

The Impact of Learning Styles and Instructional Methods on Students' Recall and Retention in Programming Education

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Abstract: Learning styles are the predetermined indicator which learners respond to and use stimuli in the context of learning. It is the preferred mode that learners perceive and process new information at a certain pace, which in turn affects their academic performance. This paper focuses on the visual-verbal learning styles as well as pair programming (PP) and direct instruction (DI) methods. A group of 83 first year computing students was involved in this experimental study. These students from two intact classes were randomly assigned either to the experimental group that received PP, or to the control group that received DI. During the seven-week treatment, the participants in PP group worked in pairs, and those of DI group worked individually to solve novel programming scenarios. Three computer programming performance tests (CPPT) – a pretest, an immediate posttest and a delayed posttest were conducted to evaluate the students' recall and retention performance on programming comprehension. The post hoc test results revealed that both the visual and verbal students taught in the PP and DI groups performed equally good in recall performance. However, only the verbal students in the DI group significantly outperformed the visual students in retention. In conclusion, the diversity of learning styles influence students' engagement in understanding the programming concepts; significantly affects information retention and later on their academic achievements.

Keywords: Learning style, direct instruction, pair programming, programming performance

Introduction

Computer programming requires students to understand the programming process stages: problem, design, coding and maintenance, in solving programming problems. It is a subject which demands complex cognitive skills such as reasoning, problem-solving and planning that students find it too difficult to comprehend and master [1]. Grand and Smith [2] describe basic programming concepts as a set of rules, like expressions, functions, variables declarative, statements, sequencing and conditionals which first year computing students need to know in following any programming courses.

Various teaching methods have been applied by instructors in teaching these concepts to undergraduate students. According to Baldwin and Kuljis [3], these methods include changing the programming languages which is to be taught first, using different textbooks, slowing the course delivery, lowering the standard, reducing the course requirements, as well as switching between bottom-up and top-down approaches in teaching basic programming concepts. However these methods did not significantly change the students' performance. Thus, some instructors opted to reduce the quality and to lower the standard of material taught and concentrate on "important topics" [3].

Programming concepts tend to be difficult to grasp and require complex cognitive task. Students who have adequate program-solving skills and manage to phase solution to programming problems, could find it difficult to turn the problems into syntactically correct program flowchart and Pseudocode [1][2]. Consequently, they tend to make the same mistakes and become frustrated trying to understand and comprehend even the most basic concepts [4]. Hence, those who are strong in logical reasoning skills outperform their counterparts in the programming course, and others who do not appreciate the beauty of programming will eventually drop out from the field.

1. Learning Styles

Learning style (LS) is a preferred learning mode in which students respond to and use stimuli in the context of learning. For James and Gardner [5] and Kolb [6], it is the way in which students perceive, process, store and recall attempts of learning. These styles have been acknowledged as the prime construct that serve as relatively stable indicators of how students respond to the learning environment [7]. However, with variation, these stable indicators somehow may change from one learning environment to another as the students adapt to the learning approach, progress and respond to the programming problems. Researchers have claimed that students consistently indicate positive improvements in performance when novel concepts are illustrated in their preferred style [8][9]. In this study, the Felder-Soloman's [10] Index of Learning Style was selected as it focused primarily on learning styles, comprehensive, parsimonious and is relevant to science education.

2. Instructional Methods

Instructional method is an approach used by educators in course content deliveries. It is an educational approach for revolving knowledge into learning which focusing on the "how to" in delivery of training [11]. In this study, two instructional methods and two experience lecturers identified are randomly assigned to the treatment groups. In programming methodology, two basic constructs: (i) sequence and (ii) selection are the syllabus covered in this study. The undergraduate semester one computing students who worked in pairs received the PP instruction method. Those in the control group are taught in the DI method.

3. Research Methodology

The prime focus of this study is to investigate the effects of pair programming as cooperative learning approach on the programming recall and retention performance amongst the visual-verbal learning style dimension computing students. The emphasis of this research is on whether the learning style preference could be the moderating factors when different instructional methods are applied in classroom environment.

3.1 Research Design

A 2 x 2 quasi-experimental design was used to examine the effects of PP and DI on the two dependent variables (recall and retention) with one LS dimension being the moderating variables. These dependent variables were based on the immediate and delayed posttest scores obtained from the computer programming performance test (CPPT). A total of 83 first year undergraduate computing students ($n = 83$) in this intact group were randomly assigned to the two treatment groups: the experimental group that received the PP treatment and the control group that received the DI treatment.

3.2 Research Instrument

The computer programming performance tests (CPPT) instrument which consist the immediate and delayed posttest were administered to measure the students' recall and retention performance. The tests were designed to assess the students' programming performance on the theories and practical knowledge of the sequence and selection programming constructs. The Felder-Soloman's Index of Learning Styles Questionnaire (ILSQ), based on the Felder and Silverman's [12] learning styles model was used to access the students' learning style preference prior to the treatment. In this study, only one dimension measuring the visual and verbal learning style (Cronbach's Coefficient alpha of 0.78 [13]) was used to determine the students' learning preference. This instrument uses a multiple choice format in presenting options. The students who responded mostly 'a' in the questionnaire were classified as visual learners and those who responded mostly 'b' were identified as verbal learners.

3.3 Data Collection Procedures

The experiment was conducted for seven-week duration to the two intact classes. These two classes were randomly selected from the first year computing course and assigned to the two treatment groups. The ILSQ questionnaire was administered to these groups prior to the treatment in order to classify the students as visual or verbal learners. During the treatment, the students in both groups received program flowchart and Pseudocode in learning the basic programming concepts: (i) sequence and (ii) selection constructs. In the PP group, each pair consisted of one visual and verbal student with an assigned role of either as "driver" or "navigator". These roles are interchangeable at regular intervals. The pairs worked together on the same programming task to discuss and provide constructive criticisms in generating quality programming solutions.

4. Findings

The quantitative data collected to corroborate the research hypotheses were analyzed using the SPSS 16.0 for Windows and computed at the 0.05 level of significant. As covariate was used in the analysis, the adjusted posttest mean scores were reported. The MANCOVA results clearly revealed a significant difference in recall performance between the visual and verbal students taught in the two treatment groups ($F=6.10$; $p=0.00$; $p<0.05$). A significant difference in retention was also observed between these students who received the different treatment methods ($F=4.30$; $p=0.01$; $p<0.05$). Therefore, a post hoc test was administered to further examine the differences. This study reveals the comparisons involved only between the visual and verbal students in both the PP and DI groups. The comparisons between the visual students in the PP and DI groups, as well as between the verbal students in both the treatment groups were not the scope of this discussion.

Hypothesis 1: There are no significant differences in recall between the visual and verbal students who received the PP method and those who received the DI method.

In this study, the post hoc result indicates no significant difference between the visual and verbal students taught in the PP group ($M_{PP-visual}=65.86$; $M_{PP-verbal}=66.27$; $p=0.89$) as well as those in the DI group ($M_{DI-visual}=55.31$; $M_{DI-verbal}=59.65$; $p=0.15$). Thus, this finding has accepted the first hypothesis.

Hypothesis 2: There are no significant differences in retention between the visual and verbal students who received PP method and those who received DI method.

For the PP group, the post hoc test result reveals no significant difference in retention performance between the visual and verbal students taught in this PP method ($M_{PP\text{-}visual} = 52.03$; $M_{PP\text{-}verbal} = 58.33$; $p = 0.051$; $p > 0.05$). However, a significant difference in retention was observed between them in the DI group ($MeanDiff = 6.53$; $p = 0.037$; $p < 0.05$), with the verbal students performed significantly better than those of visual students ($M_{DI\text{-}visual} = 46.95$; $M_{DI\text{-}verbal} = 53.48$). Thus, the second hypothesis has been rejected.

5. Discussion

This study revealed that the preferred style has significantly correlated and influenced students' programming comprehension; in return affecting their mental process [7][8]. For the recall performance, both the visual and verbal students taught in the PP and DI methods performed equally good in the programming recall test. Knowing the students' individual LS allows them to create a richer learning context of the basic programming concepts. With regards to the instructional methods, LS assists both students taught in the PP and DI methods in that they understand their individual preference in learning programming that create a higher level of conceptual understanding and promote logical thinking skills with respect to programming recall performance [14]. Despite the fact that visual students learn better with diagrams or charts, they are able to adapt and change learning approach from one learning environment to another as they progress and respond to programming problems that subsequently trigger the actual learning process in the long term memory for further information recall [15].

In retention performance, only the verbal students taught in the DI method significantly outperformed the visual students taught in the same method. Working in pairs, both visual and verbal students provided with the opportunity to explain and discuss novel concepts with their partners, thus promotes meaningful learning and retention [16]. Moreover, students are benefited from pairing with heterogeneous LS pair, especially with diversity of thought that fosters learning process [9]. The verbal students in the DI method incline to have longer retention rate on the basic programming concepts taught as the explanation of abstract concepts are predominantly conducted in the form of lectures, written texts and on the whiteboard in the classroom environment [17]. Thus, the verbal students are able to process and build better schemata in long term memory as they remember better through oral and written explanations as compared to their counterparts in both instructional methods. In contrast, the visual students learn and remember better through pictorial form than auditory clues. So, they are experiencing difficulties in attaining the pedagogical goals for programming performance in retention than those verbal students taught in both PP and DI groups [14][18].

6. Conclusion

The study has emphasized the importance of considering LS components in learning the basic programming concepts for classroom delivery. LS is a predictable stable indicator that influences the learning approach of students in perceiving, interacting with and responding to programming concepts. The preferred LS of students and the instructional methods applied in programming classes are correlated with the students' recall and retention performance. Disparity between the LS and instructional methods in comprehending the fundamental programming concepts may cause significant impact on students' overall performance (recall and retention). Therefore, both the visual and verbal representation of

novel concepts need to be embraced into the learning context in order to reinforce long term memory retention, enhance cognitive knowledge and promote logical thinking skills with respect to programming performance.

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