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Measuring Cognition and Programming Aptitude in an Introductory Computer Science Course

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Abstract Automated tests based on four cognitive factors and on six algorithms were created. The goal was to determine which among these tests measure aptitude and predict success in programming. The initial version of the tests was implemented in 2007 among students who have taken the introductory programming and algorithm courses at the Ateneo de Manila University. The scores in the algorithm tests were correlated with those of the cognitive tests and a number of significant correlations were obtained.

Keyword Computer Science Education, Introductory Programming, Cognitive Factors, Algorithms

1. Introduction

This research focuses on the programming aptitude of students in an introductory programming course. According to the ACM Computing Curricula 2001 Final Report, programming is a prerequisite for many advanced courses in Computer Science so it is necessary that it be mastered early [1]. In the Philippines, the curricula for Computer Science and other Information Technology fields approved by the Commission on Higher Education state that the introductory programming course ought to be offered in the first year [2].

2. Statement of the Problem

The main goal of this research is to come up with tests that measure the aptitude of students in an introductory programming course. In order to accomplish this, the study sought to answer the following questions:

1. How can a test or series of tests measure a person's understanding of fundamental programming and algorithmic concepts?
2. Which of these tests correspond to cognitive factors?
3. What are the cognitive factors that correlate with programming aptitude and algorithmic skills?
4. Which of the tests predict programming aptitude?

3. Methods

The framework for this research (Figure 1) focuses on four cognitive factors from the Kit of Factor-Referenced Cognitive Tests by the Educational Testing Services (ETS). These are Associative Memory, Induction, Logical Reasoning, and Spatial Scanning. The fundamental algorithms considered are Linear and Binary Search, Insertion and Selection Sort, Tower of Hanoi, and Maze Tracing. Tests that correspond to the said cognitive factors and algorithms were converted into two sets of automated tests.

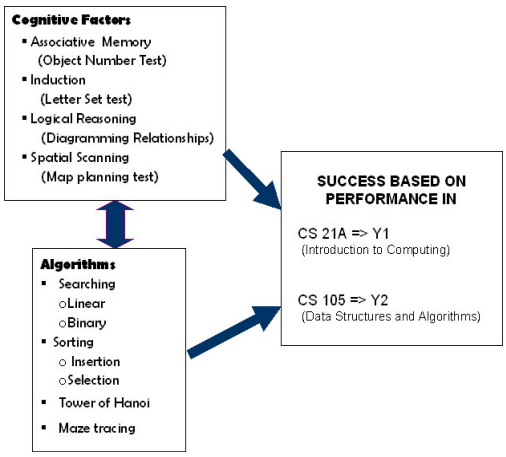

Figure 1. Research Framework

The tests were administered to fifty-nine (59) Management Information Systems students of the Ateneo de Manila University in the Summer Term of 2007. The results were correlated with their grades in the programming course (CS 21A) and in the algorithm course (CS 105). Pearson's R Correlation function and Linear Regression were used to find out which cognitive factors and algorithmic skills correlate and are predictive of programming ability.

4. Results

The cognitive factors and algorithms that correlated with each other and those that correlated with the programming performance may be used to determine programming aptitude. The developed tests may also be incorporated in the selection process for incoming Computer Science students and be helpful in predicting long-term success in the course. Correlation results may also be used in the design of the content of an introductory course in programming and algorithms.

Table 1 shows the following correlations: Associative Memory with Insertion Sort, Induction with Selection Sort and Insertion Sort, and Spatial Scanning with Selection Sort and Maze Tracing.

Cognitive Factor / Algorithm	Insertion Sort	Selection Sort	Maze Tracing
Associative Memory	.300*		
Induction	.445**	.462**	
Spatial Scanning		.320*	.265*

Table 1. Correlation values for the cognitive factors and algorithms

Table 2 shows that Selection Sort, Maze Tracing, Logical Reasoning, and Spatial Scanning correlated with CS21A performance.

Selection Sort	Maze Tracing	Logical Reasoning	Spatial Scanning
.364**	.310*	.325*	.331*

Table 2. Correlation values between CS21A performance and the cognitive factors and algorithms

(*Correlation is significant at the 0.05 level, 2-tailed)
(**Correlation is significant at the 0.01 level, 2-tailed)

Table 3 below shows that Logical Reasoning, Spatial Scanning and Associative Memory are possible predictors of success in CS 21A. There were no significant correlations with CS105.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.642	.464		3.535	.001
	associative memory	-.023	.012	-.253	-2.008	.050
	induction	.017	.017	.120	.965	.339
	logical reasoning	.034	.014	.298	2.472	.017
	spatial scanning	.021	.008	.332	2.643	.011

a. Dependent Variable: CS 21A grade

Table 3. Linear Regression results between CS21A performance and the cognitive factors.

5. Conclusions

In conclusion, the study showed that certain cognitive factors correlate with fundamental algorithms and that tests based on these cognitive factors and algorithms may be used to measure programming aptitude in an introductory Computer Science course. However, these results may still be improved by incorporating the comments made by the students on the automated tests.

6. Future Works

To further prove the results of the said tests, improvements are currently being done with the plan of implementing them among the students of Tokyo Institute of Technology and incorporating the results in designing a semantic knowledge model for an adaptive e-based programming course for novice programmers.

7. References

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