Factors Affecting the Performance of Students in a Data Structures Course at Fort Valley State University

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Abstract –Data Structures is a key a course in the curricula of both Computer Science (CS) and Computer information systems (CIS) majors at Fort Valley State University (FVSU). It is a junior level and lecture-based course that is perquisite to several advanced courses in both majors. The relatively poor performance of students in classroom and an in-house exit exam evaluated over the past several years indicate the difficulties students experience to apply concepts of data structures correctly and efficiently. This paper provides results of a survey aimed at investigating several factors that could have influenced the performance of students in the course both quantitatively and qualitatively. The analysis of the survey data revealed that course topics, workload and student involvement, and textbook selection were major factors that students believed affected their performance in the course. Based on the results, a two-prong approach was suggested to address these concerns at FVSU. The first approach would be vertical integration of relatively complex concepts in pre-requisite courses that emphasize algorithmic design and implementation rather than program coding. The second approach would be a supervised lab to help students with implementation of course concepts through real-world applications and the utilization of interactive multi-media demonstrations.

Keywords: Data structures, student performance, algorithms, survey data

INTRODUCTION

The main purpose of studying data structures and algorithms is to develop a capacity to write high-quality software programs that utilize computer resources effectively and efficiently [6]. This capacity requires more than a mere knowledge of abstract concepts and theories; it also requires the ability to tie these concepts to real-world applications. One of the objectives in a data structures course is to help students develop this ability to appreciate the underlying concepts and theories. Thus, the curriculum of all undergraduate computer science programs contains a data structures course that covers advanced topics in abstract data types (ADTs) and algorithms and helps students to become innovative programmers.

The curricula of undergraduate CS and CIS at Fort Valley State University (FVSU) require students to take various levels of programming courses. However, the common programming requirement for both majors includes

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a two-course sequence in principles of programming and data structures. The two-sequence courses are principles of programming I, a four-credit hour course: 3 hours lecture and 2 hours of supervised lab, and principle of programming II, a 3-credit hour lecture course. Both courses are taught in JAVA with emphasis on algorithms, syntax and other programming fundamentals. Also, they are prerequisites to the data structures course.

In the data structures course, students are required to understand new theories and concepts that are abstract and often difficult to visualize and/or implement. It means students need to employ the knowledge and experience gained in the sequence courses as well as develop a sound perspective for specification, application, and implementation of abstract data structures. Due to these facts, data structures course is often considered as one of the most difficult courses to understand and perform satisfactorily [6]. To facilitate some of the problems associated with the teaching and training of undergraduate students in data structures, a variety of pedagogical models have been suggested [1, 3, 4, and 6]. However, this paper examines factors affecting the performance of students in a data structures course both quantitatively and qualitatively at FVSU. It also discusses ways to improve the teaching of this course from both student and instructor perspectives.

DATA STRUCTURE COURSE AT FVSU: AN OVERVIEW

Data structures (CSCI 3410: Data Structures) is a most important a course in the curricula of both CS and CIS majors at FVSU. It is a junior level and lecture-based course that is perquisite to several advanced courses in both majors. This course is an advanced programming course that introduces different data structures for solving various data organizational problems. The main objective of the course is to provide students with both theory and practical applications of the data structures. Additionally, an in-depth knowledge of computer programming and their intermediate and advanced applications in computing sciences are presented in this course. In particular students learn to construct well documented programs using a variety of complex data structures including lists, trees, stacks, queues, etc. Further, the course is designed to nurture students' ability to evaluate and choose among alternative solutions and to develop high quality programs.

The current textbook used in this course is "Object-Oriented Data Structures Using JAVA [2]." The method of course delivery is mainly through PowerPoint presentation provided by the textbook's publisher and handouts from other sources. The performance of the students in the course is evaluated by four exams making 70% of grade and programming assignments and course project accounting for the remaining 30%.

STATEMENT OF THE PROBLEM

Students entering data structures course often have this perception that the course is a simple extension of previous programming classes. Thus, when students encounter topics such as the Big Oh Notation, induction, complex recursions and abstract data types that require the knowledge of both mathematics and computer programming, they tend to lose interest especially in the absence of meaningful applications. The other problem is the available textbook and teaching materials do not sufficiently emphasize on the real-world applications especially through simple but yet useful examples. Often many textbook examples are designed to merely illustrate the theory rather than to demonstrate students to connect concepts to real-world applications. Consequently, the examples and/or exercises become dull and uninteresting to students and have only academic values to them. Students often complain that the textbook examples are not easy to follow and do not convey the usefulness of the course topics.

STUDENT SURVEY AND PERFORMANCE ANALYSIS

The performance of students in the data structures course has been generally weak as compared to the other programming courses at FVSU, a problem which is also very common in many undergraduate computer science programs [6]. Prior evaluations of student performance in programming subjects including data structures were studied for the departmental exit exams conducted between years 2003 and 2006 [5]. According to the study, computer science majors at FVSU had consistently scored lower in data structures than programming I and II. This finding along with our own teaching experiences of the course prompted us to launch a formal investigation of the problem.

During 2007, we initiated a comprehensive survey of factors affecting the student performance in this course from the student's perspective. The survey included 38 questions grouped into six categories. These categories included: namely, Pre-course Preparation, Course Organization, Course Evaluation Methods, Course Outcomes, Student Effort and Involvement, Course Difficulty, Workload, and Pace. A total of 21 students participated in the survey. The data collected from the survey was organized and analyze to understand the detailed and overall student's viewpoint of the course. Table 1 shows the results of survey for selected questions in the categories of interest.

Table 1: Students' Responses to the Data Structures Course Survey

Categories and questions	Percentage(%) of students at each agreement levels					Satisfactory (%)	Unsatisfactory (%)
Pre-Course-Preparation*:	5	4	3	2	1		
Q1. Was student background sufficient to understand the initial course topics	25	33.3	16.6	16.6	8.3	75	25
Course-Organization							
Instructor's use of examples or illustrations to clarify material	25	41.6	25	8.3	0	92	8
Course Exams*							
Q2 The clarity of the exam questions	16.6	25	41.6	16.6	0	83	17
Q3. Exams coverage of important aspects of the course	25	41.6	16.6	16.6	0	83	17
Q4. Helpfulness of a supervised lab	41.6	41.6	16.6	0	0	0	100
Q5.Helpfulness of the assignments in understanding the course material	8.3	25	50	8.3	8.3	83	17
Course outcomes**							
Q6. Student's learning increased in the course	0	33.3	33.3	25	8.3	67	33
Q7. Student's interest in the subject has increased	16.6	0	41.6	25	16.6	58	42
Q8. Progress made by student's toward achieving course objective	0	33.3	58.3	8.3	0	92	8
Student Effort and Involvement**							
Q9 Student's effort put into the course	33.3	33.3	33.3	0	0	0	100
Q10. Student was challenged by the course	58.3	25	16.6	0	0	0	100
Course Difficulty, work load and Pace**							
Q11. Difficulty of course topics for students	25	25	50.0	0	0	0	100
Q12.Workload for this course in relation to other courses of equal credit was	16.6	8.3	58.3	8.3	0	8	92
Q13. The pace at which the course material covered was	16.6	0	75	8.3	0	8	92

*5-very effective, 4- effective, 3-moderately effective, 2-somewhat effective, 1- ineffective

-Satisfactory include agreement levels 5, 4, &3!!Unsatisfactory include agreement levels 2 & 1

**5-Much more than most courses, 4- more than most courses, 3-about the same as others, 2-less than most courses,1- much less than most courses.

-Satisfactory include agreement levels 2 & 1 and Unsatisfactory include agreement levels 5, 4, &3

The analysis of the survey data revealed that course topics, workload and student involvement, and textbook selection, were major factors that students believe affected their performance in the course. Table 1 shows almost 100% of students expressing difficulties with course topics. This is due to the fact that the topics were new and abstract in nature. Among areas of difficulties students pointed out logic application and grasp of concepts were major factors (see Table 2). Another contributing factor could be the fact that majority of students (~59%, Table 3) were not aware of course topics to be such abstract prior to taking the course. However, the survey shows 75% of students had background sufficient to understand the course topics indicating the effectiveness of the required prerequisites (Table 1).

Table 2: Student's perception about difficultness of various aspects of course topics

Course aspects	Percentage(%) of students at each agreement levels					Satisfactory (%)	Unsatisfactory (%)
	5	4	3	2	1		
Concept grasp	16.6	41.6	41.6	0	0	42	58
Logic application	16.6	58.3	25.0	0	0	25	75
Both of the above	33.3	50	16.6			22	88

5 Very difficult, 4 somewhat difficult, 3 about right 2 somewhat elementary and 1 very elementary

Students also express their dissatisfaction (92%, Table 1) with the workload of this course as compared to other courses of equal credit hours. This was expected due to the fact that students needed to spend more time to understand and implement abstract concepts that might not have been the case for other courses. Nearly all students believed that the course was too challenging and demanding as well as time consuming.

Table 3: Prior knowledge and usefulness of the data structures course

Questions	Agree (%)	Disagree (%)
Q1 Were you aware of the topics of data structures before taking the course	41	59
Q2. Were you having enough background (prerequisites) to register in the course	92	8
Q3. Are the topics useful to Computer Science curriculum	59	41
Q4. Do you think background in data structures would increase your chances with employment, graduate program?	50	50

Majority of students commented a textbook with more practical applications and examples of concepts could substantially increase their interests in the course. Further, they have pointed out that the course examples should be short, easy to follow, and relevant to the real-world applications.

As expected, ~83% of students believed that a supervised lab would effectively help them with the understanding of course topics and enhancing their programming skills. In this regard, the data showed that almost all students who were surveyed stated their difficulties with computer coding aspects. However, it should be emphasized that ~92% of students rated the quality of instruction in this course was effective and contributed to their learning and problem solving skills.

SUGGESTIONS TO IMPROVE STUDENT PERFORMANCE

Based on the analysis of results a two-pronged approach is suggested to address above concerns specifically course topics and instructional materials at FVSU. The first prong would be vertical integration of relatively complex concepts such as queues, stacks, lists in pre-requisite courses that emphasize algorithmic design and implementation rather than computer coding. The second prong would include an informal supervised lab to help students with implantation of course concepts through programming exercises relevant to the real-world applications. In addition to the lab, interactive multimedia teaching tools should be employed in the classroom in order to engage students in the learning process more effectively. In addition, we are searching for a more student friendly textbook in data structures with ample examples and online interactive tutorials and demonstrations of key concepts. These suggestions could significantly improve the performance of students in the subject matter.

CONCLUSIONS

Data structures course is a key course in the curriculum of computer science program. Students often perform poorly in this course due to the nature of many abstract concepts and complex data types. In the absence of sufficient examples and exercises to connect the course concepts to the real-world applications in a simple and effective manner, students exhibit a tendency to lose interest. Consequently, many students do not perceive this course to be useful for their future career as indicated in Table 3.

Although the solutions to these problems are not always straight forward and crisp, the two-prong approach suggested in this paper could help improve the performance of students. We are planning to implement these suggestions in the future offering of the course at FVSU.

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