

Fostering Problem Solving Ability in Technology Education

—On Woodworking Area—

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The present study examines the situation on fostering problem solving ability in Technology Education. The problem solving ability evaluation test and problem solving ability diagnosis test were created and implemented in the classes in "Woodworking" area at a junior high school. The basic knowledge has been acquired on students' fostering problem solving ability in Technology Education.

Key words: Technology Education, Problem solving ability, Woodworking

1. Introduction

In Industrial Arts Education there are six areas: "Woodworking," "Metalworking," "Electricity," "Machines," "Cultivation," and "Information Technology." Among them, fostering problem solving ability is especially expected in "Woodworking" area since this area includes productive practice and students have most interest in this area. However, regarding the fostering of problem solving ability, there are few researches conducted throughout a teaching plan or consistent study conducted on a whole class, group, or individual. Therefore, pursuing the research in these aspects is required as the practical issue.

The objective of this study is to clarify how students' problem solving ability is fostered in "Woodworking" classes. Based on the previous studies¹⁾⁻⁴⁾, the structure of problem solving ability and its components were established and the problem solving ability evaluation test and the problem solving ability diagnosis test were created. They were implemented to examine the situation on fostering problem solving ability.

2. Study Method

2.1 Structure of Problem Solving Ability and Definition of Each Component

Referring to the previous studies, the structure of problem solving ability is classified into Thinking Ability, Affective Domain, and Skills. Then, ten components are established as the subordinate structure as shown in Figure 1. "Knowledge and understanding," "imagination," "judgment," and "analysis" are created as the components of Thinking Ability; "independence," "ambition," and "curiosity" are created as the components of Affective Domain; and "planning," "information collection," and "manipulation

of teaching aids and tools" are created as the components of Skills. Their definitions were shown in Table 1.

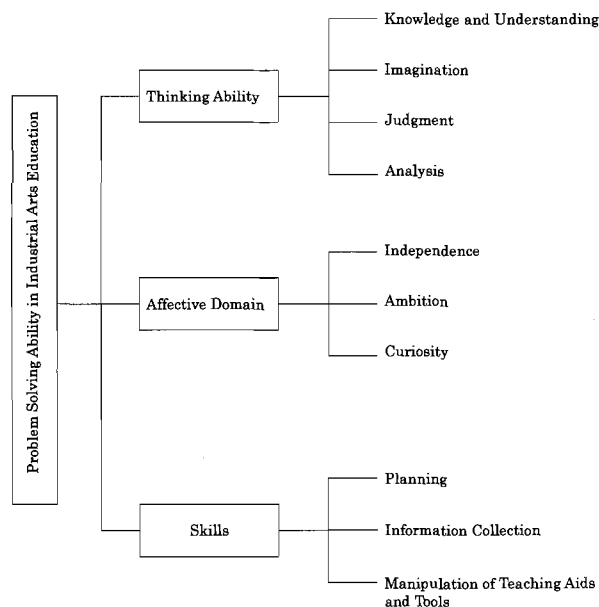


Figure 1 Structure and Components of Problem Solving in Industrial Arts Education.

2.2 Test

Two kinds of tests were created to examine the students' fostering problem solving ability: the problem solving ability evaluation test and the problem solving ability diagnosis test. Among the components above, "knowledge and understanding" was omitted in the tests because it was considered difficult for the students to do self-evaluation on the component. Therefore, the problem solving ability diagnosis test comprises 27 questions with three questions for each nine components. On the other hand, the problem solving ability evaluation test

Table 1 Components of Problem Solving Ability and their Definition.

Structure	Components	Definition
Thinking Ability	Knowledge and Understanding	Knowledge required in the process of solving a problem Ability to understand the situation of a problem
	Imagination	Ability to imagine various kinds of solving methods to solve a problem
	Judgment	Ability to make a judgment on one's own when judging something in the process of solving a problem
	Analysis	Ability to examine the situation of a problem and clarify its cause and progress
Affective Domain	Independence	Attitude of being willing to deal with problem solving without being instructed to do
	Ambition	Attitude of setting higher objective and trying to accomplish it
	Curiosity	Attitude of being curious about something unknown and new and trying to explore it
Skills	Planning	Ability to plan the method and procedure to solve a problem precisely on the basis of actual conditions
	Information Collection	Ability to sort out the information necessary for solving a problem by various ways
	Manipulation of Teaching Aids and Tools	Ability to select adequate tools and use them correctly for accurate and safe operation

consists of nine questions with one question for each component. These tests are shown in Appendix 1 and Appendix 2 respectively. Table 2 indicates the correspondence of each component with the question of the tests. The problem solving ability diagnosis test was conducted before the beginning of the whole class, before the productive practice, and after the end of the whole class while problem solving ability evaluation test was conducted after each class. Students were asked to choose one from four choices; A: It holds sufficiently true, which is counted as 4 points, B: It holds rather true, which is counted as 3 points, C: It does not hold true to some extent, which is counted as 2 points, and D: It does not hold true completely, which is counted as 1 point.

2.3 Practicing Classes

The subjects of this study were 160 female and male first graders in Class 1 through Class 4 at "A" junior high school at Nagoya City. (Each class consisted of 40 students.) The students in Class 1 and Class 2 received instruction with the purpose of problem solving. On the other hand, the students in Class 3 and Class 4 receive conventional instruction. The instruction with the purpose of problem solving means that a teacher tries to make students recognize a problem and think about it by asking questions aggressively. On the contrary, conventional instruction means that a teacher explains the learning content and he provides students with information in one direction. Also, students in Class 2 and Class 4 learned mainly in a small group and those in Class 1 and Class 3 learned mainly individually. The

Table 2 Correspondences of Components and the Question Number of Problem Solving Ability Diagnosis Test and Evaluation Test.

Structure	Components	Problem Solving Ability Diagnosis Test	Problem Solving Ability Evaluation Test	
Problem Solving Ability in Industrial Arts Education	Thinking Ability	Imagination	7, 8, 9	4
		Judgment	4, 5, 6	5
		Analysis	1, 2, 3	6
	Affective Domain	Independence	10, 11, 12	1
		Ambition	13, 14, 15	2
		Curiosity	16, 17, 18	3
	Skills	Planning	19, 20, 21	7
		Information Collection	22, 23, 24	8
		Manipulation of Teaching Aids and Tools	25, 26, 27	9

combination of teaching method and learning form is named as shown in Table 3: Class 1 is Type I, Class 2 is Type II, Class 3 is type III, and Class 4 is Type IV. For these four types, analysis of variance was calculated by statistical analysis package of computer (STAR, Ver. 4.0). This is $2 \times 2 \times 4$ design. The first factor is a teaching method, which has two levels:

"instruction with the purpose of problem solving" or "conventional instruction." The second factor is learning form, which has also two levels: "group learning" or "individual learning." The third factor is time, which has four levels: "the first hour," "the tenth hour," "the 29th hour," or "the 30th hour."

Table 3 The Combination of Teaching Method and Learning Form.

Teaching Method Learning Form	Instruction with the Purpose of Problem Solving	Conventional Instruction
Individual Learning	Class 1 (I)	Class 3 (III)
Group Learning	Class 2 (II)	Class 4 (IV)

2.4 Teaching Plan

As shown in Table 4, the teaching plan for the total 30 hours is as follows: the first hour "wood and life," the second hour "growth and tissue of wood," the third hour "how to draw an idea sketch," the fourth through the tenth hour "production of a pen holder," the 11th and 12th hour "strength and property of wood," the 13th through the 29th hour "production of a file box," and the 30th hour "utilization of wood." Among the 30 hours, the first through the tenth hour

and the final 30th hour is sedentary learning and the 11th through the 29th hour is productive practice.

3. Results and Considerations

3.1 Transition of the Total Score of Problem Solving Ability

In the result of problem solving ability evaluation test, the value that simply averaged the total scores of male and female students is held to be an average score. Figure 2 shows the transition of the total score of problem solving ability. The score of problem solving ability as a whole is 2.88 points at the first hour. Then, the score increases to 3.33 points at the tenth hour, which is the end of the first productive practice. Thereafter, the score increases gradually to 3.41 points at the 29th hour, which is the end of the second productive practice. Finally, the score is 3.25 points at the 30th hour. The results indicate that the score of problem solving ability as a whole is developed by the whole class hours of teaching curriculum in "Woodworking" area though there is some increase and decrease on the way.

Table 4 Teaching Curriculum in "Woodworking" Area.

Hour	Teaching Content
1	Wood and Life
2	Growth and Tissue of Wood
3	How to Draw an Idea Sketch
	A. Production of a Pen Holder
4	(1) Idea Sketch and Design ①: Isometric Drawing
5	(2) Idea Sketch and Design ②: Isometric Drawing
6	(3) Rough Milling ①: Marking
7	(4) Rough Milling ②: Hand Sawing
8	(5) Parts Processing ①: Planing
9	(6) Parts Processing ②: Drilling, Scraping, Grooving
10	(7) Assembling: Tenon Joint, Adhesive
11	Material ① Strength and Property of Wood
12	Material ② Strength and Property of Wood
	B. Production of a File Box
13	(1) Idea & Design
14	(2) Production of a Trial Teaching Material
15	(3) Idea Sketch & Design ①: Isometric Drawing
16	(4) Idea Sketch & Design ②: Isometric Drawing
17	(5) Materials List and Parts List
18	(6) Rough Milling ①: Marking
19	(7) Rough Milling ②: Hand Sawing
20	(8) Parts Processing ①: Planing
21	(9) Parts Processing ②: Parallel Board Joint
22	(10) Parts Processing ③: Jig Sawing (a)
23	(11) Parts Processing ④: Jig Sawing (b)
24	(12) Assembling ①: Nail Joint (a)
25	(13) Assembling ②: Nail Joint (b)
26	(14) Assembling ③: Nail Joint (c)
27	(15) Finishing ①: Polishing of Basis
28	(16) Finishing ②: Painting (a)
29	(17) Finishing ③: Painting (b)
30	Utilization of Wood ①

3.2 Transition of the Scores of Three Structures

Regarding the transition of the scores of three structures that consist of problem solving ability, the score of Thinking Ability, Affective Domain, and Skills is 2.96, 3.01, and 2.69 points at the first hour respectively. At the tenth hour, they increase to 3.33, 3.33, and 3.04 points and at the 29th hour they are 3.40, 3.35, and 3.48 points. Finally at the 30th hour they show 3.20, 3.24, and 3.30 points.

With the close look of the details of the scores of each structure, it is found that the scores of Thinking

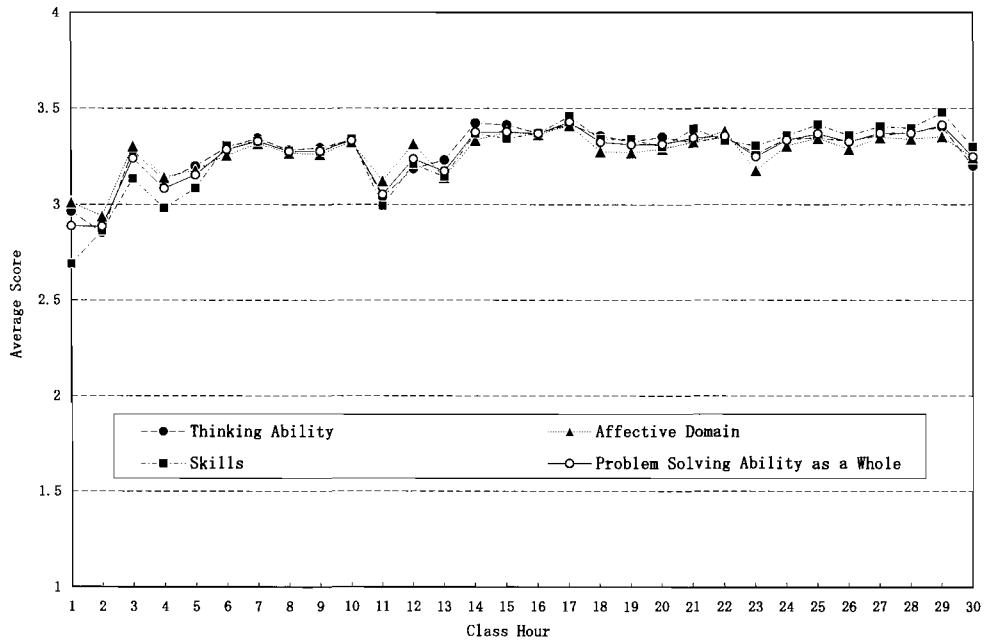


Figure 2 Problem Solving Ability as a Whole and Three Structures.

Ability and Affective Domain transit with about the same score through the first to the 30th hour. However, it is found that the scores of Skills are lower than other two structures through the first to the fifth hour since there were no scenes for productive practice during the period.

3.3 Transition of the Average Scores of Thinking Ability

The transition of the scores of "imagination," "judgment," and "analysis," which consist of Thinking Ability, is shown in Figure 3.

At the first hour, the score of "imagination," "judgment," and "analysis" is 2.77, 3.08, and 3.04 points respectively. Then, at the tenth hour, they increase to 3.24, 3.38, and 3.39 points. Also, at the 29th hour, all scores increase to 3.34, 3.43, 3.44 points. Finally at the 30th hour they are 3.05, 3.30, 3.26 points.

The details of the average scores of Thinking Ability indicate that the scores of "judgment" and "analysis" transit similarly and they are higher than the average score of Thinking Ability at the most of hours. On the other hand, the scores of "imagination"

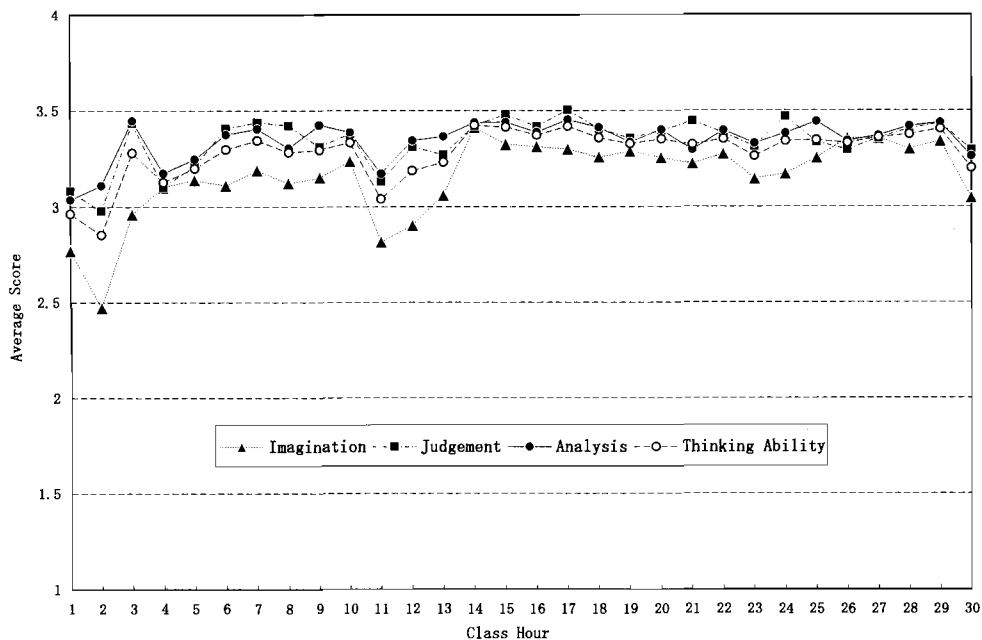


Figure 3 Thinking Ability and its Components.

are lower than the average score of Thinking Ability at the all hours. It is found from these results that fostering "imagination" would be good for developing Thinking Ability further.

3.4 Transition of the Average Scores of Affective Domain

The transition of the score of "independence," "ambition," and "curiosity," which consist of Affective Domain, is shown in Figure 4. At the first hour, the score of "independence," "ambition," and "curiosity" is 3.08, 2.92, and 3.03 points respectively. Then, at the tenth hour, they increase to 3.61, 3.40, and 2.97 points. Also, at the 29th hour, they are 3.57, 3.38, 3.11 points and at the 30th hour they are 3.31, 3.20, and 3.23 points. The scores of three components of Affective Domain indicate the similar scores though there is some increase and decrease on the way.

With the close look of the details of the average scores of Affective Domain, the score of "independence" indicates the highest points at the most of hours while the score of "ambition" progresses similar to the average score of Affective Domain. On the other hand, the score of "curiosity" is lower than the average score of Affective Domain at the most of hours. It is found from these results that fostering "curiosity" would be good for developing Affective Domain further.

3.5 Transition of the Average Scores of Skills

The transition of the score of "planning," "information collection," and "manipulation of teaching aids and tools," which consist of Skills, is shown in Figure 5. At the first hour, the score of "planning," "information collection," and "manipulation of teaching aids and tools" is 3.05, 2.76, and 2.26 points respectively. Then, at the tenth hour, they increase to 3.37, 3.04, and 3.61 points. Also, at the 29th hour, they are 3.50, 3.26, 3.67 points and at the 30th hour they are 3.23, 3.17, and 3.50 points. The scores of three components of Skills indicate the similar points though there is some decrease on the way.

With the close look of the details of the average scores of Skills, the score of "planning" progresses similarly to the average score of Skills. And the score of "information collection" is consistent and lower than the average score of Skills at the most of hours. On the other hand, the score of "manipulation of teaching aids and tools" increases by 1.25 points, which is the highest increase among all components. It is found from these results that fostering "information collection" would be good for developing Skills further. Also, high score of "manipulation of teaching aids and tools" suggests that it highly contributes to fostering the problem solving ability.

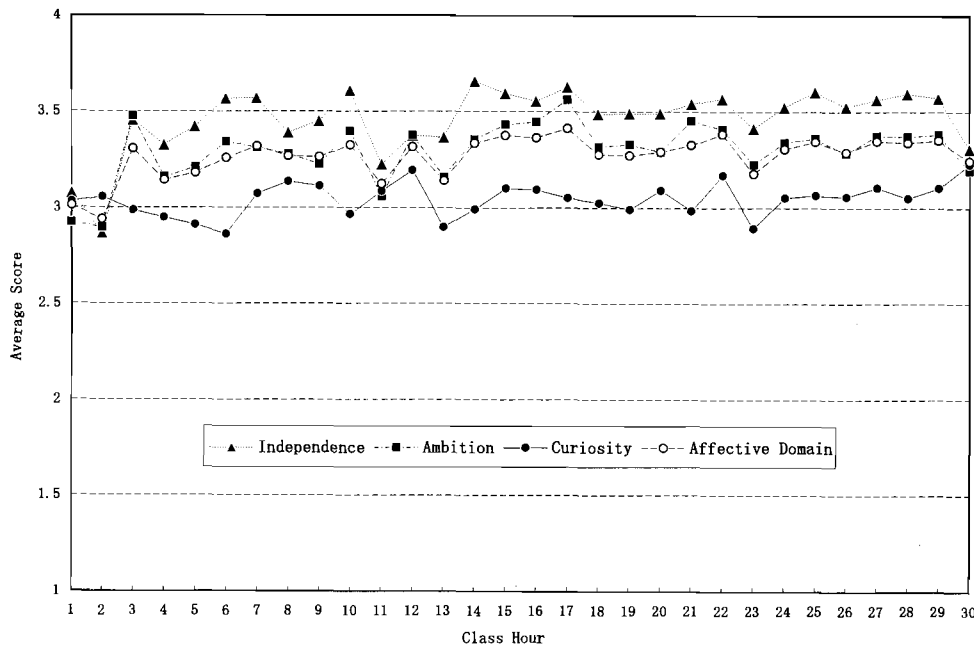


Figure 4 Affective Domain and its Components.

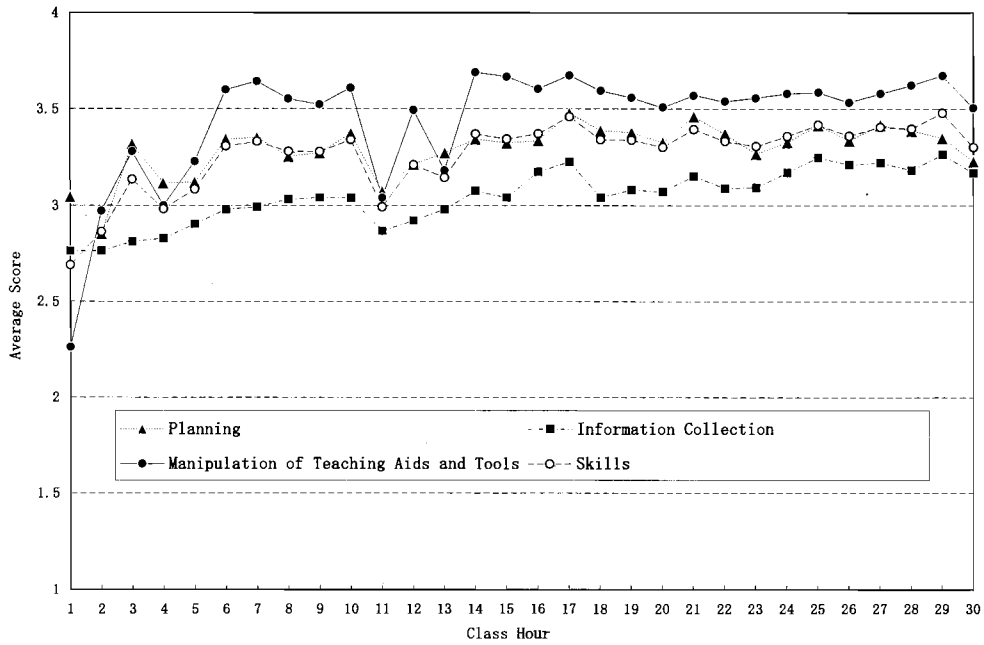


Figure 5 Skills and its Components.

3.6 Transition of Scores of Problem Solving Ability as a Whole in Each Class

Figure 6 shows the transition of the scores of problem solving ability as a whole in each categorized class. At the first hour, the score in Class 1, Class 2, Class 3, Class 4 is 2.92, 2.95, 2.86 and 2.82 points respectively. Then, at the tenth hour when the first productive practice finished, they increase to 3.41, 3.37, 3.30, and 3.25 points. Also, at the 29th hour, they

are 3.39, 3.47, 3.40, and 3.39 points and at the 30th hour they are 3.22, 3.38, 3.26, and 3.12 points. Though there are some decrease on the way, the score in Class 1, Class 2, Class 3, Class 4 increases by 0.47, 0.52, 0.54, and 0.57 points respectively through the first hour to the 29th hour, and they increase by 0.30, 0.43, 0.40, and 0.20 points respectively through the first to the 30th hour.

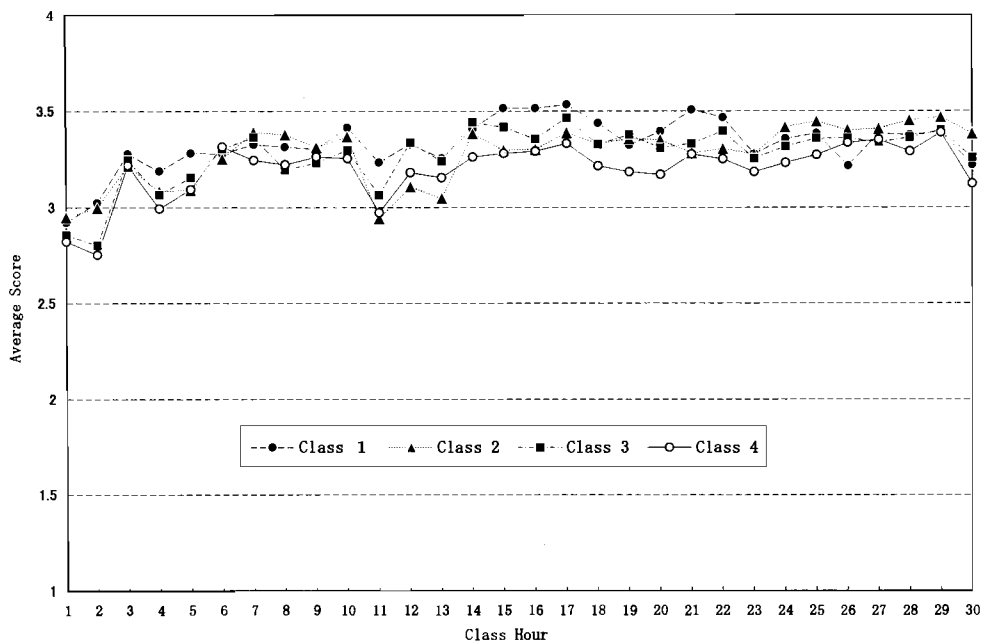


Figure 6 Problem Solving Ability as a Whole in Each Class.

Analysis of variance was conducted on combined plan with teaching method (2), learning form (2), and time (4). It was found that the main factor of time was highly significant ($F(3.369)=43.16$). Then, multiple comparisons were applied using LSD method. It was found from its result that the average score at the tenth hour, the 29th hour, and the 30th hour was significantly larger than the average score at the first hour ($Mse=0.1453$, $P < 0.5$). Also, it was found that the average score at the tenth hour and the 29th hour was found significantly larger than the average score at the 30th hour. However, there was no significant difference found on interaction between teaching method and learning form, interaction between teaching method and time, interaction between learning form and time, and interaction among teaching method, learning form, and time.

4. Conclusion

In this study "Woodworking" area was found to be generally effective for fostering problem solving ability through the first hour to the 30th hour for Type I, Type II, Type III, and Type IV. Following the results and findings of the study, fostering students' problem solving ability should be studied further including teaching and learning methods, proper teaching materials, and teaching aids.

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* : a graduate student of Master program from 1996 to 1998.

Appendix 1. Problem Solving Ability Diagnosis Test.

Let's look back our learning in the lessons of Industrial Technology

Class _____ Name _____

This survey does not affect your score. Please choose one answer for each question that applies most for yourself at present.

- A: It holds sufficiently true.
- B: It holds rather true.
- C: It does not hold true to some extent.
- D: It does not hold true completely.

No	Question	Answer
1	I can clarify the structure of task by myself.	A B C D
2	I often feel like examining the details of what I don't understand.	A B C D
3	I think well if my way is good or bad.	A B C D
4	I can distinguish what is important.	A B C D
5	I can make a judgment by myself though I waver.	A B C D
6	I decide what to do rather soon when I encounter a difficult problem.	A B C D
7	I can think of a lot of ideas to solve a problem.	A B C D
8	When a new idea occurs to me, I can develop it further.	A B C D
9	I can image the final figure of the product that I am making.	A B C D
10	I like to try to deal with my own task better than the given task.	A B C D
11	I am willing to present my idea or ask questions.	A B C D
12	I am willing to do unless being told to do by my teacher or friends.	A B C D
13	I will do my best until the result satisfies me.	A B C D
14	I always study what is uncertain until I understand it for my own peace of mind.	A B C D
15	I often set my target high and achieve it.	A B C D
16	During the class I try to look for something new or something different.	A B C D
17	I am interested in something unfinished or uncompleted and deal with it.	A B C D
18	During the class, I have many things I want to know.	A B C D
19	I can plan my learning and operation procedure by myself.	A B C D
20	Based on the plan I made, I can implement learning and operation.	A B C D
21	Before starting to learn, I think about what I am doing on the day well.	A B C D
22	I can collect information required for my objective of learning.	A B C D
23	I know what to do when I have questions about my learning or operation.	A B C D
24	I consult textbooks or reference books or ask people on what I don't understand.	A B C D
25	I devise the way for better operation by myself.	A B C D
26	During productive practice, I can precede the operation safely.	A B C D
27	I can use tools correctly and can do precise operation.	A B C D

Appendix 2. Problem Solving Ability Evaluation Test.

Let's look back the today's lesson.

Date _____

Class _____ Name _____

Please look back the today's lesson and choose one answer for each question that applies most for you.

- A: It holds sufficiently true.
- B: It holds rather true.
- C: It does not hold true to some extent.
- D: It does not hold true completely.

1. I worked on the today's lesson with my own idea. A B C D
2. I did everything I could do to get the result that satisfied me in the today's lesson. A B C D
3. I was surprised, got interested, or wanted to examine very much in the today's lesson. A B C D
4. I could think of a lot of good ideas to solve the today's task. A B C D
5. I made a judgment properly by myself and did satisfactory learning. A B C D
6. I could grasp the structure of the task clearly by myself. A B C D
7. I could work on the today's lesson willingly with my own view. A B C D
8. I could collect information required for the learning object in the today's lesson. A B C D
9. I could use tools properly and worked precisely. A B C D
10. Please write what made an impression on you in the today's lesson.
