Student Performance Q&A:

2002 AP® Computer Science A Free-Response Questions

The following comments are provided by the Chief Reader regarding the 2002 free-response questions for AP Computer Science A. *They are intended to assist AP workshop consultants as they develop training sessions to help teachers better prepare their students for the AP Exams*. They give an overview of each question and its performance, including typical student errors. General comments regarding the skills and content that students frequently have the most problems with are included. Some suggestions for improving student performance in these areas are also included. Consultants are encouraged to use their expertise to create strategies for teachers to improve student performance in specific areas.

Question 1

What was intended by the question?

This question tested students' ability to use an array structure (apvector). In part (a), students had to search the given array and detect all those indices (that represent values that were tallied) whose entry equaled the maximum entry (found by using a given function). These indices had to be stored in another apvector that is built in the function, and had to be resized appropriately.

In part (b), students had to find the index in the array that represented the kth value tallied, in increasing order. This meant students had to move through the array from the beginning, totaling the entries until the given k was equaled or exceeded (or decrement k until 0 or a negative number was reached), and return the index where this happened.

How well did students perform?

Students did quite well on this problem. Most understood how to iterate through arrays and process the values. Some students had trouble with the concept that the array entries were tallies and not values being tallied, particularly on part (b).

What were common errors or omissions?

The errors were typical of beginning students. Errors on array bounds (starting at 1 instead of 0 or going one past the end). Some students did not understand the context for part (b), that the array entries were the tallies rather than the scores, and consequently did not understand the logic for this part.

Based on your experience at the AP Reading, what message would you like to send to teachers that could improve the performance of their students on the exam?

Arrays are a standard topic in introductory computer science and virtually all teachers do a good job covering it. Teachers might note whether they include examples such as this where the array

entries are counts or tallies of the values that are the indices. Building histograms is another place where arrays are used in this way.

Question 2

What was intended by the question?

There are four important concepts tested in this question: (1) Can students work with the abstractions provided by an object that instantiates a class (store as an instance of GroceryStore); (2) Can students do arithmetic calculations (the calculation of the unit price); (3) Can students find a minimum value in an array (note that this was given to the students in question 1); (4) Can students read from a stream attached to a file, to the end of the file. In part (a), students were asked to read pairs of a name and value from a file stream, until the file was empty, and set the price of the named item for the given store, using the appropriate member function call (store.SetPrice(name, price)).

In part (b), students were asked to get an array of names of all items in a given category in the store, using the appropriate member function call (store.GetItems(category)), iterate over that array and calculate the unit price for each item (using store.GetPrice(name) and store.GetSize(name)), keeping track of the least unit price and returning that item.

How well did students perform?

Students found this question to be of average difficulty for the A exam. There was a full range of responses from poor to perfect on this question.

What were common errors or omissions?

It was quite common for students either to ignore the need to reference the object in order to call its member function — calling SetPrice(name price), for example, without any reference to store, or to use incorrect syntax when doing so, including using the class name instead of the object name. In part (a), some students did not know how to correctly read a stream until the end of file is reached. In part (b), some students did not understand that they needed to get an array from the store with a call to store.GetItems and instead tried to iterate over an array of the store. This is something they could not even know exists, since they have no specification for the data structure in the store, which would, in any case, be private data and therefore not accessible to the client function that they are writing.

Based on your experience at the AP Reading, what message would you like to send to teachers that could improve the performance of their students on the exam?

Teach students to understand and use the abstractions provided by classes that define objects. Students must know how to access information from an object and how to modify an object by correct calls to the member functions. They need to learn the difference between the class that defines these member functions and an object that is an instance of the class. Students need to learn how to use a specification for a class with no implementation details (including no specification of the data), to correctly access objects that are instances of that class. They need to learn that they can make no assumptions about how data may be represented within a class and that they cannot access private data from a client function outside that class.

Question 3

What was intended by the question?

This question tested students' understanding of the Marine Biology Case Study in several ways. First, the student needed to be familiar with certain classes from the case study, specifically the Fish class and the Position class, and possibly, depending on how they structured their answer, the Environment class. Students also needed to understand how to build new member functions using the already existing member functions. The functions to be defined implemented eight-way movement in the grid.

In part (a), students needed to define a Position member function that returned the Position to the Northeast of this position. In part (b), students needed to define a new member function ForwardNbrs that returned a Neighborhood of the three positions directly forward and angled to the right or left of the current position (based on the current direction of the Fish, a given new data member for the Fish class). This function could be modeled on the EmptyNeighbors function, with a conditional structure added that makes use of the current direction.

In part (c), students added another new Position member function, DirectionTo, that returned the direction (an apstring "N", "NE", etc.) from this position to a given position. The best use of abstraction to do this used the member functions that returned a Position in a given direction. However, many students used the equally valid, though not so elegant, method of comparing the row values and column values of the two positions.

How well did students perform?

There was a large group of students who simply did not attempt this question or scored very poorly. These students probably did not study the Marine Biology Case Study, or only briefly studied it. Students who seemed to have some knowledge of the case study did well on this problem. For these students it was, perhaps, a little easier than average for an A-level problem.

What were common errors or omissions?

Students often had the same type of misunderstanding that was common on question 2 about the proper syntax for calling member functions for an object of a class. However, most of the member function calls were for member functions within the same class for the object in question. For example, in part (a) a complete and correct response would be

```
return North().East();
```

However, some students did not take full advantage of the given member functions and instead constructed their answers from more primitive parts of the class. For example, another correct solution for part (a) would be

```
return Position(myRow - 1, myCol + 1);
```

However, in the latter case, it is easier to make careless mistakes such as incrementing instead of decrementing the x-value of the position. Similarly, in part (b) students would not take advantage of the helper function AddIfEmpty and would instead essentially recode it using calls to the Environment IsEmpty member function within an conditional. This can be done correctly, but is

more prone to other errors including incorrect syntax and incorrect parameters. The same comment can be made about part (c) where few students took full advantage of the tools available by using a comparison like

```
if(other == North())
```

and instead compared the components of the Positions as in

```
if(other.myRow == myRow - 1 && other.myCol == myCol)
```

The latter is correct, but is more prone to a variety of errors.

Based on your experience at the AP Reading, what message would you like to send to teachers that could improve the performance of their students on the exam?

First, be sure that you teach the students about the case study. The case study can be used to teach or review many of the concepts in the AP Computer Science A curriculum. Students seem to gain the best understanding when they use the case study at several points in the course, rather than just as a stand-alone unit at the end.

Among the concepts that are important in using the case study is the use of the abstractions provided, namely using the given member functions when appropriate, rather than reinventing them. It is also important for the students to understand the relationships among the different classes in the case study. It is an excellent example of an object-oriented program.

Question 4

What was intended by the question?

This question tested students' ability to work with two-dimensional arrays, as represented by the apmatrix class. In addition, students needed to be able to work with accessing and modifying objects, instances of the Seat class, by using their member functions, similar to question 2, but in a more complex context.

In part (a), students were required to scan over all objects stored in an array and count the elements conditioned on characteristics obtained from accessor methods of the objects. In part (b), students were to iterate over a single row of the array and determine whether there are a given number of empty seats in a contiguous block, using the Seat accessor methods to determine whether a seat is empty. If there was such a block, the index of the first seat in the block is returned.

In part (c), students use the function from part (b) to find a block of empty seats of a given size in some row. If such a block exists, then the given array of passengers was assigned to that block.

How well did students perform?

This question was very difficult for the students. It combined accessing a two-dimensional data structure with accessing objects using their member functions. It also included moderately difficult logic. This was the longest question on the exam as well, with three significant parts.

What were common errors or omissions?

Most students understood part (a). Some made mistakes on using the class abstraction, with mistakes on the accesses to the elements of the seat class. On part (b), many students had difficulty with the logic of scanning the one dimensional array (for a row of seats) and then counting a contiguous block of empty seats. This could be done with either an inner loop or a

counter that is reset when a seat is not empty within the main loop. There were also the same problems with the abstraction.

On part (c), students sometimes had difficulty with the indexing of two arrays that was needed in order to copy the elements from the passengers array, with index starting at 0, into the seat row, with column index starting at the first empty seat of the block found.

Based on your experience at the AP Reading, what message would you like to send to teachers that could improve the performance of their students on the exam?

Teachers should be sure that they cover the indexing of two array structures with different starting points, as was needed in part (c) of this question. This has been a common thread in two-dimensional array problems. Of course, students should understand the fundamental data structure and the scanning of the elements of such a structure in different orders. Part (b), finding a contiguous block of empty seats within the one dimensional row was an example of a moderately difficult algorithm that is in a difficult context in this problem. The best students should have been able to understand this algorithm.