students learned from the process of problem-solving. They could learn and gain new knowledge from the process of data collection and problem-solving during the student-centered activities. The backgrounds of the students were deeply explored at the beginning of the study. Therefore, the pre-test of structured programming knowledge was conducted to evaluate the beginning proficiency of the participants. Their Internet self-efficacy, information commitment, and attitudes toward the Internet were also investigated. In addition, the experiences of using information and computer technologies, such as the operating system, data processing, the Internet, and the search engines, were surveyed by questionnaire so that the backgrounds of the students were considered as much as possible.

Procedure

One group used the open-resource network, called Meta-Analyzer, to search for related knowledge and solve the given problems while the other group utilized the closed information inquiry mode, called the Web-Quest Library, to find the related data constructed in the digital library by the teacher. The study aimed to avoid making meaningless comparisons between the open-resource network and a closed-resource network with insufficient information for solving the tasks. Therefore, the prerequisite of the activities in the closed information inquiry mode was that there were sufficient resources, which was confirmed by the teacher in advance. In other words, the teachers not only increased and constructed the knowledge or instructional materials in the digital library, but were also sure that the knowledge and information was plentiful enough for solving the problems they designed. If the students had ability to find the information, they could structure their answers and solve the problems. The flowchart of the study is shown in Figure 1.

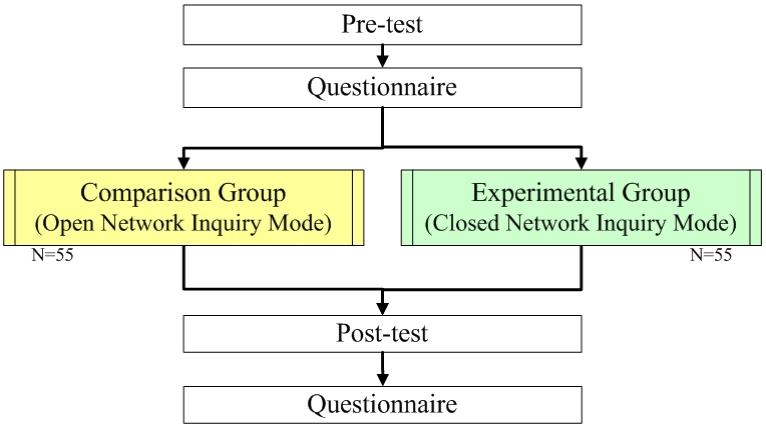

Figure 1. The experimental procedure

System functions

No matter whether using the open or closed information inquiry modes, all of the information inquiry processes, such as which web-site the students browsed or bookmarked, which keywords the students used for searching, what answer the students filled in on the form, and so on, were recorded under their teacher's account in the database. The difference between the two information inquiry modes is the scope of the information resources. In the closed information inquiry mode, called the Web-Quest Library, the data of one theme is constructed by the teachers and the data can be accumulated, but the range is not as vast as that found by the more popular search engines. In the open-resource network, called Meta-Analyzer, the data resource used in the system is the Google search engine, so the students can look for any universal data on the net. For convenience of naming the two groups, the study defines the Meta-Analyzer users as the comparison group, and the Web-Quest Library users as the experimental group. A comparison of the two different inquiry modes is explored in the study.

Participants

One hundred and ten 10^{th} grade students were randomly divided into an experimental group and a comparison group. Fifty-five students in the comparison group carried out the activities

using Meta-Analyzer, while the other fifty-five students in the experimental group performed the activities using the Web-Quest Library. All the students' actions in the two systems were recorded in the database. The teachers could be well aware of all the problem-solving processes of each student, what keywords each student used, and all the websites or data each student reached or read by observing the e-portfolios. In each group, the students whose grades were in the top twenty-seven percent based on the pretest were classified as the high-achievement group. They were deemed to remember some prior structured programming knowledge. The students whose grades were in the bottom twenty-seven percent of the pretest were classified as the low-achievement group. The others in the medium rank were classified into the medium achievement group. Moreover, all the participants have computers and network access at home, and have a chance to surf on the Internet every week, so the background of the participants' individual computer and Internet experience was also assessed to be approximate.

Questionnaire concerning Internet environments

This study used the Internet Attitude Scale (i.e. IAS) for measuring Internet attitudes, which was developed and validated by previous research [21]. Therefore, it can be ensured that the Internet attitude background of the users was identical. Moreover, the students' Internet Self-Efficacy (i.e. ISE) was also taken into consideration to prevent interference when the two different information inquiry modes were compared, because previous studies have provided evidence that the factor of ISE influences how participants use the system; for example, high ISE students have better information searching strategies [16]. In addition, the background of using computer experience had to be found to be alike in this study because individual computer experience is also one of the key factors affecting individual feelings about using the system as an information retrieval tool [10]. Last but not least, information commitment has an impact on the results of information seeking [19]. Therefore, the information commitment of the students may affect the answers they find and the knowledge they can gain from the network.

3. Results

To ensure that the two groups had similar backgrounds, an independent t test of the pretest for the two groups confirmed that there was no significant difference ($t=-1.023$, $p=.309$). In addition, the Information Commitments Survey, Internet Self-Efficacy and attitudes toward the Internet are controlled items, and the survey of the questionnaires and scales showed no significant difference between the students in the different modes at the beginning. The following three sections respond to the three research questions designed in the study.

3.1. Analysis of the e-portfolios in the different network inquiry modes

All the behaviors online were recorded in the database. When the students integrated their existing knowledge and information search strategies to solve the problems, the inquiry times and their problem-solving records were stored in the database so that the completion ratio of the problem solving task could be further analyzed. The results show that a higher ratio of the experimental group than the comparison group successfully completed all problems after examining the problem solving process online. The statistical results display that a higher percentage of participants finished the task but failed in one problem in the comparison group. Most of the students in each group were frustrated by the second problem because the

resources for solving the problem are not easily found using just the topic as the keywords, that is structured programming. The students had to comprehend the first problem and solve it, and then use the answer to the first problem as the keywords to search for the resources to answer the second problem; otherwise, they would not easily find the complete answer. The task completion ratio of each group is shown in Table 1. There were two students who did not finish the task on the net because the open-resource network provides users with such extensive information that it may result in misconceptions, or the students may spend too much time searching.

Table 1. The task completion ratio of the two groups on the net

	Comparison group	Experimental group
The percentage of the people who successfully completed all PBL tasks on the net	43.64%	61.82%
The percentage of the people who finished the task but failed in one problem	43.64%	29.09%
The percentage of the people who finished the task but failed in two problems	3.64%	9.09%
The percentage of the people who finished the task but failed in three problems	5.45%	0.00%
The percentage of the people who did not finish the PBL task on the net	3.64%	0.00%

The findings of the study remind instructors that unlimited resources in an open inquiry mode bring more trials to learners when they search for data to solve their tasks. It is imperative for teachers to confirm that there are enough resources and provide appropriate search domains when problem-based learning is carried out on a network.

3.2. Analysis of the Pretest and Posttest

Before the activities of problem-based learning in the different inquiry information systems were carried out, the students in each group were divided into three achievement levels. Moreover, the pretest results showed that there was no significant difference between the two groups (*t=-1.023, p=.309*). After the treatment of the problem-based learning activities in the two inquiry information systems, the post-test showed that students in both groups had made progress. The paired-samples t tests of the pretest and posttest in each group are shown in Table 2. The results indicate that the learning outcomes of the students in both the comparison and the experimental groups improved remarkably. It can be found that the low-achievement students in both the comparison and the experimental groups made great progress after the problem-based learning activities on the web. It can thus be concluded that open and closed information inquiry modes both benefit low-achievement students, as they gained the most improvement in terms of the concept of structured programming.

Table 2. Paired-samples t test of the pretest and posttest of each group

All achievement grouping		N	Comparison group				Experimental group			
			Mean	SD	MD	t	Mean	SD	MD	t
High achievement	Pretest	15	65.67	9.04			72.33	12.66		
(Posttest-Pretest)	Posttest	15	77.67	8.84	12	4.58**	86.67	7.94	14.33	4.90**
Medium achievement	Pretest	25	43.4	5.35			42.8	8.55		
(Posttest-Pretest)	Posttest	25	66.8	11.63	23.4	9.25**	66.8	15.06	24	8.86**
Low achievement	Pretest	15	20.5	7.81			17	7.75		
(Posttest-Pretest)	Posttest	15	57.5	18.6	37	11.52**	59	15.72	42	10.16**

**p < .01

From Table 2, it is found that the low-achievement students in the experimental group increased forty-two marks on average after the experimental treatment; however, the low-achievement students in the comparison group only increased thirty-seven marks on average. To examine whether the posttest results show a statistically significant difference, ANCOVA was executed to compare the posttest of each group by excluding the influence of the pretest. The results show that the high-achievement students in the experimental group had significantly better performance than the high-achievement students in the comparison group. However, there was no significant difference between the learning outcomes of the medium-achievement students in the experimental and comparison groups. There was also no significant difference between the learning outcomes of the low-achievement students in the experimental and comparison groups. This means the students in the high achievement group who learned by problem-solving in the closed-resource network had better learning effectiveness than those in the open-resource network. The information searching activities in the open-resource network bring finite benefits to the high-achievement level students. The students who applied problem-based learning by information searching in the closed-resource network made more progress than the students in the open-resource network on average, although there is no significant difference between the posttest of the low-achievement students in the two groups. Therefore, the open inquiry mode is also useful in many circumstances.

3.3. Analysis of the Technology Acceptance Model

The relationships of enjoyment, usefulness, ease of use, and satisfaction with the system quality are analyzed in the study, and user intentions are further inferred. A seven-point Likert scale questionnaire was used to evaluate the technology acceptance model of the two different network inquiry modes. The descriptive statistics results are shown in Table 3. From the comparison of the two groups in the table, the users perceived higher enjoyment, ease-of-use, and satisfaction with the closed-resource network than with the open-resource network. The three factors achieve significant difference in the independent sample t test. Although the differences of perceived usefulness and user intention between the two groups do not reach significance, the two factors in the experimental group appear to have a higher mean than those in the comparison group.

Table 3. The independent sample t test of the technology acceptance model variables between the two groups

Descriptive Statistics	Comparison group			Experimental group			t
	N	Mean	SD	N	Mean	SD	
Perceived Satisfaction with the quality of network inquiry mode	55	5.19	1.18	55	5.58	0.83	-2.00*
Perceived Enjoyment	55	4.84	1.35	55	5.36	1.04	-2.30*
Perceived Ease-of-use	55	4.87	0.79	55	5.26	0.86	-2.42*
Perceived Usefulness	55	5.25	1.09	55	5.43	0.87	-0.956
Intention to use	55	5.18	1.05	55	5.40	1.09	-1.092

*$p < .05$

After analyzing the agreement and disagreement percentages of the five TAM variables, it was found that around 87 percent of the students gave positive feedback about their perceived satisfaction with the closed-resource network, while only 4 percent stated the opposite. In addition, more than 80 percent of the students in the experimental group gave positive feedback about its perceived usefulness, and more than 70 percent gave positive

feedback about their perceived ease of use and enjoyment of the closed-resource network. As a result, more than 75 percent of the students were interested in using the closed-resource network. However, the comparison group had relatively less interest in using the open-resource network.

4. Discussion and Conclusion

Information-searching competence has been recognized to play an important role in problem solving [9]. In this study, we attempt to compare the effects of using closed and open network resources on students' intentions and learning effectiveness in web-based problem-solving activities. Experimental results show that both the closed and open network systems had contributions to assist the students in problem-solving and learning performance. However, the learning effectiveness of the high-achievement students in the experimental group was significantly better than those in the comparison group. Accordingly, this study suggests the instructors to conducted problem-solving activities in a closed network for those high-achievement students.

On the other hand, the results of TAM investigation show no significant difference between the two groups in the dimensions of user intention and perceived usefulness. Nevertheless, for the dimensions of satisfaction, enjoyment, and ease-of-use, the students in the experimental group gave significantly higher ratings than those in the comparison group, implying that the learning system with closed network resources was more acceptable to the students than the open network resources.

The results of the study suggest that digital libraries can be put into use more widely and are worth developing. Collecting the instructional resources into a digital library prevents the students from searching for information which they are not sure is correct. However, one drawback is that the two modes only use text to search for and answer the problems. Pictures cannot be inserted into the answer sheet of the two modes during problem-solving. Therefore, in the future, it is suggested that researchers increase the functions of the two modes so that pictures can be used when answering problems. Moreover, the instructors are encouraged to continue providing diverse information resources and constructing more instructional materials in the closed-resource network. Future studies can try to combine other appropriate pedagogies such as BIGSIX pedagogy into the network information inquiry modes in addition to problem-based learning.

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