

A Study on Programming Ability Assessment Tool Development for the No-Programming Experienced

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Abstract

Programming is very important subject in computer science and similar computer-related areas such as electronics engineering, etc. Programming is also important for information education for elementary, middle, and high school students since programming is one of the most basic subjects in computer science courses and other similar areas. In current information and knowledge society, raising programming ability is a key factor for everyone's competitiveness. With highly-competitive programming ability, one can enjoy his or her daily life abundantly. He or she also can get a highly-paid job, and make money using his or her programming ability. In this paper, a programming ability assessment tool is developed and introduced for the no-programming experienced. It is very difficult to test programming ability for the no-programming experienced with non-programming tools or activities. In this paper, a programming ability assessment tool is developed based on logical thinking ability. Especially the proposed tool consists of 15 questions for test one's logical thinking ability. The tool does not require any computer science or programming background. The proposed tool will be helpful as criteria for entrance examination or job screening examination for programming-related areas or subjects.

Keywords: *Programming, logical thinking, assessment, computer science*

1. Introduction

Programming (more generally computer programming) is a process that leads from an original formulation of a computing problem to executable computer programs[1]. According to [1], a complete programming process needs to be involved in activities such as problem analysis, developing ideas on a given problem, generating algorithms, verification of algorithms including their correctness and resources requirement, and implementation of algorithms using a specific programming language.

The purpose of programming is to get a sequence of computer commands(instructions) that will execute performing a specific job for a given problem. Programming is very important and a basic background for computer science subjects. Traditionally, for computer science major students, it is mandatory to learn a

couple of programming languages such as Java and C. Nowadays, elementary, middle, and high school students are also highly recommended to have some programming experience with EPL(educational programming languages).

Testing one's programming ability is very important for one's academic achievement assessment or job competitiveness. In the literature, there have been works on programming ability test tools for the programming-experienced. However, there are little works on the tool for no-programming experienced. In this work, a programming ability assessment tool is developed for no-programming experienced. The tool is developed on basis that programming ability is highly related with logical thinking ability.

The paper is organized as follows. In chapter 2, related works are presented. In chapter 3, a programming ability assessment tools is proposed. Finally, in chapter 4, the conclusions and further research issues are presented.

2. Related Works

In this section, literature review works on programming ability assessment tools are introduced.

2.1. The Walden Test

The Walden Personnel Test & Consulting Inc.(<http://www.waldentesting.com>) provides for two programming ability tests for job seekers. The tests are called 'Programming Aptitude Test(PAT)' and 'Programming Analyst Aptitude Test(PAAT)', respectively[2].

PAT is for both entry-level and experienced job candidates. The test can evaluate a person's aptitude and potential for programming. The test assumes no prior experience or knowledge of information technology. The test consists of 4 problems that simulate job skills and abilities for most programmers. The test requires total 60 minutes. The test evaluates the following areas of a person.

- Logic and reasoning skills
- Ability to follow procedures, attention to detail, basic mathematical skills, and ability to reason with symbols
- Ability to follow instructions and create symbolic instructions
- Ability to manipulate graphic images, comprehend written commands, perform table look-up, and display logic.

On the other hand, PAAT simulates what a person must do on the job as programmer and a business analyst. The test is very comprehensive and difficult for most candidates. The test requires one hour and consists of 4 problems. The problems are concerned with logical ability, skills in interpretation of complex specifications and potential for translating business works into symbolic logic. Especially the first three problems evaluate one's programming potential such as logical ability, attention to detail, the basic mathematical understanding, symbolic reasons, etc. The last problem is to test one's analytical ability and skill in interpreting business specifications to solve a given problem. The test evaluates the following areas of a candidate.

- Ability to think logically
- Ability to follow procedural logic
- Ability to accurately solve problems

- Ability to reason with symbols according to stated definitions
- Ability to perform basic arithmetic calculations (add, subtract, multiply, divide)
- Ability to understand complex relationships
- Ability to follow instructions precisely
- Ability to analyze a problem not solvable by trial and error alone
- Attention to detail
- Ability to sustain concentration
- Ability to analyze data contained in charts and tables
- Ability to work under pressure
- Ability to work independently
- Ability to translate detailed specifications into symbolic logic
- Ability to handle new problems
- Ability to learn
- Ability to comprehend written material
- Ability to create procedural logic
- Ability to solve problems utilizing reasoning with symbols
- Ability to persevere
- Ability to interpret business specifications

2.2. University of Kent Computer Programming Aptitude Test

University of Kent in UK provides aptitude tests for computing jobs for three groups as follows[3].

- 1) A standard battery of tests that evaluates competencies such as numerical reasoning, logical reasoning and non-verbal reasoning that are required in technical computing jobs.
- 2) A hybrid test evaluates logical reasoning, numerical problem solving, pattern recognition, ability to follow complex procedures and attention to detail.
- 3) A programming simulation involves pseudocode, control structures, look-up tables, sets, arrays, boolean algebra, looping and other programming structures.

The first two tests do not require any knowledge of programming. However, the third test is for experienced programmers.

A hybrid test(the second type test above) consists of 26 questions and 40 minutes are given. The test evaluates the followings:

- Logical thinking and problem solving
- Pattern and syntax recognition
- Ability to follow complex procedures

3. Programming Ability Assessment Tool Development

3.1. The Rationale for Assessment Tool Development

In the literature, there have been works on programming ability tests for no-programming experienced. However, those works are for adults, especially for programming-related job seeker. In this work, the

proposed test is for all ages including elementary school students, and for both experienced and no-experienced for programming.

The proposed test actually evaluates logical thinking ability with very weak mathematical background. The proposed test is based on assertion that one's programming ability and logical thinking ability highly correlate each other[4,5]. The proposed test does not require specific academic backgrounds. Anyone with simple mathematical background is qualified for this test.

3.2. Programming Ability Assessment Tool Development

In this section, a programming ability assessment tool is introduced. It has 15 questions with different difficulties. The total time requires 40 minutes and 100-point perfect score.

Q1) We want to sort randomly listed K numbers (N_1, N_2, \dots, N_K) with ascending order. We also use the following rules for sorting. How many comparisons are at least required for sorting 4 unsorted numbers?

Step 1) Find the minimum number among K numbers

Step 2) Exchange the minimum number with N_1

Step 3) Find the second minimum number in $K-1$ numbers and exchange it with N_2

Step 4) Repeat step 3) and step 4) until all numbers are sorted

- ① 5 ② 6 ③ 7 ④ 8 ⑤ 9

Q2) Assume that there are two dices that show unbiased numbers when tossed. When two dices are tossed at the same time, what is the most occurring difference from surface numbers of two dices?

- ① 0 ② 1 ③ 2 ④ 3 ⑤ 4

Q3) John has a family tree that represents only men. In this family tree, a man has maximum three children. This relationship is represented as a field (N_1, N_2, N_3) . Note that $N_1, N_2,$ and N_3 represent a child name if any, X if there is no child. For example, if John has two children, Jeff and Steve, John's field is represented as $(Jeff, Steve, X)$. If a family tree has total 9 X s, how many men does this family tree represent?

- ① 4 ② 5 ③ 6 ④ 7 ⑤ 8

Q4) Assume that nations A, B, C, ..., I are represented in the map as below. How many colors are necessary to differentiate each nation?

A	B	C
D	E	F
G	H	I

- ① 5 ② 6 ③ 7 ④ 8 ⑤ 9

Q5) A personnel organization of a computer company requires that each person has two direct subordinates. Also, each person is supposed to communicate only with either direct boss or direct subordinate. If this

company has total 63 persons including CEO, how many bosses does a far-subordinate person go through to communicate a CEO?

- ① 4 ② 5 ③ 6 ④ 7 ⑤ 8

Q6) In the following table, what number should X represent?

3	9	8	7	6
4	17	35	51	
5	27	80	167	
6	39	147	X	
7	43	229		X

- ① 320 ② 360 ③ 394 ④ 400 ⑤ 480

Q7) We want to find a minimum number among three numbers a, b, and C listed unordered. If we find a minimum number using comparing two numbers, how many comparisons are at least required?

- ① 1 ② 2 ③ 3 ④ 4 ⑤ 5

Q8) Each light bulb has two states, that is, on and off. How many states can 9 light bulbs represent?

- ① 128 ② 200 ③ 256 ④ 510 ⑤ 512

Q9) Assume that three symbols \star , \blacklozenge , \blacktriangle represent multiplication, addition, and subtraction, respectively. What is the result value for the following expression?

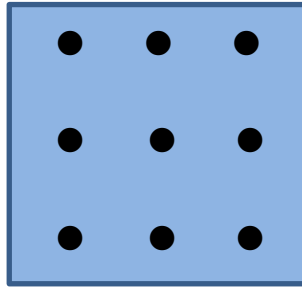
$$10 \blacktriangle 2 \star 3 \blacklozenge 2$$

- ① 0 ② 2 ③ 6 ④ 7 ⑤ 26

Q10) Assume that there are 13 students listed randomly. In order to find a particular student, each student's name is asked one by one. In this case, what average comparisons are required to find a particular student?

- ① 5 ② 6 ③ 7 ④ 8 ⑤ 9

Q11) The following picture represents an electronic display board of a baseball park. In order to represent a letter, 9 light bulbs in an electronic display board are used. Each light bulb has two states, that is, on and off, respectively. Assuming that arbitrary 3 light bulbs out of 9 bulbs are changed to represent 3 states, that is, on, off, dark, respectively, how many letters can this display board represent more than before?



- ① 256 ② 320 ③ 512 ④ 1,028 ⑤ 1,216

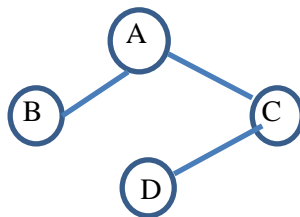
Q12) An encoding technique converts an input to an encoded output. An encoding technique, called K, converts a given input number to the following output number as follows.

Input String	Output String
59	59
138	61
500	38

For an input number 200, what is output number using the above encoding technique?

- ① 8 ② 11 ③ 23 ④ 46 ⑤ 69

Q13) The following graph represents a family tree showing only man. Assume that each man has up to two children(man) and a generation gap is 30 years. The following family tree can be interpreted as follows: a grandfather A has two children B and C, also C has only one child D. Also, generation gap between A and D is 60 years.



If we represent 7 persons in above family tree, what are minimum and maximum generation gaps?

- ① 30, 60 ② 30, 90 ③ 60, 90 ④ 60, 120 ⑤ 60, 180

Q14) In a given computer storage device, the following method is used to store numbers between 1 and 1,000 as follows.

1, 3, 5,,,,,,,,,,,,,999, 1000,,,,,,,,,,,,,,6, 4, 2

Assuming that we search a particular number beginning at the left, what order does number 257 have?

- ① 117 ② 128 ③ 130 ④ 187 ⑤ 200

Q15) The following represents computer programming instructions. An instruction $A = B$ means that a value of storage B is copied to a value of storage A. That is, a value of storage A has the same value as the value of B. In the meanwhile, an instruction $A = 20$ means that number 20 is stored as a value of storage A. That is, the value of storage A has 20.

Consider the following instructions

$X = 10$ (A)

$Y = 10$ (B)

$X = Y+10$ (C)

$Y = X-10$ (D)

Assume that instruction C and D are repeated, what is an instruction necessary between C and D in order that values of X and Y are same?

- ① $X=X+10$ ② $Y=X$ ③ $X=Y$ ④ $Y=Y+10$ ⑤ $X=X-10$

The following table 1 shows difficulty, point, and answer for all 15 questions. Note that difficulty easy, intermediate, and hard has a point in range 1~5, 6~7, 8~10, respectively

Table 1. Difficulty, points, and answers of the test

Problems	Difficulty	Point	Answer
1	Intermediate	6	2
2	Intermediate	6	2
3	Intermediate	7	1
4	Hard	8	1
5	Intermediate	6	1
6	Hard	10	3
7	Easy	5	3
8	Easy	5	5
9	Easy	5	2
10	Easy	5	3
11	Intermediate	6	5
12	Hard	10	4
13	Intermediate	7	5
14	Intermediate	7	2
15	Intermediate	7	4
		100	

4. Conclusions and Further Works

Programming becomes very important factor for one's competitiveness in the current information and

knowledge society. In this sense, measuring one's programming ability is a big concern for testing one's academic achievement and job qualification in computer-related fields. Thus, it is very meaningful to provide a programming ability test tool for both experienced and no-experienced in programming.

In this paper, a programming ability assessment tool is developed. The test is to test one's logical thinking ability based on an assertion that one's programming ability is highly correlated with logical thinking ability. The test does not require any special academic background so that anyone can test.

The further research work is to apply the proposed test to various people such as students, job seekers, etc. The final goal is to get stable scores depending on different qualification of programming ability and provide index for one's programming ability.

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