The Role of Cognitive Styles in Computer Programming Learning

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Keywords: Cognitive Style, Computer Programming Learning, Data Structure.

Abstract: Cognitive style is one of the most important factors in determining the success of computer programming learning. There are two characteristics of cognitive styles: field dependent and field independent. Cognitive style in programming learning has been widely studied; however, there are no studies that discuss the relation of cognitive style and data structure learning, which is an integral part of programming learning. This article describes the results of an experiment that examine the differences in the characteristics of cognitive styles (field dependent and independent fields) in Programming Algorithms and Data Structure. This study involves 118 students who take Programming course and 108 students who take Data Structure course in the Informatics Engineering Study Program at STMIK Bumigora. Based on the research findings, there is a significant difference between the dependent field and the independent field in both courses. The Computer Programming teacher should take importance of cognitive styles during preparing their instructional strategies.

1 INTRODUCTION

Cognitive style is defined as psychological constructs related to how individuals process information (Brown *et al.*, 2006). Cognitive style can be referred to type of differences owned by an individual that is generally nurtured since childhood. Perception, memory, attitude in the problem-solving process, and ways of expression development of individual can be seen through the style; however it has no significant relation to intelligence quotient (Riding, Smith and Sadler-smith, no date). Cognitive styles are classified into field dependent and field independent (Witkin *et al.*, 1977). The classification of the cognitive style is based on the acceptance and retention of concept. The formation of concept relates to how data/information are observed and analyzed, whereas concept formation and retention relates to hypothesis submission, problem solving, and memory process. Research results state that cognitive style is influential in the learning process and consequently brings different learning outcomes.

Students have different cognitive styles that can affect the learning process which consequently leads to different learning outcomes. Teaching styles and content level that well-suited with an individual's cognitive development and cognitive style will be most successful. Therefore, students who take computer programming courses will receive more benefits by having prerequisite that make them to be in a course that suitable with their cognitive characteristics (White and Sivitanides, 2002). Students placed in classes that best fit their cognitive characteristics have a higher probability of success.

Furthermore, cognitive style is closely related to instructional strategy (White *et al.*, 1997; Oh and Lim, 2005; Shi, 2011) and it also has correlation with instructional strategy (Dowlatabadi and Mehraganfar, 2014; Science and State, 2015). In a study about the relation between cognitive styles and instructional strategy, Cognitive style significantly affects the choice of instructional strategy (Shi, 2011). It means that learners with field independent learning style have bigger potential to succeed in computer programming learning, while learners with field dependent learning style needs additional support to be able to learn computer programming. This claim appears in a study conducted by (R. Mancy and Reid, 2004) suggesting that field independent cognitive style is proven to be more effective than field dependent.

In studying computer programming there are two important courses that cannot be separated, namely Programming Algorithm and Data Structure. In order

Susilowati, D., Degeng, I., Setyosari, P. and Ulfa, S.
The Role of Cognitive Styles in Computer Programming Learning.
DOI: 10.5220/0008410102160220
In *Proceedings of the 2nd International Conference on Learning Innovation (ICLI 2018)*, pages 216-220
ISBN: 978-989-758-391-9

to learn about the fundamentals of data structures and algorithms approaches used in software design and development, computer programming students require to take data structures and algorithms course since it is an essential foundation course in computer science. In addition to be used in software design and development, basic data structures and algorithms are also used to solve various problems in computer science fields (Liu, Wang and Wang, 2013). Data structures are important because they are the most important tool that is going to be directed by a programmer. By knowing the use of each data structure as well as its weakness and strengths the programmers could solve problems effortlessly.

Several studies related to cognitive style and computer programming have been carried out; however, there are no studies that examine the influence of cognitive style on learning outcomes of data structures. Therefore, this study aims to identify the influence of cognitive style on learning outcomes of programming algorithm and data structure. The following research hipotesis will been tested

- There is a significant difference in programming algorithms learning outcome of students with different cognitive styles
- There is a significant different in data structure learning outcome of students with different cognitive styles

2 METHOD

The research was a descriptive correlational research aimed to describe the correlation between cognitive style and students' learning outcomes in Programming Algorithm and Data Structure courses. There were two variables observed, cognitive styles as the independent variable and learning outcomes as the dependent variable.

The research subjects were students of Informatics Engineering Study Program at STMIK Bumigora Mataram consisted of 181 students participated in the Programming Algorithms course (1st semester of the first year) and 108 students participated in Data Structures course (2nd semester of the first year).

The instrument used in the research was Group Embedded Figure Test (GEFT) cognitive style test adopted from (Witkin *et al.*, 1977) and post test. The measurements of learning outcome were done using comprehension test on programming algorithm and data structure developed by the lecturer. Comprehension test was in form of essays test.

Data collection was carried out with cognitive style tests on students who took Programming Algorithms and Data Structures courses. In the following stage, the research also collected the post test scores in Programming Algorithm and Data Structure.

Data tabulation was conducted and followed by t-test using SPSS to test the following hypothesis:

H_0 = the average score of students with FI cognitive style and the average score of students with FD cognitive style is identical

H_1 = the average score of students with FI cognitive style and the average score of students with FD cognitive style is not identical

The testing criteria are as follows:

- H_o is accepted and H_1 is rejected if probability (Sig.) > 0.05
- H_o is rejected and H_1 is accepted if probability (Sig.) < 0.05

3 RESULT AND DISCUSSION

To find out the influence of cognitive style on the learning outcome, a statistical analysis was conducted to obtain a difference in mean score between students with field dependent (FI) and field dependent (FD) cognitive styles in Programming Algorithms and Data Structures courses. The result of the analysis can be seen in Table 1 and Table 2 for Programming Algorithms and Data Structures courses, respectively.

Table 1: Mean scores of programming algorithms based on cognitive style group statistics.

Cognitive Style	N	Mean	Std. Deviation	Std. Error Mean
Programming Algorithms Score	FI	58	92.8879	14.07064	1.84757
	FD	60	82.0833	19.02923	2.45666

It can be seen in Tables 1 that the mean score of students with field independent (FI) cognitive style (92.88) was higher than the mean score of students with field dependent (FD) cognitive style (82.08), both in Programming Algorithms and Data Structures. Therefore, it can be concluded that students participating in Programming Algorithms who had field independent cognitive style could achieve better learning outcomes than students who had field dependent cognitive style.

Table 2: Mean scores of data structures based on cognitive style group statistics.

Cognitive Style	N	Mean	Std. Deviation	Std. Error Mean
Data Structures Score				
FI	51	86.5196	15.58107	2.18179
FD	57	77.6316	19.44211	2.57517

Based on data analysis in Table 2, it can be concluded that the mean score of students with field independent cognitive style was higher (88.51) than the mean score of students with field dependent cognitive style (77.63). Therefore, students participating in Data Structure course who had field independent cognitive style could achieve better learning outcomes than those who had field dependent cognitive style.

Hypothesis testing was conducted using t-test in order to find out whether or not the average score of students with the FI cognitive style and the average score of students with FD cognitive style is identical. The result of hypothesis testing for Programming Algorithm and Data Structures Courses is presented in Table 3 and 4, respectively.

Based on Table 3, it can be concluded that H1 was accepted since the sig. Value (0.001) < 0.05. It means that both data had non-identical average (significantly different). The Algorithm average value of students with field independent cognitive style (92.8879) was higher than that of students with field independent cognitive style (82.0833).

Based on Table 4, it can be concluded that H1 was accepted since the sig. Value (0.011) < 0.05. It means that both data were non-identical average (significantly different). The Data Structure test's mean score of students with field independent cognitive style (86.5196) was higher than those students with field dependent cognitive style (77.6316).

This finding is in line with the findings of (Ford, Miller and Moss, 2001) confirmed that cognitive style has influence on learners' learning outcomes. The finding also supports a claim that students should have the needed cognitive style to succeed in programming (White and Marcos, 2012) and that programming learning needs some prerequisites (White, 2007). Furthermore, this finding is in line with the finding of (Rebecca Mancy and Reid, 2004) stated that working memory space had a marginal influence on levels of achievement on the course, whereas field dependency become an essential success determinant factor.

Table 3: T-test result independent samples test.

Algorithm Score	Lavene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig	t	Df	Sig (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	4.800	.030	3.497	116	.001	10.80460	3.08931	4.68583	16.92336
Equal variances not assumed			3.515	108.641	.001	10.80460	3.07387	4.71206	16.89714

Table 4: T-test result independent samples test.

Data Structures Score	Lavene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig	t	Df	Sig (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	11.068	.001	2.601	106	.011	8.88803	3.41664	2.11421	15.66185
Equal variances not assumed			2.633	104.781	.010	8.88803	3.37516	2.19555	15.58051

The research finding proved the cognitive style theory. Cognitive style is a characteristic self-consistent mode of functioning which individuals show in their perceptual and intellectual activities as well as the two dimensions of FI and FD cognitive styles (Witkin *et al.*, 1977). The finding of this study indicated that students with field independent cognitive style were better in programming and data structure learning abilities compared to student with field dependent cognitive style. It was due to students with field independent cognitive style have a good analytical ability, which is an ability to view information and perception as a separated part of its surrounding context as well as to compile and assimilate them. FI students have a tendency to be smarter and faster in looking for problem solving alternatives. Students are required to have various abilities during computer programming learning, such as, ability in analysis, logic, mathematics, problem solving, and programming language syntax (Sarpong and Arthur, 2013). In addition, programming is a complicated process with various stages and different content knowledge as well as cognitive processes would be required for each sub process (Ambrósio *et al.*, 2011). Therefore, it will require a strong analytical ability and this ability owned by students with field independent cognitive style. Students with field dependent cognitive style, on the other hand, have a tendency to face difficulty in separating a concept or perception from its surrounding context thus information acceptance is unclear and difficult to be assimilated. Therefore, students with field dependent cognitive style tend to face difficulty in problem solving process. The condition is likely to be the cause of students with field dependent cognitive style would need more hard work and extra time in computer programming learning process compared to students with field independent cognitive style. The research result is in line with previous research results stated that students with field independent cognitive style are better at identifying and representing problems (Rebecca Mancy and Reid, 2004b). In addition, another research result also stated that the learners with field-independent cognitive style outperformed those with field-dependent cognitive style (Lu and Lin, 2018)

Considering the significant role of student cognitive style in computer programming learning, an appropriate learning strategy plan is needed that accommodates student cognitive style to achieve learning objectives. Teacher/learners of computer programming should identify student cognitive style in the beginning of learning that subsequently can be used as one of bases to compile an appropriate learning strategy thus learning objectives can be achieved optimally. It is in line with previous research stated that teaching styles and content level that well-suited for an individual's cognitive development and cognitive style will be most successful. Therefore, students who take computer programming courses will receive more benefits by having prerequisite that make them to be in a course that suits their cognitive characteristics (White *et al.*, 1997). Due to resources limitation, class division based on cognitive style group is hard to obtain. A specific method should be considered for students with FD cognitive style along with specific time service for assistance outside the classroom. The use of flowchart in programming learning process could be an alternative to facilitate students with field dependent cognitive style in computer programming learning process. Considering the work pattern of computer science graduates that mostly work in a team and in response to twenty-first century learning and skill, learners could implement group assignment (group programming). The formation of work group should be consisted of students with different cognitive style (there are students with field dependent and field independent cognitive styles in one group). It is in line with previous research result stated that scholars found that a heterogeneous group that consisted of learners with field independent and field dependent is significantly better in performance compared to those groups that divide based on other methods (Gagné and Gagné, 2009). The grouping pattern is expected to give mutual benefit among individuals in a group. Based on the previous research, learners with field-independent cognitive style had less active discussion messages but more passive responses. When the learners with field-independent cognitive style assisted others to complete the task, they can also benefit by it (Lu and Lin, 2018). Students with independent cognitive style who have strong analytical ability in problem solving could share in the learning process. On the other hand, students with dependent cognitive style who like to socialize and make friends tend to be more active in discussion.

4 CONCLUSION

Based on the research findings, it can be concluded that students with field independent cognitive style were superior in computer programming learning than those with field dependent. Therefore, it can be suggested to the lecturers of computer programming that they should pay attention to student' cognitive style in formulating instructional strategies in order to

improve the learning process, especially for students with field dependent cognitive style.

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