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A Study of Problem-based Instructional Strategies for Technological Literacy

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ABSTRACT

The purpose of this 1-year study was to investigate the improvements in problem-solving ability and cognitive learning achievement or technological literacy, with regard to the issue of waste disposal, using a problem-solving approach guided by classroom and web-based instruction. The important technological and social issues for different educational levels were identified in a previous study. Waste disposal was chosen as the topic for this study. A nine-step problem-solving strategy was used for the development of instructional materials for elementary (5th grade) and junior high school (8th grade) levels, both in classroom and website environments. A pre-test/post-test design was adopted to evaluate the effectiveness of and differences between the two conditions. The results showed that overall problem-solving skills improved in the elementary school classroom instruction group, and that waste-disposal knowledge improved in the junior high classroom instruction group. No significant change was found in either the overall problem-solving skills or waste-disposal knowledge of web-based instruction groups at the two educational levels. This study encourages efforts to integrate problem-solving training and technological literacy education, but repeated practice with different topics (or issues) is required for significant results. The web-based instructions designed for this study were unsuccessful. Student's limited competency in word processing and unfamiliarity with interactive computer instructions may have been the key reasons for this failure.

Key Words: problem solving, technological literacy, web-based instruction

I. Introduction

1. Background

Technology is a product of human imagination, inventiveness, and creativity. Technology education is a core subject that provides fundamental knowledge for the development of future citizens, family members, consumers, and workers (Wright, 1999). Every citizen should be technologically literate.

After discussing a variety of sensors – specifically those of the NASA Mars Pathfinder Lander – Deal (1997) suggested that using sensors to solve technological problems is limited only by one's creativity and imagination. In other words, creativity should be regarded as the most essential resource of technological invention and innovation. Moshe & Yaron (1999) explored the role that technological activities can play in developing students' higher-order thinking skills, and described a Creative Thinking in Technology (CTT) program in which creative thinking is presented as a synthesis of lateral and vertical thinking.

Collectively, technological problem-solving can have social, ecological, or technological goals and may be classified into four types: invention, design, trouble-shooting, and procedures (Custer, 1999). Funded since 1985, Mission 21 is an important project that promotes technological literacy in the elementary school classroom and which has developed field-tested materials that integrate technological concepts into the present curriculum; these guide activities emphasize creativity using a problem-solving approach to learning (Brusic, 1990).

Abbott and Warfield's study was conducted at the secondary level. The main findings were that (1) the lack of problem-solving abilities originates from a lack of student motivation, lack of experience with problem solving, and inability to think critically; (2) cooperative learning, multiple intelligence, and Problem Solving Teaching were the major interventions selected; and (3) post-intervention data indicated an improvement in targeted students' problem-solving abilities and they showed a more-positive attitude toward problem solving (Abbott & Warfield, 1999).

In other curriculum areas, many studies have been conducted to explore problem solving, creativity, and related factors. In physics education, Tao (2000) explored high school students' collaborative efforts in solving qualitative physics problems. The study investigated whether confronting students with varying views helps to improve their problem-solving skills and develop better understanding of the underlying physics concepts, and how it does that. Varying views were provided to 18 (12th grade) students by requiring them (1) to work in dyads on problems, during which time they had to consider and confront each other's ideas; and (2) to consider, in a feedback session, multiple solutions to each problem, comparing other solutions with their own and reflecting on their mistakes. Theory of the structure of awareness was adopted as its theoretical underpinning: that is, varying views can bring different critical aspects of a problem situation to students' focal awareness, thus enabling them to better discern the situation and helping them develop a conceptual understanding of the problem. Results show that confronting students with varying views can have three positive effects: (1) It can enhance students' understanding and improve their problem-solving skills; (2) It can induce students not only to reflect on the object of learning but also spontaneously to consider their approach to learning physics; and (3) It can enable students to see things differently and to consider, and possibly adopt, new approaches to learning physics.

Hamil's study was conducted to determine the effects of problem-solving activities in physical science classes designed for elementary education majors. A post-test-only control group design was used, with 50 students participating during a 5-week treatment period. Instrumentation consisted of the Test of Integrated Process Skills II and the Problem-Solving Inventory. Multiple linear regression analysis indicated that there were significant differences between the experimental and control groups. The process skill ability mean score was significantly higher for the experimental than for the control group. There was also a significant relationship between the independent variables of logical reasoning ability and process skill ability. The experimental group had better perception of their ability to approach problems and had more confidence in their problem-solving ability; however, the control group had better perception in the area of personal control (Hamil, 1997).

For mathematics education, Costello & Chapin (2000) described approaches taken at a middle school to improve student problem-solving abilities and test results for the Indiana Statewide Testing for Educational Progress (ISTEP) mathematics tests. Posters were designed and placed in classrooms, and teachers were encouraged to refer students to them as they worked on solving problems to improve their problem-solving and critical thinking skills. As a result, those students' achievement on a local problem-solving test, the Mathematics Proficiency test, and on the ISTEP test showed continual improvement.

Another report on mathematics curricula, investigated the extent to which a curriculum designed to actively teach critical thinking skills resulted in students' utilizing higher-order thinking skills (*e.g.*, analysis, synthesis, and evaluation) (Jackson, 2000). An interventional strategy was designed for a 6th-grade class located in a diverse suburban community in northern Illinois. This intervention targeted the mathematics curriculum and was designed to incorporate the teaching of critical thinking skills. Students were administered a pre-test to determine baseline data. The intervention included the daily use of a variety of thinking skill enhancers and a guided assessment of problem-solving strategies over a 20-week period. Results indicated success on many levels. Students displayed increased self-esteem and confidence in their abilities to solve problems. Self-reflection by students on their work was also observed. Students were able to verbalize their thought processes when analyzing problems. As an indicator of success, however, it had been hoped that there would be a higher number of students displaying improvements in post-test results. Nevertheless, with over 50% of students involved in the intervention showing improved scores, the time and energy expended in this project were justified.

In those studies, problem solving was found to be an effective teaching strategy to improve student's personal learning motivation, higher-order thinking skills, and conceptual understanding of subject matter (Hamil, 1997; Costello & Chapin, 2000; Jackson, 2000; Tao, 2000).

Consequently, improving creativity has now become one of the most important goals of technology education, and problem solving plays a crucial role in improving technological creativity. Through the use of creative problem-solving skills, students are able to develop solutions to future societal problems. Technology education teachers must incorporate the teaching of these skills into their curricula (James, 1990; Lewis, Petrina, & Hill, 1998).

In addition, development of the internet has fostered a revolution in communication that is providing new opportunities for delivering instruction (Teh, 1999). Cyber exploration is a strange and novel experience on many levels for students. Unlike other classes and academic situations relying heavily upon recall, Web-based instruction promotes independent learning skills (Joette, 1998).

Joette's study indicated that students taking a Web-based course had fewer absences: a group average of three compared to previous skills-based groups that averaged five. Better attendance means more instructional time, greater involvement, and more reading. Test results showed that an Internet-based course improved students' reading skills more than did a text-based course (Joette, 1998).

Sullivan's paper addressed some different views, and proposed that Web-based training is cheaper and faster, and it is easier to keep updated than with other training methods, but it is not always the best choice. The best choice depends on what – and whom – is being taught. The best solution may be a combination of approaches – using classrooms, the Web, and even outside sources in just the right mixture (Sullivan, 1998). Nevertheless, what would the situation be in technology education?

Traditionally, face-to-face instruction combined with hands-on activities has been adopted in technology education to develop students' technological literacy and problem-solving skills (Fang & Yang, 1996). However, as the world moves into the information era, computers and related technologies have become increasingly powerful tools to deliver knowledge – from lower-level cognitive knowledge, such as drilling and patterning materials, to higher-level thinking skills such as problem solving and critical thinking. There is no doubt that problem-solving skills will be critical in the future; meanwhile, the application of computer technology is becoming increasingly convenient and popular (Lee, 1995; Lin, 1995).

Along with the development of various learning and delivery technologies, researchers have explored several issues, among which, the major ones are effectiveness, student background, learning style, motivation, course design, instructor roles, and cost-benefit analyses (Sankaran, 2001). This research project utilized an approach using Web-based instruction combined with hands-on activities to investigate the different effects of these two instructional environments on the development of students' problem-solving skills outside the traditional classroom.

2. Purpose

Based on the above background, the purpose of this study was to compare the effectiveness of problem-solving instructional strategies in classroom and Web-based environments in developing students' (1) problem-solving skills, and (2) cognitive learning or achievement of technological literacy at different educational levels.

II. Methods

1. Research Design

A quasi-experimental research design including a pre-test and a post-test was employed to measure differences in the problem-solving skills and cognitive learning (achievement of technological literacy using waste disposal as the topic) of students under conditions of classroom instruction and website instruction at elementary and junior high school levels. The intervention period was 6 weeks. One 80-min activity was designed for each week. Pre-tests and post-tests were administered 1 week before and after the intervention. The intervention period was April to May 1999.

2. Subjects

This study was conducted in an elementary school and a junior high school in Taipei County, Taiwan. Schools with efficient website equipment and a high degree of cooperation were chosen for the study.

At the elementary school level, four 5th-grade classes with a total of 122 students were randomly selected to participate in the study. Two classes (n = 62) were randomly selected for Web-based instruction, and another two classes (n = 60) for classroom instruction.

At the junior high level, four 8th-grade classes with a total of 155 students were selected in the same way. Two classes each were randomly selected for classroom (n = 77) and Web-based instruction (n = 75).

3. Instruments

Two types of instruments were used in the study: an educational instrument and a measurement instrument.

A. Educational Instrument

Waste-disposal was chosen as the issue for this study based on a previous study (Lee, 1998). It was one of ten issues evaluated as being both interesting and important by experts and students. Elementary school students focused on waste-disposal issues in the family, while the junior high students focused on school waste-disposal issues. The nine-step problem-solving instructional strategy (Fig. 1) refined by Fang (1995) was used for designing classroom courses and webpages. The strategy is based on the design loop model proposed by Hutchinson & Karsnitz (1994). Classroom and webpage activities were designed separately

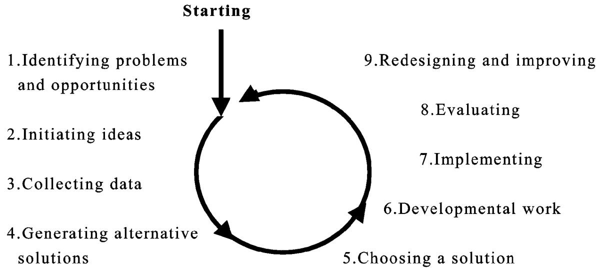

Fig. 1. The nine-step problem-solving model.

for the two different educational levels. Group discussions and assignments were required in almost every activity. Six 80-min classroom activities were designed, one for each week. The educational goals and procedures for each activity were thoroughly described, and activity sheets were provided in the teacher's manuals for the classroom instruction group. Based on the same contents and activities, webpages were designed. Students in the Web-based instruction group had to collect information from websites, but they were allowed to hand in activity sheets and assignments due to their limited word processing abilities. To assure that both groups of students had sufficient resources to fulfill the assignments, school libraries and related websites were checked. Books and reference materials were provided for the classroom instruction group, and a related website was created by the research group.

For the elementary school level, research personnel gave instructions for both classroom and web-site conditions. For the junior high level, a technology education teacher with training in problem-solving instructional strategies gave the instructions for both conditions. Web-based instructions were implemented in the school computer rooms. Every student had his own computer which was equipped with a web system. The teacher's classroom records were required for every class in both groups.

B. Measurement Instruments

The main measurement instruments used in this study were the problem-solving inventory (PSI) and a waste-disposal knowledge test.

The PSI, which includes problem-solving confidence, approach avoidance style, and self-control dimensions, was translated from the PSI developed by Heppner & Petersen (1982) in order to find difference in the problem-solving skills of the two student groups.

Based on the content of the PSI, scales for individual educational level were drafted according to students' reading abilities. The original design of the scale has 35 items with a six-point Likert-type format. The response items range from "strongly agree" to "strongly disagree;" one to six points are assigned to each response item, and 17 items are scored inversely. Problem-solving skills are evaluated according to the total score, with lower scores representing better skills. Sample items from the scale are shown in Table 1. To assure the accuracy and appropriateness of the translation, drafts of the two scales were inspected by experts, and pilot tests were conducted. Modifications were made according to the experts' opinion and item analysis results. The construct validity was also checked by factor analysis. At the elementary school level, factor analysis results indicated three factors, and the distribution of items was very similar to the original design. There were 18 items in the problem-solving confidence subscale, nine items in the avoidance approach style subscale, and eight items in the personal control subscale. For the junior high level, factor analysis results showed some differences in the distribution of items compared to the original scale; 32 items in all were selected, and there were 11 items on the problem-solving confidence subscale, 16 items on the avoidance approach style subscale, and five items on the personal control subscale. Cronbach α coefficients of the elementary school and the junior high level problem-solving inventories were 0.75 and 0.72, respectively.

Table 1. Sample Items of Problem-Solving Inventory for the Elementary School Level

Item	
A. Problem-solving confidence subscale	
Item 5	I am usually able to think up creative and effective alternatives to solve a problem.
Item 10	I have the ability to solve most problems even though initially no solution is immediately apparent.
B. Approach avoidance style subscale	
Item 1	When a solution to a problem is unsuccessful, I do not examine why it didn't work.
Item 4	When I have to solve a problem, I do not analyze what went right or wrong.
C. Personal control subscale	
Item 3	When my first efforts to solve a problem fail, I became uneasy about my ability to handle the situation.

Note: Response items are: strongly agree, agree, slightly agree, slightly disagree, disagree, and strongly disagree. One to six points was assigned to each response accordingly. Some items are scored inversely.

Waste-disposal knowledge tests were also designed for each educational level to measure achievements in the cognitive domain based on the course contents and Bloom's cognitive taxonomy (knowledge, comprehension, application, analysis, synthesis, and evaluation). Drafts of the two knowledge tests were evaluated by experts, and pilot tests were conducted. The tests were modified based on experts' opinions and item analysis results. The final knowledge tests had 25 true/false and 18 multiple choice questions for the elementary school level, and 50 multiple choice questions for the junior high level. One or two points were given for each correct answer. The total score on the knowledge test was used to evaluate academic achievement: a higher score represented greater achievement. Cronbach α coefficients of the knowledge tests were 0.75 for the elementary school and 0.73 for the junior high level.

III. Results

Data from the students' test scores were analyzed using SPSS 9.0 for Windows. Pre- and post-test scores

Table 2. Comparison of Pre- and Post-Test Scores for the Elementary School Level

	Traditional group (n = 62)					Web-based group (n = 60)				
	Pre-test		Post-test			Pre-test		Post-test		
	M	SD	M	SD	t	M	SD	M	SD	t
Problem-solving total score[a]	104.90	18.55	98.76	20.82	-1.73*	105.88	15.40	104.52	17.00	-0.46
Problem-solving confidence[a]	45.48	12.01	41.73	11.25	-1.79*	44.52	11.99	42.60	11.44	-0.90
Approach avoidance style[a]	30.29	7.10	28.24	8.45	-1.46	29.37	6.48	30.88	8.09	1.13
Personal-control[a]	29.13	5.34	28.31	7.19	-0.72	32.00	3.31	31.03	5.41	-1.18
Waste-disposal knowledge[b]	23.58	5.24	24.52	5.08	1.01	24.35	6.04	24.52	5.74	0.16

[a] A lower score indicates greater ability.
[b] A higher score indicates better performance.
*p < 0.05.

Table 3. Summary of Covariance Analysis for the Elementary School Level

	Source	SS	df	MS	F
Problem-solving total score	Between groups	803.80	1	803.80	3.25
	Within groups	29414.37	119	247.18	
Problem-solving confidence	Between groups	57.79	1	57.79	0.64
	Within groups	10756.80	119	90.39	
Approach avoidance style	Between groups	307.23	1	307.23	5.79*
	Within groups	6316.94	119	53.08	
Personal control	Between groups	35.3	1	35.3	1.01
	Within groups	4144.38	119	34.83	
Waste-disposal knowledge	Between groups	5.89	1	5.89	0.31
	Within groups	2257.92	119	18.97	

*p < 0.05.

were compared with the t-test for each group. Analysis of covariance (ANCOVA) on post-test scores with pre-test scores as the covariate was used to investigate differences in students' problem-solving skills and academic achievement in the classroom and web-based instruction groups.

1. Elementary School Level

The mean scores with standard deviations of the pre- and post-tests for the two groups at the elementary school level are shown in Table 2. Results of the t-test (Table 2) show that significant differences ($p < 0.05$) existed between the pre- and post-test scores for the overall problem-solving inventory and problem-solving confidence subscale of the classroom instruction group, but not for waste-disposal knowledge or other problem-solving subscales. Changes were shown, but no significant change was found between any of the pre- and post-test scores for the web-based group. This result indicates that overall problem-solving skills and problem-solving confidence improved only under traditional classroom conditions.

To further compare differences between classroom and web-based instructional environments, post-test scores of the two groups were compared using ANCOVA with pre-test scores as the covariate. The ANCOVA results (Table 3) reveal that no difference between the two groups existed for the overall problem-solving inventory and waste-disposal knowledge on the post-test scores.

In comparing scores of three dimensions of the problem-solving inventory, a difference ($F = 5.79$, $p < 0.05$)

Table 4. Comparison of Pre- and Post-Test Scores for the Junior High Level

	Traditional group (n = 77)					Web-based group (n = 75)				
	Pre-test		Post-test			Pre-test		Post-test		
	M	SD	M	SD	t	M	SD	M	SD	t
Problem-solving total score[a]	100.55	13.78	100.72	14.32	0.08	93.59	15.97	96.35	11.95	1.2
Problem-solving confidence[a]	32.38	5.54	32.98	5.10	0.70	29.30	5.64	29.84	6.01	0.57
Approach avoidance style[a]	49.93	7.14	50.20	7.56	0.23	46.48	9.37	48.87	5.19	1.93*
Personal control[a]	18.23	4.55	17.53	3.76	-1.04	17.80	3.92	17.63	3.45	-0.28
Waste-disposal knowledge[b]	65.63	10.18	75.68	13.70	5.15*	68.29	9.53	67.72	8.72	-0.38

[a] A lower score indicates greater ability.
[b] A higher score indicates better performance.
*$p < 0.05$.

was found for the approach avoidance style subscale but not for the problem-solving confidence subscale or the personal control subscale. The adjusted means of the post-test score of the approach avoidance style subscale for the classroom instruction group (adj. $M = 27.98$) was lower than that for the web-based instruction group (adj. $M = 31.16$). From the mean scores of the pre- and post-tests (Table 2), we found that this difference was probably due to the fact that the post-test scores of the web-based instruction group slightly increased in the approach avoidance style dimension, and therefore the difference between the two groups also increased.

2. Junior High Level

The mean scores with standard deviations for the pre- and post-tests of two groups at the junior high level are shown in Table 4. For the classroom instruction group, results of the t-test (Table 4) show that no difference existed between the pre- and post-test scores of the overall problem-solving inventory and the three subscales of the classroom instruction group; however, the post-test waste-disposal knowledge score was significantly ($t = 5.15$, $p < 0.05$) higher than the pre-test score. This result indicates that the 6-week problem-solving course of instruction significantly improved junior high school students' waste-disposal knowledge but not their problem-solving skills under traditional classroom learning conditions. For the web-based instruction group, no significant difference was found between the pre- and post-test scores of the waste-disposal knowledge test or of the overall problem-solving inventory. A significant difference existed in the approach avoidance style subscale, with the post-test score being higher than the pre-test score, which indicates that students in the web-based learning environment performed worse in that dimension after 6 weeks of instruction.

In comparing the effectiveness of the two instructional environments, the ANCOVA results (Table 5) revealed that a difference ($F = 47.38$, $p < 0.05$) existed in the waste-disposal knowledge post-test scores of the two groups. The adjusted mean score of the classroom instruction group (adj. $M = 76.30$) was higher than that (adj. $M = 68.10$) of the web-based instruction group, which means that the classroom instruction group had a higher level of academic achievement than did the web-based instruction group.

No difference was found between the overall problem-solving inventory post-test scores of the two groups, but there was a significant difference ($F = 7.53$, $p < 0.05$) in scores of the approach avoidance style subscale. The adjusted mean score of the classroom instruction group (adj. $M = 49.23$) was lower than that (adj. $M = 49.83$) of the web-based instruction group, which means that the classroom instruction group performed better in that dimension of the problem-solving process.

IV. Discussion and Conclusions

1. At the Elementary School Level

Overall problem-solving skills and problem-solving confidence of the classroom instruction group improved after 6 weeks of instruction, while no improvement was found in the web-based instruction group.

Results also indicate that after completing 6 weeks of problem-solving activities centered around household waste-disposal issues, the 5th graders' waste-disposal knowledge did not change under the two conditions.

2. At the Junior High Level

The overall problem-solving skills did not change in either group after the 6-week intervention, but the students' waste-disposal knowledge improved with classroom instruction.

From the above results, we can conclude that the

Table 5. Summary of Covariance Analysis for the Junior High Level

	Source	SS	df	MS	*F*
Problem-solving total score	Source	SS	df	MS	*F*
	Between groups	39.11	1	39.11	0.41
	Within groups	13118.66	136	96.46	
Problem-solving confidence	Source	SS	df	MS	*F*
	Between groups	4.59	1	4.59	1.94
	Within groups	3227.33	136	23.73	
Approach avoidance style	Source	SS	df	MS	*F*
	Between groups	243.89	1	243.89	7.53*
	Within groups	3918.81	136	28.82	
Personal control	Source	SS	df	MS	*F*
	Between groups	1.38	1	1.38	0.18
	Within groups	1053.13	136	7.74	
Waste-disposal knowledge	Source	SS	df	MS	*F*
	Between groups	2477.04	1	2477.04	47.38*
	Within groups	16380.29	147	111.43	

*$p < 0.05$.

problem-solving strategy integrated with technology literacy education under conditions of classroom instruction is more effective than web-based instruction, but the effects differ with educational level. One possible explanation is that the instructional design focused on applying the problem-solving process to solve a chosen technological social issue. Therefore teachers acted as process facilitators instead of knowledge providers. Students had to search for related information to complete assignments. Students' abilities to collect information and engage in self-directed learning would have affected the outcomes. Results of this study reveal that 5th graders were not familiar with the self-directed learning method, and even though they were capable of finishing their assignments, there was little improvement in their technological literacy. On the other hand, 8th graders showed significant improvements in technological literacy, but there were only small changes in their problem-solving skills. More-rigid problem-solving processes may already be established in 8th graders as compared to 5th graders. Therefore a longer period or repeated problem-solving skill training may be necessary for older students in order to change their existing patterns for handling problems.

Earlier studies showed inconsistent results as to the effects of problem-solving training. Some studies showed positive results (Mendonca & Siess, 1976; Dixon, Heppner, Petersen & Ronning, 1979; Heppner & Petersen, 1982; Wang, 1985; Lerner & Clum, 1990; Huang, 1994; Hamil, 1997; Abbott & Warfield, 1999; Costello & Chapin, 2000; Jackson, 2000; Tao, 2000), while others did not (Carey, Carey & Meise, 1990; Wu, 1993). These studies focused mainly on training for problem-solving skills; few of them incorporated cognitive contents into the problem-solving process. Costello & Chapin (2000) showed that middle school students improved their problem-solving and test results on the Indiana Statewide Testing for Educational Progress (ISTEP) mathematics tests. Jackson (2000) investigated the effects of a 6th grade mathematics curriculum into which critical thinking skills were incorporated. After a 20-week period, students displayed self-esteem and confidence in their ability to solve problems, and over 50% of students achieved higher mathematics scores. Two studies on creative problem-solving ability focusing on natural sciences and social studies showed no difference in academic achievement as compared to the control group (Liu, 1993; Jan, 1994).

The web-based forms of instruction designed in this study were unsuccessful as evaluated by the problem-solving inventory and waste-disposal knowledge test scores. The teacher's classroom records showed that students had the following problems: lack of attention, access of unrelated websites, limited word processing abilities, and unfamiliarity with interactive computer instruction. Students' competency in computer technology is essential for their capability of using websites as a teaching tool. Due to the limitation of funds, webpages were designed by graduate students. The designs might not have been interesting enough to capture the young students' attention.

V. Suggestions

Based on the results of this research, several suggestions can be made concerning problem solving-related instruction and research in the future.

(1) The results indicate that problem-solving instructional strategies integrated with technological literacy education can be useful in improving students' problem-solving skills and technological literacy. But a longer period or repeated practice may be required in order to help students develop self-directed learning abilities and familiarity with the problem-solving process. Therefore, instructional activities applying the nine-step problem-solving model, and focused on different technological social issues, could be designed for technology education in schools.

(2) In this study, trained teachers or research personal gave the instructions. In order to smoothly implement problem-solving instruction, teachers should be trained in problem-solving instructional strategies.

(3) For successful web-based instruction, internet facilities, innovative and vivid web-page design, and students' competency in word processing and familiarity with interactive computer instruction are important. These factors should very carefully be evaluated before implementing web-based instruction at the elementary school and junior high levels.

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References

Abbott, L., & Warfield, A. (1999). *Improving the problem solving skills of math and science students at the high school level.* Master' Action Research Project, Chicago, IL: St. Xavier University & IRI/Skylight. (ERIC Document Reproduction Service no: ED439 018)

Brusic, S. A. (1990). *An overview of mission 21. A program designed to assist teachers in integrating technology into their present curriculum through a problem-solving approach. Grades 1 through 6*. Blacksburg, VA: Virginia Polytechnic Inst. and State Univ. (ERIC Document Reproduction Service no: ED334 407)

Carey, M. P., Carey, K. B., & Meisler, A. W. (1990). Training mentally ill chemical abusers in social problem solving. *Behavior Therapy*, **21**, 511-518.

Costello, R. W., & Chapin, D. W. (2000). *Problem solving within a changing Indiana state testing program*. (ERIC Document Reproduction Service no: ED445 054)

Custer, R. L. (1999). Design and problem solving in technology education. *NASSP Bulletin*, **83**(608), 24-33. (ERIC Document Reproduction Service no: EJ594 828)

Deal, W. F. (1997). Sensing the world around us. Resources in technology. *The Technology Teacher*, **57**(2), 11-16. (ERIC Document Reproduction Service no: EJ551 576)

Dixon, D. N., Heppner, P. P., Petersen, C. H., & Ronning, R. R.(1979). Problem solving workshop training. *Journal of Counseling Psychology*, **26**, 133-139.

Fang, C. H. (1995) *An experimental study of the problem-solving based curriculum for technology education in junior high schools*. Taipei, Taiwan: Chinese Industrial Arts Education Association.

Fang, C. H., & Yang, J. S. (1996). *A study on the contents of technological literacy for the elementary school students*. Final project report for NSC 85-2511-S-003-070. Taipei, Taiwan: National Science Council.

Hamil, J. B. W. (1997). The influences of physical science problem-solving activities in teacher education programs. Paper presented at the Annual Meeting of the Mid-South Educational Research Association. (ERIC Document Reproduction Service no: ED427 011)

Heppner, P. P., & Petersen, C. H. (1982). The development and implications of a personal problem-solving inventory. *Journal of Counseling Psychology*, **29**(1), 66-75.

Huang, S.-J. (1994). *Effects of problem-solving training on the problem-solving ability, coping and mental health status in college students.* Unpublished master's thesis, National Changhua University of Education, Changhua, Taiwan.

Hutchinson, J., & Karsnitz, J. R. (1994). *Design and problem solving in technology*. Albany, NY: Delmar.

Jackson, L. (2000). *Increasing critical thinking skills to improve problem-solving ability in mathematics*. Master of Arts Action Research Project, Chicago, IL: Saint Xavier University and Skylight Professional Development. (ERIC Document Reproduction Service no: ED446 995)

James, W. K. (1990). Development of creative problem-solving skills. *The Technology Teacher*, **49**(5), 29-30. (ERIC Document Reproduction Service no: EJ401 989)

Jan, P. L. (1994). *The effects of creative problem solving program in social study on elementary students' performance*. Unpublished master's thesis, National Tainan Teachers College, Tainan, Taiwan.

Joette, S. (1998). Designing a web-based reading course. *Journal of Adolescent & Adult Literacy*, **41**(7), 556-559.

Lee, T. W. (1995). *A study on the possessed technological literacy of secondary and elementary school teachers*. Final project report for NSC 84-2511-S-003-018-TL. Taipei, Taiwan: National Science Council.

Lee, T. W. (1998). *Developing a problem-oriented technological literacy learning module.* Final project report for NSC 87-2511-S-003-054. Taipei, Taiwan: National Science Council.

Lerner, M. S., & Clum, G. A. (1990). Treatment of suicide ideators: a problem solving approach. *Behavior Therapy*, **21**, 403-411.

Lewis, T., Petrina, S., & Hill, A. M. (1998). Problem posing – adding a creative increment to technological problem solving. *Journal of Industrial Teacher Education*, **36**(1), 5-35. (ERIC Document Reproduction Service no: EJ574 852)

Lin, W. (1995). *A study on the possessed technological literacy of secondary and elementary school students*. Final project report for NSC 84-2511-S-003-033-TL. Taipei, Taiwan: National Science Council.

Liu, C. W. (1993). *The effects of creative problem solving program in natural science on elementary students' performance*. Unpublished master's thesis, National Tainan Teachers College, Tainan, Taiwan.

Mendonca, J. D., & Siess, T. F. (1976). Counseling for indecisiveness: problem solving and anxiety management training. *Journal of Counseling Psychology*, **23**, 339-347.

Moshe, B., & Yaron, D. (1999). Integrating the Cognitive Research Trust (CoRT) programme for creative thinking into a project-based technology curriculum. *Research in Science & Technological Education*, **17**(2), 138-151. (ERIC Document Reproduction Service no: EJ600 218)

Sankaran, S. R. (2001). Impact of learning strategies and motivation on performance: a study in web-based instruction. *Journal of Instructional Psychology*, **28**(3), 191.

Sullivan, E. (1998). The Web isn't always the best teacher. *PC Week*, **15**(6), 36.

Tao, P. K. (2000). *Developing understanding through confronting varying views: the case of solving qualitative physics problems*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, New Orleans, LA. (ERIC Document Reproduction Service no: ED443 722)

Teh, G. (1999). Assessing student perceptions of internet-based online learning environments. *International Journal of Instructional Media*, **26**(4), 397-402.

Wang, M. L. (1985). *The effect of interpersonal problem-solving training on the interpersonal problem-solving skill, attitude and adjustment of junior high female students*. Unpublished master's thesis, National Taiwan Normal Univ., Taipei, Taiwan.

Wright, R.T. (1999).Technology education: essential for a balanced education. *NASSP Bulletin*, **83**(608), 16-22. (ERIC Document Reproduction Service no: EJ594 827)

Wu, J. M. (1993). *A study of the effect of a problem-solving training group on problem attitude and job stress for the elementary school teachers.* Unpublished master's thesis, National Kaohsiung Normal Univ., Kaohsiung, Taiwan.

問題解決的技學素養教學策略研究

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摘　要

本研究旨在探討以問題解決法為教學策略下，學生在傳統教室教學與電腦網路兩種不同教學情境中，對技學素養認知與問題解決能力的學習效果及差異。研究分兩年進行，第一年之工作重點在界定現實社會中相關之技學議題，根據專家意見及學生興趣選定垃圾處理此一議題，規劃及發展適用於國小高年級及國中教學之二套以問題解決法為教學策略的教材。第二年之工作重點則在運用第一年所開發之教材，分別進行教學實驗，教學實驗期間並對技學素養認知（以垃圾處理議題為例）及問題解決能力做前後測驗，以瞭解學生在兩種教學情境中，在技學素養認知（垃圾處理知識）及問題解決能力的改變及兩種情況下之差異。研究結果顯示，國小課堂教學組的學生在教學實驗後的問題解決量表得分有顯著進步，國中課堂教室教學組在技學素養認知（垃圾處理知識）上有顯著進步，而不論是國小及國中網路組之教學均無顯著成效。研究結果顯示，運用問題解決教學策略於技學素養教學中是可行的，只是可能需要以較長時間或以不同主題多次教學才會有更顯著的成效。網路教學效果不彰除應改進網頁設計外，亦可能和學生電腦打字能力較差以及不熟悉網路學習方式等因素有關。