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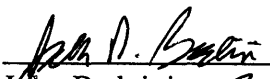
**Improving Group Interaction in the Frontiers CS Program**

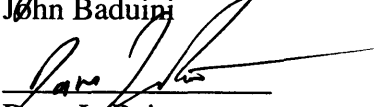
An Interactive Qualifying Project Report

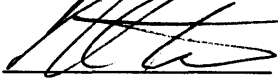
Submitted to the Faculty  
of the  
WORCESTER POLYTECHNIC INSTITUTE

In partial fulfillment of the requirements for the  
Degree of Bachelor of Science

By

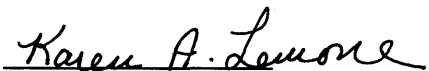
  
John Baduini

  
Dave LaPointe

  
Matthew Toczek

  
Josh Winslow

Approved:

  
Professor Karen Lemone

Date: August 28, 2001

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## **Abstract**

The theory of group- and problem-based learning is discussed and applied to the Computer Science Frontiers Program. Results of implementing the developed methodology show its inclusion in future Frontiers classes will be beneficial to students.

# **Executive Summary**

## **Overview**

This Interactive Qualifying Project covers the development, planning, and execution of the 2001 Computer Science Frontiers/Strive program. There are several sections to this report, each detailing a phase of preparation or work completed. Below is a brief overview of each section, followed by an overall summary of the report.

## **Goals**

One of the two main goals of this project was to improve the quality of group interaction within each of the project groups. In order to complete this goal, the team decided to incorporate teaching skills based on proven techniques, further develop the group formation process, closely advise the students to encourage productive activity, and gather data to allow next year's team to continue refining the Frontiers program.

The other major goal concentrated on better developing the Frontiers Qualifying Project (FQP), which had been introduced to the Frontiers program last year. Accomplishing this involved enhancing the design process based on available research, integrating project traits into the group formation process, and creating a range of projects that provide a wide survey of the field of computer science.

## **Background**

The background discusses academic sources that were studied to both gain an understanding of the material and to develop the methodology. These sources include literary works such as journal articles and books, as well as articles located on the Internet and IQPs from previous Frontiers programs. In the first section (2.1), we describe the principles behind Collaborative Learning, a teaching paradigm that embodies the advantages of learning in groups. We then move on to a related concept, Problem Based Learning (2.2), which describes the motivational and educational benefits of giving students a realistic, open-ended problem, and asking them to determine a solution without

strict guidance. In our discussion of Group Learning (2.3), we relate the various ways of forming student groups based on the principles described in the previous sections.

## **Methodology**

The methodology section discusses the process we followed in teaching the group of Frontiers/Strive students throughout the two weeks of the program. Included are the ways in which we apportioned the students into groups (3.3), the system used in developing the projects (3.4), and our means of assessing student progress and gathering their feedback (3.5).

## **Results**

The results cover the data gathered while following the methodology. This section contains detailed observations of each project group's progress, a discussion of the survey results for each group, and some notes describing the interaction within each group. We also cover specific observations of each student.

## **Analysis**

The analysis section discusses some of the reasons why some the events reported in the results occurred. This section briefly covers some snags with groups and project work as well as performing a brief comparison between the 2001 CS Frontiers/Strive students and their 2000 counterparts.

## **Group Results and Analysis**

This section covers in depth each of the groups and their work on their project. A lengthy discussion of group interaction and progress is followed by some suggestions on how that specific project could have proceeded more smoothly

## **Conclusions**

This section summarizes our feelings on the success of the project and provides some further, general suggestions for next year's team.

## **Primary Authors by Section**

<b>Abstract</b>	<b>Matthew</b>
<b>Executive Summary</b>	<b>Josh</b>
<b>1 - Introduction</b>	<b>Matthew</b>
<b>2 – Background</b>	
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# 1 – Introduction

The Frontiers program, sponsored by and conducted at Worcester Polytechnic Institute, provides prospective college students with a “sneak preview” of WPI life. The participating students, usually high school juniors, live the unique brand of college life as offered by WPI. While the students are exposed to dorm life and its associated social experiences, the main focus of the Frontiers program is academic.

Frontiers students engage in the study of technical material at WPI, such as engineering, biology, mathematics, etc. While the material offered is within one discipline, it is broad enough to assist each student in the selection of a major once the college career is formally started. Additionally, the WPI Frontiers program is designed, in part, to aid in recruiting. By evaluating Frontiers students and their work while at WPI, the admissions department is better able to gauge the potential of these prospective full-time WPI students. In the same respect, potential undergraduates are able to get a closer look at WPI, assisting their college selection process.

The WPI Plan is the central focus of education at WPI. At the Plan’s core is the goal that a university-level education should not be just learning technical information and processes; rather, the student should develop personally, professionally, technically, and be able to take theory taught in the classroom and apply it to the real world. Perhaps the most important goal of the WPI Plan is developing a student’s curiosity and discipline: that is, a WPI student “learns how to learn.” These lofty aspirations are met by the presentation and completion of team-based project work, theoretical instruction, real world applications, and the experimental process.

In order to more efficiently execute the goals of the Frontiers program and the WPI plan, the Frontiers IQP 2000 students introduced final projects, Frontiers Qualifying Projects (FQP), for the Frontiers students to complete. The projects were well received, but had both design and execution flaws.

After deciding to continue with an FQP implementation, the authors researched and implemented a formal, group- and problem-based learning methodology. This methodology addressed concerns regarding group formation, project subject matter and complexity, and assessment. Both the quantitative results collected and the nearly



unanimous opinion response from the Frontiers students indicated the methodology and projects were valuable additions to the Frontiers program.

## 2 - Background

Education styles have progressively shifted over the past few decades to cater to developments in technology, new types of problems, and changes in group dynamics. A goal of the Computer Science department at WPI has been to foster group collaboration in its courses. Similarly, successfully providing the students involved in the Frontiers Project with a fulfilling learning experience calls for effectively implementing the principles behind collaborative learning. The concepts involved in achieving these goals are relatively simple: students are divided into small groups and given a common goal toward which they work together, helping each other learn in the process.

However, there are a number of issues to be considered in applying these principles to those of Frontiers. One such issue is forming groups from a collection of students with varying levels of knowledge and experience in their fields of study. The criteria for assembling groups, outlined in this document, are based on empirical observations and well-tested methods. It is therefore a reasonable supposition that research in this area is valuable to our goal of improving the Frontiers program.

Problem-based learning is valuable to the process of collaborative learning in that it relates directly to group work. Using open-ended problems that encourage students to fully understand the material involved helps to establish a productive, motivated student team.

Similarly, choosing projects that encourage group cooperation is also essential, as many future projects a typical student can expect in the field of computer science will have similar properties. Projects also need to adequately meet the requirements defined in the field of problem-based learning.

Though these are the most critical issues in implementing productive group work into a curriculum, a strong understanding of how students effectively learn and collaborate is the most significant aspect of teaching in general. The basis of our investigation will therefore begin with the rationale behind collaborative learning.

## **2.1 - Foundations of Collaborative Learning**

As the field of computer science becomes increasingly project-oriented, students will find that teaching methods that are geared toward effective group work are employed more often than those that have mostly independent applications. This is primarily due to the development of a business model that distributes people into teams, each of which focuses on a particular aspect of a company's responsibilities.

This model generally dictates that people will be interdependent, that is, they will have to rely on each other in order to accomplish their goals. This is already true in education from a constructivist, rather than the traditional instructivist, point of view. Instructivism centers on the age-old ideology of lecture and demonstration. The responsibility of education lies in the hands of the instructor alone. Constructivism, on the other hand, is more oriented toward pointing the student at determining or "constructing" the meaning of the material, rather than receiving the information directly. The responsibility of ensuring a quality education is still held by the instructor, but students are more involved in the process of learning because they determine, on their own, what they must do, as well as what knowledge they must seek, in order to achieve the goals presented to them.

Constructivism also promotes itself as a more natural form of learning; as Kenneth Bruffee writes, "knowledge is a consensus: it is something people construct interdependently by talking together." [113, Bruffee 1993] Generally, this philosophy states that people learn from what they take in through their senses, and that knowledge is therefore "a construction of how the world works, one that is viable in the sense that it allows individuals to pursue particular goals." [Lorsbach and Tobin 1997] In this manner, constructivism lends itself very well to collaborative learning, as it embodies the ideals of problem-solving as well as interdependence.

### **2.1.1 - A Model of Collaborative Learning**

Typically, the application of collaborative learning to the classroom is organized in this fashion, according to Bruffee: the class is divided into small groups that work

collaboratively on a limited but open-ended task. [28, Bruffee 1993] There are generally four steps involved in this process:

1. They divide a large group – the class – into small groups.
2. They provide a task, usually designed (and preferably, tested) ahead of time, for the small groups to work on.
3. They reconvene the large group into a plenary session to hear reports from the small groups and negotiate agreement among the group as a whole.
4. They evaluate the quality of student work, first as referee, then as judge.

[28, Bruffee 1993]

This model has been applied to the WPI CS department's curriculum in a number of courses. The software engineering course (CS3733) applies this process, sometimes assigning different parts of a whole software system to arbitrary student groups.

The collaborative learning model, whether the one described above or any model that allows students to interdependently work toward a common goal, is a considerable progression in education. It is readily applicable to modern educational, as well as professional, concepts and environments, and therefore provides a solid basis for teaching small groups through project-oriented, collaborative processes. We look next into the principles behind project-oriented learning in order to establish the most important concepts in designing useful projects.

## **2.2 - Problem Based Learning**

The main goal of Problem-Based Learning (PBL) is to motivate students by presenting them with an interesting problem to solve. PBL encourages students to first study the problem and identify areas of knowledge that will be helpful in constructing a solution. The students then conduct research, learning about the respective areas until they have enough information to solve the given problem.

PBL can be an excellent motivator. If students are interested in the problem, they take a more active role in learning about the problem area. With some guidance, students

presented with PBL will know what they need to learn and why they need to learn it. With a concrete, specific problem, students can directly apply what they have learned and gain a sense of accomplishment.

### **2.2.1 - Building PBL Problems for Groups**

When teaching with PBL, effective problem design becomes an important goal. Because student motivation is directly related to the appeal of the proposed problem, designing interesting problems is the key to a successful PBL curriculum. Savery and Duffy (1995) offer a set of instructional principles for creating cooperative problem-solving activities. These principles are discussed below.

The learner should be encouraged to develop ownership of the problem and the process used to construct a solution. The feeling of ownership encourages the students to immerse themselves in the problem, because it is *theirs*.

It is also important to construct a real problem. The students must feel they are solving an authentic problem in order to capture their interest. The problem's complexity should equal what the students are expected to be able to accomplish at the end of their learning.

Dutch (1996) suggests presenting student groups with problems that require judgments be made on logical processes such as rationalization and critical analysis. Additionally, Dutch recommends that all decisions regarding problem assumptions and solutions be justified by the students; there should be a reason for everything. These guidelines are exceptionally important regarding the subject matter at hand; a very large part of any computer science project will be driven by logical analysis.

Millis and Cattel (1998) discuss the use of open-ended problems in order to require the students rely more heavily on logical processes in their solutions. However, if no one solution is evident, the students must first brainstorm possible solutions. These possible solutions are analyzed for merits and faults. Once a single solution plan is agreed upon, the students must logically execute it to a working, acceptable answer.

## **2.3 – Group Formation**

Before groups are made, it is vital to know which type of group is appropriate. The two group types of interest are heterogeneous and homogeneous. As the names indicate, heterogeneous groups are composed of dissimilar students while homogeneous groups consist of similar students. Each group type has its own advantages and disadvantages. Neither is appropriate for every situation, and for that reason, decisions on group types should be made on an application-specific basis. With both group types, there are a variety of group selection practices that apply to that specific group type. An overview of these practices is intermixed with the analysis of each group type.

### **2.3.1 - Heterogeneous Groups**

Heterogeneous groups are often advocated with the argument that groups with variety are better equipped to solve challenging problems [Cromwell 1999]. Forming heterogeneous groups can ensure a mix of learning styles, areas of knowledge, abilities, or even cultures. Having a good mix means being able to attack the problem from many different angles.

Heterogeneous groups do have a downside, however. Because of such diversity within the group, students may find communication to be a problem. Cooperation can be hindered in a number of different ways. As the group dynamic manifests itself, clashing personalities can be the result of perhaps too much diversity. As most group problems are a result of either poor communications skills or poor social skills, groups may need outside assistance to resolve these issues. Careful monitoring of group progress is essential to avoid ineffective cooperation.

### **2.3.2 – The Value Line**

One technique for forming heterogeneous groups is known as the Value Line. The Value Line approach ranks students according to some heuristic [Millis & Cattel 1998]. The heuristic chosen can be almost anything.

It may be helpful to sort students based on their opinions concerning a controversial issue, or perhaps a belief or personal choice. The ranking heuristic can also be something measurable, like a student's height; or more commonly, a student's test score or ability level.

When all students have been ranked "in a line," the midpoint is found. Using the line, groups are then formed by taking students from both extremes, and from the midpoint-area. This ensures that the group remains diverse, according to the heuristic chosen.

### **2.3.3 - Homogeneous Groups**

Although heterogeneous groups are supported for most activities, some activities may benefit using homogeneous groups. Many educators believe that homogeneous grouping helps solve the problem of teaching a single curriculum to both over and underachieving students by separating them into groups of like ability [Cromwell 1999].

### **2.3.4 – Ability Grouping**

Ability grouping is a controversial subject, and its value is highly debated among teachers [Rogers 1991]. Advocates claim that it allows different teaching techniques to be applied to students that excel and students that struggle. By grouping students by ability, in theory, it should allow them to move at their own pace. Advanced students can explore further topics, while struggling students can take the time needed to fully learn the core material.

Opponents of ability grouping claim that it merely helps the gifted and stifles the remainder of the students. By augmenting the curriculum for the advanced students, it is argued that resources are being shifted away from the struggling students that could be used to bring them up to speed. Additionally, in separate groups, the struggling students gain nothing from the advanced students. They will not learn anything from their classmates, nor will they be able to feed off of the excitement and motivation that the advanced students show for the material.

### **2.3.5 – Bringing it all Together**

The question to be answered here revolves around three hypothetical groups. Group A is heterogeneous in ability, group B is homogeneous in ability, consisting of low-achieving students, and group C is homogeneous in ability, consisting of high-achieving students. So the actual question is, “How well do students in both groups B and C learn compared to those in group A?” The analysis of how these hypothetical groups learn and function in various instructing environments is of utmost importance in determining which group formation technique is best suited to the CS Frontiers program.

### **2.4 – Assessment**

Quality assessment is vital in determining if our program is successful. To understand how to correctly assess how well the Frontiers' students work together, as well as to determine how the project work was designed, education references need to be consulted. However, most educational references don't deal with teaching technological materials to technologically oriented students. Of the subset of works that does deal with group work and technology, non-technical educators write most. Beyond the use of these comments in developing the methodology, these works are of limited use.

#### **2.4.1 - Assessment Styles**

The thinking among educators is that there are two main methods of developing assessment programs, positivism and constructivism. Positivist assessment is a top-down, management driven assessment technique that focuses on a more scientific analysis of the system as a whole. Positivist assessment tends to be driven more by the administration rather than the educators or students and tends to be generic across scholastic fields. (Gilroy, 2001) An example of a positivist assessment technique is the blue assessment forms WPI uses to evaluate its lecturers. There is a single survey form that students fill out for every teacher, irrespective of department and class level. This form uses a numerical system to judge the effectiveness of the teacher in several categories, some of which may be irrelevant. Due to the numeric nature of the results, they can be used readily in statistical analysis. Due to the limited size of the Frontiers



program, a positivist approach to assessment of this program would probably not be the best choice.

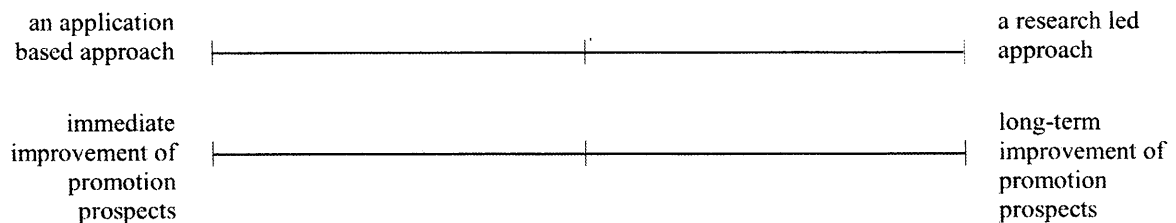
#### **2.4.2 - Constructivism**

At the other end of the spectrum lies a constructivist approach. This type of approach is bottom up and user driven. Constructivism attempts to focus more on what the instructors and students find to be the parts of their specific course they think needs reviewing rather than what the administration feels are important criteria for all courses. (Gilroy, 2001) It attempts to either determine what the students expect to get out of the process and how they felt the course met those needs or how the instructor felt their teaching applied to self set benchmarks. This method is better for groups who are only trying to evaluate a small group of students on a specific topic because it yields a more accurate analysis of how the students and educators feel about the goals that they themselves set. This type of assessment seems more oriented towards the sample size of the Frontiers program.

There are many different ways of running a constructivist assessment program. Take for example a template created by educators for use in their department. It indicated that, among other things, the instructors should set several benchmarks for themselves before each class begins. After the class is finished, the instructors should evaluate themselves on how they met their own goals. As another key component of this process, the students need to provide feedback as to whether the instructors met a set of standards, determined by the group of teachers at large. (Moreland, 2000) Elements of this particular program, specifically the self-set goal of the instructor, should be used in any assessment we perform.

Another example of a constructivist program uses a survey geared towards the students that attempts to determine what the students' expectations were coming into the class, as well as how they felt the class met those expectations. A survey is given to the students at the end of the program with two sections, their expectations and what they felt the class actually taught. Each section has the same number of questions that consist of value neutral opposites on an analog scale. (See example below) The students from the

class mark the scale at one point to indicate where they thought the class fell. (Gilroy, 2001) Another method would be to give a survey before the class starts on what the students expect from the class. After they have completed the class, another survey similar to the method above could be given. This would allow students with little up-front knowledge of the subject to change their expectations as they learned. These types of constructivist systems are helpful in programs where the syllabus is flexible, like the Frontiers program.



### 2.4.3 - Summary

It is important to note that constructivism and positivism are very broad categories and that an assessment process of nearly any program can be developed as either type. Crucial to developing an assessment process is the knowledge of what are the key educational goals of a given program. Equally important is a solid foundation of knowledge of the type of teaching style(s) to be used when teaching the program. Several different tools may be used when developing an assessment program that is applicable to a specific class.

One such commonly used tool is a questionnaire, used in the Gilroy study. Others include benchmarking (Moreland et al, 2000), one on one interviews, and focus groups. For our purposes, one on one interviews would take too much of our limited time and benchmarking with such a small group isn't applicable. The questionnaire has the advantage of getting the untainted opinions of each student on topics we specify. The focus group approach allows for the students to voice their opinions on topics that they feel is important and results in a less rigidly defined collection of information.

## **3 - Methodology**

Implementing the issues discussed above requires some degree of planning, and there are a number of ways in which the goals can be achieved. In this section, we outline the procedure that defines exactly how we put our ideas into practice.

### **3.1 - Presentation**

The format for presenting projects, references, and other information to the students is best expressed over the web. Posting everything on a web site is the best way for students to be able to access the material from any place, at any time. In addition to the ability to quickly find relevant data for their project work, they are able to review the curriculum outside of the labs as well. However, such a site must be organized for easy navigation so that needed information can be accessed quickly. The pages are already in place from previous projects, so any changes made were be in the interest of preserving the purposes of the project, as well as providing its students with a good interface with the program in general.

In general, course management systems make the many tasks of administrating a course simpler, and this is certainly (potentially) true with the Frontiers program. These systems absorb many of the details that tend to curb an instructor from performing the more important duties of running a course. With this is mind, we chose my.wpi for our program.

The my.wpi system has been proven useful in keeping information organized for many WPI courses already. The Course Documents page, readily available in a side menu, contains links to the modules, projects, and all internal documents, while the external links (reference documents outside of the Frontiers domain) are made available from appropriate pages. To make the entire site even more navigable, this menu appears on every page within the site. In addition to the Course Documents link, the menu contains links to a Staff Information page, an Announcements page, and a discussion board for addressing any issues that develop over the course of the program.

The Announcement page simply served to let the students know when a new quiz or survey was posted. They were told to take the pre-test, post-test, and last day survey as soon as they became available, so this section provided a quicker way of accessing them.

The my.wpi pages adhere to a uniform set of fonts, styles, and graphics; this creates a sense of unity throughout the site, effectively establishing the site as a consistent, organized entity. In addition, all web material was printed into booklets that the students could take home, and a suitably amalgamated booklet has a more professional look.

### **3.2 - Encouraging Collaboration**

If students are to effectively work together comfortably, the responsibility is ours to take the necessary steps involved in establishing good, short-term professional relationships. As the students are not likely to know each other coming into the program, a few "ice-breaking" activities could have aided in making them more comfortable with working together. Unfortunately, we simply did not have time for that. A simple group introduction exercise in which students state their names and something relatively unique about themselves, such as where they each live, sufficed.

Fortunately, interaction in small groups has its own rewarding way of achieving these goals. Using small groups invites every member of the group, rather than the more active members of a large group, to participate in discussions and contribute to group work. In addition, small groups allow students to compare their thoughts with those of their peers in a more comfortable environment than a large classroom would provide. This is especially helpful to shy students, as fears associated with public speaking are diminished in the presence of such a small audience. [109, Erickson and Strommer 1991]

#### **3.2.1 - Providing Outside Assistance to Struggling Group Members**

Groups with large disparities in experience levels tend to experience a disparity in individual value over a relatively short period of time. When students with more experience begin to work at a faster pace than other group members can maintain, the group dynamic begins to fall apart, and the less experienced gain little from the project.

In order to compensate for this effect, the trailing students were approached and given a quick lesson in the parts of their projects in which they were struggling, either by the staff or other group members.

There is also the possibility that one can influence a group into bringing its struggling members up to speed by assigning a title or task to those students that would require them to know more about their project. To make one of them a "group representative" would require the others to instruct him or her as to what they are doing if they are to provide a substantial report of their activities when asked to do so.

Another, more radical approach is to reveal pre-planned hints that would give the less-experienced students the advantage needed to keep up with those for whom the material is less difficult.

### **3.3 - Forming Groups**

Our goals for forming groups were threefold. First, we wanted to construct groups that could work well together. Second, that students should learn from their partners; groups should have some variety concerning ability. Third, that students should feel like they belong and play an important role in the group, so there should not be too much variation in skill level.

The first point is an imperative group-building goal. Building groups that can work well together is one of the most important goals for all teachers that employ group work. In the case of the Frontiers CS program, this is primarily an issue of motivation. It is desirable that all of the students in a particular group share an equally high motivation for the completion of their project. As such, project selection among individual students was a high-level criterion for forming groups. Many of the issues that could impede this goal are those that are not addressable with group building techniques. These include personal qualities such as social/communication skills and work ethic.

From a teaching standpoint, the second point is extremely important considering that the students we dealt with had a very wide range of capabilities. It was of utmost importance that every single student learned as much as possible throughout the program. For this reason, it was decided to form a hybrid homogeneous/heterogeneous group

construction technique, which is discussed below. As there are many arguments for and against each group type, a hybrid technique should provide the best of both worlds. That is, group members can learn from each other (as in pure heterogeneous), but extreme skill levels (both advanced and lagging students) will not lose motivation by having to deal with students at the opposite end of the spectrum (as in pure homogeneous).

### **3.3.1 - The Value Line Approach with Ability Ranking**

Our hybrid grouping technique is a modified value line (see Background 2.3.2) approach. First, a value line was built with the entire class ranked by ability. The students' abilities were determined by how well they did on the pre-test. As our goal was to have three person groups, we attempted to select one student that ranked high, one that ranked low, and one somewhere in the middle. With only 13 students this year, we decided that it would be acceptable to have two 2-person groups in order to allow more projects to be used. In the case of these groups, there was either: one high-ranked student and one middle-ranked student, or one middle-ranked student and one low-ranked student.

### **3.3.2 - Grouping Methodology**

The Value Line approach is not sufficient for grouping given that student project selection must be incorporated. The solution was to first ask students to rank all projects in order of most-wanted to least-wanted. In the end, we formed groups manually, by trying different combinations until we found one that best fit the following conditions:

1. The value line must remain as intact as possible. That is, there should be a relatively high-ranked student, a middle-ranked student, and a low-ranked student for all 3-person groups. For 2-person groups, there should be either a high-ranked student and a middle-ranked student, or a middle-ranked student and a low-ranked student.
2. Maximize the number of students getting their first project choice; minimize the number of students getting 3<sup>rd</sup> or less favored project choices.

3. Use more projects rather than fewer; that is, with a number of students not evenly divisible by 3, create several 2-person groups rather than a 4 or 5-person group, in order to use more projects. By using more projects, we were able to introduce the students to more areas of computer science.

When we refer to students in the report as “Student N” where N is a number, the number refers to their ranking in the value line. The following list illustrates the value line rankings:

1. Student 1
2. Student 2
3. Student 3
4. Student 4
5. Student 5
6. Student 6
7. Student 7
8. Student 8
9. Student 9
10. Student 10
11. Student 11
12. Student 12
13. Student 13

The groups we formed are as follows:

XML:	Student 8, Student 11
Graphics:	Student 2, Student 6, Student 10
Software Engineering:	Student 4, Student 7, Student 12
Databases:	Student 1, Student 5, Student 13
Networks:	Student 3, Student 9

- 10 students got their first project choice.
- 1 student got his/her second project choice.
- 1 student got his/her third project choice.
- 1 student got his/her fourth project choice.

### **3.4 - Project Design**

The primary goals of each of the projects presented to the Frontiers students are exactly those given in the WPI Plan. While helping the Frontiers students learn new programming languages and techniques, completion of the projects also develops problem solving skills. The projects also present real-world situations where technical skills learned can be readily applied. Additionally, the project material aims at developing the students' personal and professional curiosity, so that they may become the lifelong learning at the crux of the WPI Plan. Furthermore, each project has specific technical instruction purposes which are enumerated within each project description. Full project descriptions are available in Appendix A.

#### **3.4.1 - Design Guidelines**

From the references cited in the Background section of this work, the following simple guidelines were used in the design of projects to be used in the Computer Science Frontiers program for the summer of 2001:

1. Use projects that capture the student's interest.  
It may be difficult to capture every student's interest with just one or two problems, so an array of problems, one taken from each of the subdivisions of Computer Science, were presented.
  
2. Require each project to be complex enough to require critical analysis and independent student decisions, as well as to allow for multiple solution approaches. This guideline is perhaps the easiest to factor into the design of Computer Science projects, as students must make design decisions about their programming solutions within the problem



domain. The students must then deal with the ramifications of these decisions, for good or otherwise.

### 3. Use real-world problems.

This assists in capturing the student's interest, but also provides a sense of accomplishment. The student, knowing he or she just solved a problem relevant to industry or academia, is much less apt to ask the question "When are we actually gonna use this stuff?"

### 4. Provide problem/subject matter background information.

Providing the background information of where and why this problem arises assists in stimulating the student's interest and motivation. Additionally, if problem domain research is necessary, background information can provide a starting point from which the student may begin.

#### **3.4.2 - Subject Matter**

As noted in the first guideline given above, many of the subdivisions of Computer Science were covered in the projects presented to the Frontiers students. The subdivisions are: databases, discrete theory and logic, XML, algorithms, software engineering, interface design, graphics, and networks.

While the issue of professional ethics in Computer Science does lend itself quite nicely to group discussion, the Frontiers program operates under certain time constraints. So instead of calling for collaborative conversation on the topic, it was decided that ethical concerns would be written into as many of the project descriptions as possible. For example, recent media coverage of the FBI's Carnivore "email snooping system" has raised concerns about the integrity and privacy of electronic communications. This issue was easily raised to the students in the Cryptanalysis project.

### **3.5 - Assessment**

Determining how to set up our assessment program was a difficult decision. The host of tools that are available make it difficult to select the best tool for any given program. It would appear that due to the focus on Problem/Group Based Learning, tools specific to those areas would be required. However, it is important to remember that assessment techniques are generic. It is best to pick a technique that applies to the number of students, their composition, and their location with respect to the instructor. Given this wide variety of options, we decided to start with a constructivist assessment setup because it works well for groups the size of a CS Frontiers/Strive class.

#### **3.5.1 - Questionnaire**

A questionnaire or survey as an assessment tool has a number of advantages and few downsides. First and most importantly, it is familiar to nearly everyone, certainly to our entire study group. It is applicable to groups of any size, though it is most useful in studying larger groups. When taking a questionnaire, charismatic students are unable to influence their classmates' answers at the time of the survey, unlike in a focus group. A survey also allows a uniform set of information to be gathered from all students as they are all answering the same questions. Finally, taking a questionnaire is much quicker than a focus group or a one-on-one interview because all the students are answering questions in parallel rather than in series.

#### **3.5.2 - Format**

There are several options for the format of any questionnaire. How the questions are formatted, their order, the number of questions, and categories (if any) all needed to be decided upon. For formatting, the options include short answer, multiple choice, or a sliding scale. A sliding scale is too variable for statistical use unless the accepted answers are vastly restricted. Multiple choice gives the best results from a statistical perspective because it restricts the students' options to a particular set of answers. However, some questions require the use of the short answer type, due to the open-ended nature of

particular subsets of topics. Due to time restrictions, the questions themselves had to be reasonably short (a few sentences at most) to allow slower readers to finish within a reasonable time frame (about thirty minutes).

### **3.5.3 - Number of Questions**

Deciding on the number of questions was important because it determined how much data we could gather from the students. A smaller number of questions would have taken less time to write and less time for the students to take. We felt that students were more likely to lose interest in a questionnaire if it took too much time and could lose interest, resulting in a rushed, incomplete answer. A large number of questions on the other hand, would have allowed for more detail on each topic and a greater breadth of topics. It also made it easier to insert check questions to test the validity of the answers we received. Asking the same question, phrased more than one way, helps catch surveys that are answered in an intentionally false fashion. This ensured that we would know if a survey should have been discarded due to false information.

### **3.5.4 - Question Organization**

Due to the fact that we kept the length of questions short, the total number of questions was relatively large. We decided that somewhere on the order of 30 questions was appropriate for our survey. We also felt that dividing the questions into categories was important to avoid confusing the students with unrelated questions in a seemingly random order. Category selection is also important. Questions in categories should generally seem logically related, but should not reveal what we are trying to study. Questions were included about group work and project work, as well as group and project selection. We also included other data that might be valuable for future projects, such as the students' general feelings about the program, how well designed they felt the modules were, the quality of the instructors, and a section on what material on which they would have liked to spend more time. Our goal was to have no more than 6 or 7 questions per section.

## **4 - General Results**

### **4.1 - Introduction**

The IQP team collected both quantitative and qualitative data in their assessments of the Frontiers students. Perhaps more important though is that the authors walked away from the program with statements similar to "...that was a good crew. I'd work with them again.<sup>1</sup>"

The results span two basic sections: module progress, and group-project progress. For the first week of the Frontiers program, all the students worked on modules; these modules are collections of instructions and small programming projects written for previous Frontiers classes. During the second week of the Frontiers program, the students were assigned and worked on group projects (see Appendix A). General results of the students' progress are below, while project group-specific results are located in chapter six.

### **4.2 - Assessment Results**

The formal assessment results included in the instructors' decision-making process include a pretest, posttest, and final survey. Additionally, included are charts listing where each of the students started with the modules, as well as the progress they made.

#### **4.2.1 - Pretest, Posttest, Final Survey**

Full results are located in Appendices B, C, and D, respectively.

#### **4.2.2 - Student Module Progress**

RoBOTL is a simple language, based in a Java applet, designed to teach the basics of programming to students without prior programming experience. It teaches

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<sup>1</sup> Dave LaPointe at the conclusion of the Frontiers 2001 program.

rudimentary syntax and flow of logic using conditionals and functions. JavaBOTL expands on RoBOTL, adding Java-like syntax onto that of RoBOTL. JavaBOTL is a functional subset of Java, so everything learned carries on to the next set of modules, which are based in Java.

Following is a count of student starting positions; that is, a count of how many students started with RoBOTL, JavaBOTL, etc., as well as a count of student ending positions.

No. Students				Web	post-Web	No
Starting with:	RoBOTL	JavaBOTL	Java	Programming	Programming	Response
	7	3	3	0	0	0

No. Students				Web	post-Web	No
Ending in:	RoBOTL	JavaBOTL	Java	Programming	Programming	Response
	0	3	2	5	1	2

Please note that the one student listed as “Ending in post-Web Programming” finished all the Web Programming modules well before the end of the modules section of the Frontiers program was closed. After finishing the Web Programming modules, this student made significant headway in self-learning JavaScript.

### 4.3 - Instructor Evaluations of Individual Students

The results included in this section are the authors’ opinions and impressions of the Frontiers students. The advising professor contributed to the collection of data.

#### 4.3.1 - Student 1

Student 1 was a fast learner with extensive background experience. Student 1 also assumed the leadership position in group work, as he was usually the first to learn any new material. However, he was unhappy with the project to which he was assigned because it was his fourth choice, and he did not thoroughly read the project description.

#### **4.3.2 - Student 2**

Student 2 was another fast learner with much experience. However, the antisocial attitude she presented made group participation difficult. Additionally, referring to the modules section of the Frontiers program, Student 2 commented “I don’t think I’ll ever use any of this.”

#### **4.3.3 - Student 3**

Student 3 displayed an ability to move quickly through any Java-related material. He also displayed some deficiencies in communicating with his group partner, but to a minimal extent. Overall, Student 3 seems to be a fast learner who will not likely experience much difficulty in adapting to new challenges in his Computer Science career.

#### **4.3.4 - Student 4**

Student 4 had significant programming experience, but had difficulty concentrating on the problem at hand, necessitating a group member that would keep him focused. He consistently drifted to playing web-based games, instead of staying on task. He was especially good with programming the more difficult sections of his project.

#### **4.3.5 - Student 5**

Student 5 brought a good attitude to his group, as well as an ability to learn new material rather quickly. He acted as a stable and positive influence from which both the more- and less-advanced students in his group could function.

#### **4.3.6 - Student 6**

Student 6 did not display exceptional excitement or apathy toward any aspect of the Frontiers program, though he did display a measure of curiosity at times, towards both Perl and Java. However, student 6 did present a problem when he suggested his group members change projects in midstream.

#### **4.3.7 - Student 7**

Student 7's position at the middle of our value-line evaluation could not have been more appropriate. Student 7 had little programming experience, but worked well, both alone and in groups. She had a great deal of interest in learning Java beyond what she learned in the modules, and this interest carried very well into her project group.

#### **4.3.8 - Student 8**

Student 8 had little programming experience coming into the Frontiers program, but displayed willingness, though not necessarily an ability, to learn. Student 8 also presented himself as a good group worker, with leader potential. Unfortunately he was paired with a student whose ability levels were significantly below his own; this limited his ability to explore the extensions to his project.

#### **4.3.9 - Student 9**

While Student 9 learned well, alternating attitudes of excitement and boredom were manifest. Student 9 was seen multiple times "tinkering" with given examples and self-authored programs, but also commented "sometimes I just get bored with this stuff." He also presented a rather passive method of group interaction.

#### **4.3.10 - Student 10**

Student 10 had previous programming experience in C and was both enthusiastic and quick to learn Java. Student 10 originally started with RoBOTL, but moved on to JavaBOTL at the recommendation of one of the instructors. Additionally, Student 10 took the leadership role within his group when no one else would accept it.

#### **4.3.11 - Student 11**

Student 11 learned reasonably well, though very slowly. He also communicated quite well, but had difficulty using loop structures effectively, a consequence of his inability to grasp basic computer science concepts.

#### **4.3.12 - Student 12**

Student 12 had little programming experience before coming to the Frontiers program, and worked very slowly, but learned very thoroughly. Additionally, he brought a good attitude and good communications skills into his project group.

#### **4.3.13 - Student 13**

Student 13, while having no prior programming experience and difficulty learning computer science-related material, had a good attitude and enthusiasm at the beginning of the Frontiers program. This enthusiasm waned somewhat as the program progressed.

### **4.4 - Student Conflicts and Concerns**

Here we outline various inter-student conflicts and issues that made a strict value-line group-construction methodology impossible.

#### **4.4.1 - Camaraderie of Students 1 and 4**

It was immediately obvious that Students 1 and 4 were good friends. They would continuously goof off during lab periods, accomplishing just enough work to keep them either on par or just ahead of their classmates. Placing them both in the same project group would not only have been anti-productive, but would also not have been in accordance with the methodology.



#### **4.4.2 - Antisocial Student 2**

Student 2 was very reluctant to speak with anyone. As such, it was imperative that she be placed with someone who would “reach out,” in a sense, to get her to share her thoughts with the group. When approached by an instructor she would rarely respond with substance.

#### **4.4.3 - Agreeability of Students 1, 7 and 11**

Student 1, 7, and 11 said they would “be happy with any project.” This provided a useful degree of flexibility when creating student project groups.

#### **4.5 – Course Management System Issues**

Information on my.wpi was stored in a highly relational SQL database with a web-based front end. The way this database is structured, all information about each student is reported as having a relationship with the student’s account on my.wpi. We had been accessing student data using the web-based front end throughout the course of the program and when we were working on our report. Due to a miscommunication between the my.wpi staff and our project group, a serious loss of data occurred when the my.wpi administrator deleted the user accounts. Because the data was so tightly coupled with the students’ accounts, it was removed from the database at the same time. The accounts had been scheduled for removal two weeks after the end of the program; though we were informed that this was a standard procedure, we did not expect the results of the students’ quizzes to be deleted when the students were removed.

There were a number of ways in which to solve this problem. All of them began with contacting the my.wpi administrator and requesting that the data be restored. Though the data was backed up, it could not simply be re-loaded into the running my.wpi database, as the old data could potentially corrupt the current database. Another seemingly simple solution would have been to restore the old database onto an isolated my.wpi server, and then access the data through the my.wpi front end. This relatively

simple solution did not, however, appeal to the my.wpi administrator, who instead chose to export the relevant database tables to Microsoft Excel worksheets.

Unfortunately, due to the nature of the database, the export turned out a very convoluted set of spreadsheets that were terribly difficult to read, and made for an incredibly unsightly hard copy. Dave was relegated the task of turning this group of worksheets into a coherent database from which we could draw information efficiently, and from which we could produce a clean report.

The first task in achieving this goal was to manually cut and paste a great deal of text between columns. This method was the most time-efficient method to employ because of the amount of data, and the amount of time that would have been required in order to write a similarly functioning program. The problem arose because Excel's import function treats all newline characters as line delimiters; that is, every time the student pressed the enter key on his or her keyboard, the text following the newline was treated as a new entry in the database table, and in the wrong column. After this had been fixed, Dave wrote a Perl script that processed one of the fields on a worksheet which had its data values blemished with extra characters. These data values were actually the indices of concrete data values.

The next step in producing a working database was to import the tables into Microsoft Access and re-generate the relationships. Before this could work successfully, however, two adjoining columns in an Excel worksheet had to be merged. Since Excel does not allow this to be done for every row with a single command, a macro was defined that iteratively accomplished this task.

After creating and running another Perl script, this one designed to replace index numbers that had been merged with text answers with their corresponding text (which was in another worksheet), the database was ready. Tables that represented all of the data had been created and linked together. Queries on this data produced the questions, answers, and student-to-answer relationships with which we could generate reports.

## 5 – Analysis

Evaluating the effectiveness of the Frontiers program as implemented by our methodology involves examining three things: how well the students learned overall, how the grouping methodology enhanced or worsened their learning process, and how the project design improved or hindered their learning process.

Examining the table in 4.2.2, we can see that of the thirteen students that participated in this year's Frontiers program, at least eight of them got to the Java modules or more. Considering that seven of the students started at the lowest level (RoBOTL modules) and all of them moved on, it's safe to say that some learning took place.

### 5.1 – Groups

In general, the grouping methodology employed was a success. Almost all students were able to not only work well with their partners, but also learn from them. Unfortunately, there were several students that seemed to learn very little while working in groups.

Throughout the group work experience, Student 2 seemed to lack interest in the project. As one of the higher ranked students in this year's program, the project did not really challenge the student. As a result, Student 2's interest waned and she learned very little. Although she did not learn in her group, the cause should be attributed to the relatively unchallenging project and not the grouping methodology.

From the beginning of the Frontiers program, Student 11 showed a constant need of assistance with almost all tasks he was asked to perform. During the group work sessions he was no different. His group's project advisor needed to hold his hand through every little task. He showed almost no interest in learning how to do his part by himself, and unfortunately, his group suffered because of it. Regrettably, Student 11 would probably have performed identically regardless of what group he was placed in.

## **5.2 – Projects**

This year's projects were generally well received by the students yet also managed to teach their subject well. Out of thirteen students, five rated the projects "Very interesting", two rated them "Interesting", five rated them "Somewhat interesting", and Student 2 was the only one that rated them "Somewhat dull."

## 6 – Group Results and Analysis

### 6.1.1 – Database Group Results

The Frontiers students completed the Database Project to satisfactory levels. A Java front-end was written with all necessary functionality. However, this front-end was command-line only, so the students attempted an applet solution. At the end of the Frontiers program, the applet solution was not functional.

The student instructor initially led the Frontiers students through a crash-course in command-line Oracle operation. After familiarizing themselves with this program operation, the students, on suggestion from the project instructor, drew up a simple requirements document for their solution. The project group finished a first solution (command line Java interface, as above) after about two and a half lab sessions.

Seeing their solution was satisfactory, but could do well with some improvement, the group members took it upon themselves to code a Swing applet that would mimic the command-line's functionality, but ease the user-load. The group worked on this solution for the remaining two lab sessions, but was unable to resolve persistent compile errors.

There were no blatant expressions of antisocialism or negative group friction throughout the project group's efforts.

Once the learning and planning phases ended, and the coding began, it was clear that Student 13 would be unable to contribute as much as either Student 5 or Student 1. Student 13 asked questions regarding some of the things he did not understand, and Student 1 and Student 5 did their best to explain their actions to him. However, the assistance provided was not enough to put Student 13 on the same level. This became a rather established pattern when Student 1 and Student 5 started the Swing applet, and Student 13 became somewhat disinterested with "boring details [of syntax.]"

There seemed an uncommon leadership role shift during the group's efforts. Initially, when the group was learning new material (Oracle command-line and how Java code interacted with it) Student 1 and Student 5 roughly shared the leadership role. However, when the "learning new material" phase was complete for Student 1, he

successfully took charge of the group's efforts, delegating some responsibility and deciding the course of the rest of the solution. The same phase for Student 5's did not last much longer than Student 1's, perhaps two to three hours of lab-time at most, but apparently that was long enough.

The project group required little guidance once they began coding their solution. The two main points of assistance provided by the project instructor were the Oracle command-line tutorial and the suggestion of writing a requirements document to guide the students' efforts. Once these two tasks were completed, the only assistance the students required was short periods (no more than five to ten minutes' worth) of syntax assistance.

### **6.1.2 – Database Group Analysis**

Given a strictly Java-oriented problem of similar complexity with the Oracle front-end, the students would have presumably made more progress than they did. This is due, in large part, to the students having to learn both basic Oracle command-line syntax and how to use the JDBC library before being able to “just code” a Java program. With this extra work at hand, it is not surprising that the students failed to complete a functioning applet. However, their quick mastery of both command-line Oracle and use of the JDBC library merits more than just satisfactory credit. Additionally, the critique of the group's progress should be tempered with the fact that the project was never meant to be finished fully by a Frontiers group in the time allotted.

One explanation of the group's dynamic is quite simple: throughout the project, the value line rating for the group, from most to least skilled, was Student 1, Student 5, Student 13. It should also be noted that, at the beginning of the project, Student 5's abilities were closer to Student 13's, while Student 1 was much more skilled than either of his partners. However, at the project's conclusion Student 5's abilities were closer to Student 1's, as subjectively evaluated by the project advisors.

At the project's beginning, no members of the group knew anything about Oracle, knew how to use the JDBC library, nor had any of them formally studied the principles of software engineering. As such, one might say the value-line disparities were negligible.

However, the student instructor noted that while each of the group members had some difficulty learning the new material, Student 5 and Student 1 digested and understood this material faster than Student 13. This is almost certainly due to their having significantly more programming experience than Student 13.

Once the group started formally coding their Java command-line solution the group-member ability discrepancies became quite apparent. Having made little headway into the JavaBOTL modules, Student 13 was in unfamiliar syntactic territory. Both Student 1 and Student 5 though had completed all the Java modules. Hence, Student 1 and Student 5 had a strong advantage just in being able to “get around” the Java code, their choice compiler, and its returned errors.

Students 5 and 1 also held the advantage that, since they were both more comfortable with Java, they would experiment with new techniques to fix problems or improve their solution. This same enthusiasm was not shared by Student 13, who busied himself by trying to track down basic solutions to problems on Sun’s Java development website.

Student 13’s interest was briefly piqued when Student 5 and Student 1 finished the Java command-line program solution. As is usual when finishing a sizable programming project, much stress testing, marveling at the solution, etc. ensued. When this excitement wore off and Student 1 and Student 5 began looking ahead to a Swing applet, Student 13’s interest again waned. When Student 5 and Student 1 finally did start coding the applet, Student 13 became almost completely disinterested; he mostly busied himself with talking to friends over AOL Instant Messenger.

The largest problem for the group was Student 13’s skill level lagging behind those of Student 1 and Student 5. The group members attempted to address this issue rather valiantly, with Student 13 asking questions and Students 1 and 5 giving helpful and insightful answers. However, the disparity between the skill levels was too great for them to resolve. As such, Student 13 was unable to contribute significantly to the Java command line and Swing applet phases of the project. His interest in the project waned until the group members began speaking about and rehearsing for the short project presentation they were to give in the last hour of the last Frontiers lab session. Given a

role he could finally dig in to, Student 13 became more animated and interested in the problem.

Explaining the shift in group member abilities, that is, from Student 1 being farther ahead than either Student 5 or Student 13, to the Student 1-Student 5 ability cluster more advanced than Student 13, is rather simple. Almost without exception, anything that Student 5 did not understand, Student 13 understood less.

Providing Student 1 knew the answer to what was vexing Student 5 and Student 13, Student 1 would explain the answer to his partners. Inevitably, Student 5 would learn it earlier and more thoroughly than Student 13.

With this in mind, there is little wonder why Student 5 learned so much. Since there was such a great disparity between Student 1 and Student 13, Student 1 had to explain almost everything regarding Oracle and Java to Student 13. In these situations, Student 5 got an almost “free ride.” If Student 5 knew what Student 1 was explaining to Student 13, he helped. If he did not know, he would apply his very sharp learning skills to the explanation, learning it before Student 13 on every occasion.

Student 1 was somewhat held back by his group members, in terms of what he might have learned. Having to explain things he already understood to his partners, Student 1 spent time teaching “old material” instead of “tinkering with and learning” new material. However, since teaching a subject is probably the best way to learn it, Student 1’s learning areas centered around things he knew, or at least thought he knew. He walked away from the project with a far stronger understanding of Java than he initially had.

To some degree, Student 13 capitalized on being in the same group as two students whose skills were significantly more developed than his own. His many questions asked were answered; Student 1 and Student 5 went out of their way to explain things to him when he looked puzzled. However, this was not exceptionally useful, since he lacked the logical background and programming experience that his partners had. If he had even the beginnings of such a background, he could very well have outdistanced both of his partners in terms of “how much he learned throughout the project.”



### 6.2.1 – Graphics Group Results

As one of the most popular groups in project selection, we expected the chosen students to be highly motivated in completing the graphics project. Unfortunately, just the opposite occurred, as the students displayed very little excitement towards the project. The selected group consisted of Students 2, 6, and 10. Student 2 was ranked highest, followed by Student 6, and then Student 10. Both Students 10 and 6 knew that Student 2 was very intelligent, and at first they looked to Student 2 for direction. Regrettably, Student 2 was very antisocial at the start of the project, and as a result the group was very disjointed. Student 6 was repeatedly overheard urging the two other group members to offer their ideas and input.

Student 6 was not happy when he learned that the graphics library they would be using did not do everything for them. He expected the library to provide methods for drawing lines, circles, and other primitives; yet the project was designed to teach them how to build those methods themselves.

After learning of the projects true nature, Student 6 convinced the other two group members that they should switch to the encryption project. The group advisor told them that they could not switch outright; however if they completed the graphics project, they could then move on to the encryption project.

At first the group had very little direction and it seemed that they did not really want to work together. The group's advisor pushed them to come up with a plan, but wanted them to figure things out on their own. During the group's first morning session together, they mostly just sat and stared at their computer monitors, not doing any work.

Eventually Student 10 decided to show his leadership skills, as he took over the group and came up with a plan of action. The others eagerly followed him, yet still gave their own input. At this point the group was working together fairly well, and the project was underway. Student 10 crafted an algorithm to draw lines, seemingly from his own mind, even though links had been provided on the well-documented Bresenham algorithm. Explaining the algorithm to the other students convinced them that it was feasible and they set off on writing the code for it.

They started by handling cases for both vertical and horizontal lines and then tested their code to make sure it worked. It did, and then they set out to handle diagonal lines at arbitrary angles. Their basic concepts were fine, but they failed to handle a few cases that they didn't expect, having to do primarily with the ordering of the input points and whether the line is increasing or decreasing on a particular axis. After troubleshooting it for a while, they decided to read the provided links in an attempt to find their error. In the end they decided to scrap their idea and work entirely with the Bresenham algorithm, which they successfully coded.

Once their line-drawing code was written and they had a firm grasp of the low-level graphics concepts, they decided to work on their new goal, which ended up being a picture of a house. They primarily worked with one student at the keyboard while the others voiced their ideas about what should be done next. The keyboardist would then add the code to draw the particular suggested feature. Disappointingly, towards the end Student 2 became bored with the project. In the final days Student 2 could be seen listening to music with headphones and playing Flash games while the other two were working on completing the project.

In the end, the students completed the project. They wrote code to draw lines, and using their understanding of bitmapped graphics they were able to create a drawing of a house. They wanted to add animation, but they had run out of time.

### **6.2.2 – Graphics Group Analysis**

It would seem that, despite our repeated urging, the students did not clearly read through the project description, and expected something else from the graphics project. The students' disappointment with the project seemed to stem mostly from its open-endedness, as they were free to build anything they wanted. The project's focus was, perhaps mistakenly, on teaching very low-level graphics concepts that the students seemed to have little interest in. Towards the end of the project, it seemed that Student 2 lost interest, presumably because her skills, as one of the smarter students in the class, were not needed in the final stages.

Despite these problems, the success of the project should be judged by how much the students learned. Both Student 6 and 10 worked well together, and probably got the most out of the project. Out of the three, Student 10 seemed to learn the most, and was the most enthusiastic member of the group. Student 10's leadership skills are most likely the reason he was not left behind.

Student 2, on the other hand, probably learned the least. She was the least enthusiastic of the group and probably felt that the project's difficulty level (fairly easy) was beneath her. Also, it was clear that Student 2 did not like dealing with people and perhaps resented the fact that she was being forced to work in a group. Perhaps the most valuable lesson for Student 2 was that working in groups is not easy. Student 2 could have easily learned all other topics covered by the project on her own time, alone.

Student 6 lies somewhere between 2 and 10, concerning how much they learned. He showed a distinct lack of enthusiasm for the project once he learned its true details. Due to his opinion of the project, he didn't make a real effort to learn, and merely tried to get the work done so he could move on, hoping to eventually tackle the encryption project. Fortunately, in order to get the work done, he had to at least learn something about graphics, and came out of the project with more than he had coming in.

While the graphics group's students all learned something, it was mostly unrelated to the grouping methodology. Due to Student 2's antisocial attitude, the other two group members did not learn very much from her. Student 10, while being the lowest ranked student in the group, managed to almost *force* Student 6 and himself to learn, by taking control of the project's direction. It would seem that having the least technically skilled group member leading the others was beneficial to the group as a whole. If nothing else, Student 10's leadership solved the all-too-common problem of the most technically proficient group member doing all the work.

### **6.3.1 – Networks Group Results**

Student 3 and Student 9 were the members of this small group. Student 3 was high on the value line and Student 9 was considered medium. They made very quick progress on their assignment, having coded their client within the morning session in

which they started the project. This was primarily due to the examples to which they had been directed in the assignment. The work required to make the client was minimal, so they were quickly able to finish it and connect to the server (constructed already by the project advisor). However, they ran into difficulty when confronted with stream I/O in Java. Making the client's stream handlers work with those of the server presented them with two major obstacles: they had to sequence their messages with the server properly, and they had to figure out how messages were exchanged based on how Java handlers functioned.

The first task proved simple; they were already instructed as to how the client and server were to communicate, and they quickly applied this to their code. The second task, however, sent them staring at their screens, searching for information that would aid in accomplishing this goal. They did this for a very long time, and without requesting any help from their project advisor. Eventually, however, their advisor went to them and pointed them in the right direction. This led to successful communication with the server, and the completion of the first part of their assignment.

Their next goal was to modify the server so that it would be able to handle multiple clients. Again, they spent a great deal of time looking through the Java language docs for the specifics in handling threads. They ran out of time to implement it completely, but they managed to get into the first stages of debugging their code. At this point, however, they did not seem to be working together very effectively. Student 3 had surpassed Student 9 in progress and, it seems, motivation. The remainder of their time was consequently spent on studying the Java docs independently. Student 3 was working alone on coding the server extension by then, but Student 9 did seem to be able to follow Student 3's progress, if only as an observer.

### **6.3.2 – Networks Group Analysis**

Student 9 indicated on his survey that the project was only "somewhat interesting" whereas Student 3 thought the project to be "very interesting." This could be part of the reason Student 9 did not offer very many contributions to solving their problems. He was also evidently behind Student 3 in ability, as indicated when Student 9 listed his inability

to “contribute a lot due to [a] lack of programming skill” as his least favorite part of working in a group. Student 9 also took the major role in preparing a website for the project presentation, as a way of staying useful in the wake of Student 3’s coding ability. However, Student 9 also believed that the variation in skill level between himself and Student 3 was “just right.” A possible reason for this seeming contradiction is that Student 9 considered, specifically, his programming experience to be his only fault. In all other areas, he understood the principles behind the project very well.

It seems obvious that they both rated the project as “very difficult” primarily because of the nature of their obstacles. They ran into the type of problem that does not immediately present a clear path to a solution. When faced with the task of choosing the proper I/O classes and implementing their handlers, they could not see the code for the server, and though they were told which handlers had been chosen for the server, they were not easily able to piece together their own code based on this knowledge. This is primarily due to their lack of experience in Java.

#### **6.4.1 – Software Engineering Group Results**

This group consisted of Student 4, Student 7, and Student 12. On the value line, they were a high, a medium, and a low, respectively. Their assignment was unique in contrast with the others because it involved a design phase that had to take place before any programming could be done. They handled this reasonably well. The first part of the assignment called for the construction of a diagram that would illustrate the ways in which their objects interact in order to solve a problem. They were able to produce an initial draft of this artifact by the end of their first (morning) session. The final version of this artifact was completed in the afternoon of the same day, and they managed to produce a diagram that represented their objects as Java classes by the end of their first afternoon session. Though their advisor anticipated a longer design phase, they had already finished it.

The implementation phase, however, proved to be a great deal more difficult for the group. In this phase, they had to produce Java code from scratch. They had determined the data members and methods for each of their objects, and it was time to

write the code for them. They divided the work by class; essentially, they each decided to choose a class and do the work on their own. It became apparent at this point that Student 12's lack of experience in Java, combined with his lack of progress in the modules, was going to prevent him from making major contributions to the project's code. He required a great deal of assistance in producing a data-only class, having never seen any Java before the assignment. Student 4 and Student 7 plodded along at a satisfactory pace, each writing code for their classes. Student 12, without the ability to contribute to the code, instead constructed web pages that they would use in their final presentation. Working without a third coder, Student 4 and Student 7 were still able to get all but two of their classes finished. In the end, however, they simply ran out of time. They had coded most of their objects, but did not progress far enough that they could see their program run.

#### **6.4.2 – Software Engineering Group Analysis**

Student 4 generally seemed to take charge of the group, but was not overbearing in discussions. He was an effective leader, and all three members of the group worked very closely during the first phase of the assignment. They were taken to a conference room with a whiteboard, where they were left with the task of producing their design artifacts. They produced these artifacts by the end of the first day of project work because they were so effectively able to communicate ideas. There was always someone writing on the board when their advisor checked on them, with the other two always actively participating in the design process. They seemed to step up to the board when their ideas were best expressed visually, and were quick to come to a consensus on every issue that arose.

However, once the time for coding came to pass, Student 12 was essentially alienated from the other two members of the group, evidently because he did not yet understand Java. He had begun with Robot1 and never moved on to Javabot1. We, the instructors, all agreed that this was mainly due to Student 12's tendency to over-examine the curriculum, insisting on knowing every detail about his topic before moving on. This tendency was the primary reason for his slow progress in the modules, and ultimately

hampered his ability to work with Student 7 and Student 4 on the Java code for their assignment. Student 7 and Student 4 had each worked with Javabot1 and Java; Student 4 had even completed the Java modules. Student 7 and Student 4, from then on, tended to collaborate on making their sections of code work well together, and Student 12 chose to abandon learning Java in favor of preparing the web page for the group's final presentation. On his survey, Student 12 indicated that he thought the group's skill diversity to be too varied because he "had much less skill than the others," but admitted that without this level of variety, he would not have been able to learn as much. So while the difficulty of the programming phase was somewhat divisive, the group otherwise worked very well together throughout the design phase.

One aspect of the project that Student 7 and Student 4 both seemed to enjoy greatly was the concept of building different pieces of a large entity, and making them work together to perform the task at hand. They both mentioned this as their favorite part of the project, and were excited when they saw their objects interacting as they had planned. This aspect of software engineering therefore seems to provide additional motivation to a project, and boosts the students' interest in the process. In fact, all three members of the group recommended that future projects have this property.

### **6.5.1 – XML Parser Group Results**

Group XML consisted of a middle skill student, Student 8, and a low skill student, Student 11. Both students chose the XML project as their first choice.

In order to complete the task, the low skill student was assigned to complete the GUI portions of the program, which required lots of repetitive work and had immediately tangible results. The middle skill student, being very interested in the actual XML material, worked on the back end. This student, though unable to complete all the tasks assigned to him/her due to lack of Java experience, conducted a search for some publicly available XML utilities to complete part of the project. Integrating the GUI with the back end proved to be beyond the student's abilities, however, so the advisor integrated some of the features, leaving others for the students to complete. Given this new sample source, the students were able to integrate the remaining components with ease.

The lack of a high skill student in the group required the advisor to spend a large amount of time with the group (more so than any other group) in order to provide guidance. The advisor also provided large portions of code midstream to the team due to the inability of the students to progress rapidly on their own. Both students reported that they enjoyed working in groups and thought their group worked well together, despite observations to the contrary. Student 11 also felt that there was too much skill disparity within the group despite the fact that this group had the students that were closest in skill according to the value line.

Despite these problems, the group managed to get a functional program working by the end of the time allotted that satisfied 4 of the 5 requirements. They were unable to delete a record from the list, but were able to complete all the other basic requirements. They also made significant progress on a search function but it was limited to searching by one specific key instead of by any key as was specified in the project description.

Due to the difficulty of the work, the students became frustrated and combative with one another. The advisor was forced to fill the role of the high skill student, but could not act freely, leading to a lack of progress. The students seemed to feel overwhelmed at the sheer size of the project and would sit idle if not directed. Neither student took on a leadership roll, so the advisor was forced to fill that roll. The students also looked to the advisor to divide the work. Finally, Student 11 had difficulty motivating him/herself to learn and had to be told what to do and how to do it in detail for each individual task and sub task.

### **6.5.2 – XML Parser Group Analysis**

The challenge of the project combined with the lack of a high skill student caused great difficulty to the project team. The resulting frustration led to arguments between the group members and left them feeling overwhelmed. It is especially telling to observe the responses of the students when asked about their least favorite parts of group work. They both disliked the smallness of their group and made comments about friction between themselves. It should be noted here that Student 11's comments appear to be as



minimal as possible and should possibly be disregarded, as they most likely do not give an accurate representation of his/her viewpoints.

The sniping between members could have been alleviated by several factors. Primarily, the project could have been designed with the possibility of a lower skill group working on it. Both students ranked the project as "Very Difficult" and it was very obvious after a few hours that they could not handle the work required. The extensions that were written into the project could have easily filled a week worth of work for an advanced group. Providing more source code at the onset may have helped this lower-skilled group work more efficiently on the project. Providing multiple possible divisions of labor in the project descriptions may give the students a better idea of how to work together. Finally, more examples of possible solutions should have been provided instead of relying on the student to read the online Java documentation and figure it out.

## **7 - Conclusion**

This section includes both an ending summary of the work, as well as methods for improving subsequent years' Frontiers programs.

### **7.1 - Summary**

Overall, this year's program was an enriching experience for everyone involved, and a definite success. In implementing the procedures and protocols for teaching and project development as outlined in our methodology, we were able to watch our students move remarkably quickly and smoothly through their studies. In fact, they greatly surpassed our expectations coming into the program and demonstrated that project work, properly incorporated into group activity, produced a higher quality of education regardless of the individual abilities of any given student.

Our process of placing the students into a value line and developing groups using collaborative learning principles and proven grouping guidelines was crucial to the success of this year's program. The learning experience was greatly enhanced by the other members of every student's group, and each student conveyed positive responses on the value of working together.

Developing our projects using the same collaborative learning principles in addition to concepts in problem-based learning brought an exceptional level of motivation and interest to the students that worked on them. The projects were designed to reflect the best qualities of real-world scenarios, and represented a wide range of topics. The students all believed this representative survey of their field enhanced their interest in computer science, and one student expressed a desire for his high school to offer programming classes as a result.

The feedback on students' surveys was very encouraging, and they showed a great deal of satisfaction with the program throughout the learning process. The instructors enjoyed the experience as well. We had an excellent group of motivated, talented students, and were able to learn a great deal about teaching, as well as creating an effective curriculum. We expect that the procedures and protocols executed by the

Frontiers/Strive 2001 staff will be useful to future Frontiers programs, and anticipate continued success in these endeavors to provide a higher quality of education to aspiring computer scientists.

## **7.2 – Future Work**

When asked on the final survey, students gave their thoughts on potential improvements to the projects. Improvements for next year could include tailoring projects to specific skill levels, including more detailed instructions, requiring more student-exploration to find the solutions, and giving the students more time to work on them.

The clearest available avenue to improving the Frontiers program lies in meticulous project design. An important goal for future groups will be fine-tuning the delicate balance of key project characteristics. Projects must contain specific tasks while maintaining enough open-endedness to allow students to investigate other related goals. Enough projects must be available to cater to all skill levels—or perhaps each project should accommodate all skill levels; providing a hierarchy of tasks to be completed, successively increasing in difficulty.

Special attention must be given to proven project design guidelines (see section 3.4.1) in order to design effective projects. The importance of capturing the students' interest simply cannot be overemphasized, as proven by the relative unpopularity of a few of this year's projects. Appealing to the students' curiosity can be a difficult task, considering that the set of topics that interest instructors and those that interest students may not intersect. Projects that received the most attention were those that centered around exciting terms such as “Networks”, or “Graphics,” while the relatively vague jumble solver project received little notice. It would certainly be worthwhile to do extensive research in order to determine the most appropriate project topics.

Finally, there was a feeling among both the students and instructors that there was too little time for the projects. Perhaps this was caused by the extremely open-ended nature of the projects, but it may have been caused, in part, by a large number of modules. The slowest students needed to complete nearly 20 modules before being able to

contribute effectively to the projects. Some students felt that the RoBOTL modules didn't aid in their project work, and it was certainly true that even after completing the advanced modules, the high-skill students had difficulty with some portions of the project work such as creating new classes, reading documentation, and integrating multiple classes. Changing some of the modules and more appropriate student placement might alleviate these issues.

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## **Appendix A: Frontiers Qualifying Projects**



# Introduction to Bitmapped Graphics: Drawing Lines

Project Advisor: John Baduini

## Overview

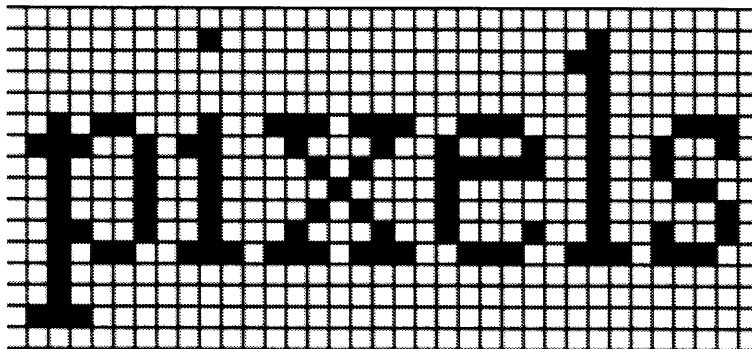
In this project you will learn about two-dimensional bitmapped graphics and how to write a program to draw lines.

## Background

The smallest building block in graphics is called the **pixel**, or picture element. A pixel is a small dot of a particular color. An image on the screen can be thought of as a grid of pixels, each with its own particular color. See figure 1, where some text has been magnified to show the individual pixels that make up the text.



**Figure 1: Text magnified to show individual pixels**



**Figure 2: Text magnified further, showing pixel grid**

Things to know about pixels:

### A pixel..

- ..refers to two pieces of information
  - A location on the screen (coordinates), and
  - A color (represented by a number)
- ..is a single point (a dot) on the screen.
- ..is the smallest detail that can be displayed (no details smaller than a single pixel can be represented by the display.)

## Bitmaps

Earlier we mentioned that a given pixel has two attributes: location, and color. If we wanted to store an image in memory (so that we could display it on screen), we could create a Pixel data-structure that contained the coordinates (x and y) and the color information. Then we could create a list of all the pixels in the image and draw them one at a time. The problem with this method is that typically images consist of thousands of pixels, and we are storing coordinates for every single one. This is certainly more memory than we need to use. Furthermore, if we need to get access to a particular pixel knowing only its coordinates, we would need to search the whole list to find the right one. No, this is not an effective method for storing a two-dimensional image made up of pixels.

This is where bitmaps step in. Bitmaps are a method for storing a rectangular image made up of pixels that solves both problems mentioned above. In figure 2, you can see the grid organization of the pixels. A rectangular array of pixels is known as a **bitmap**. Since the pixels are stored in an array, their coordinates can be inferred from their position (index) in the array. As you can see, it is not necessary to store coordinates, now only color must be stored.

## Coordinate System

If a bitmap is just a big array of pixels, we need some way of identifying each pixel with a set of coordinates. The bitmap's **coordinate system** will help us determine a mapping of two-dimensional (x, y) coordinates to an index in the array. Bitmaps typically have the origin (that is, coordinates (0,0)) at the upper-left corner of the bitmap. X increases going to the right, and Y increases going down. When you get to the pixel at the end of a row, the next pixel in the array wraps around to the beginning of the next row. See Figure 3 for a visual description of the coordinate system.

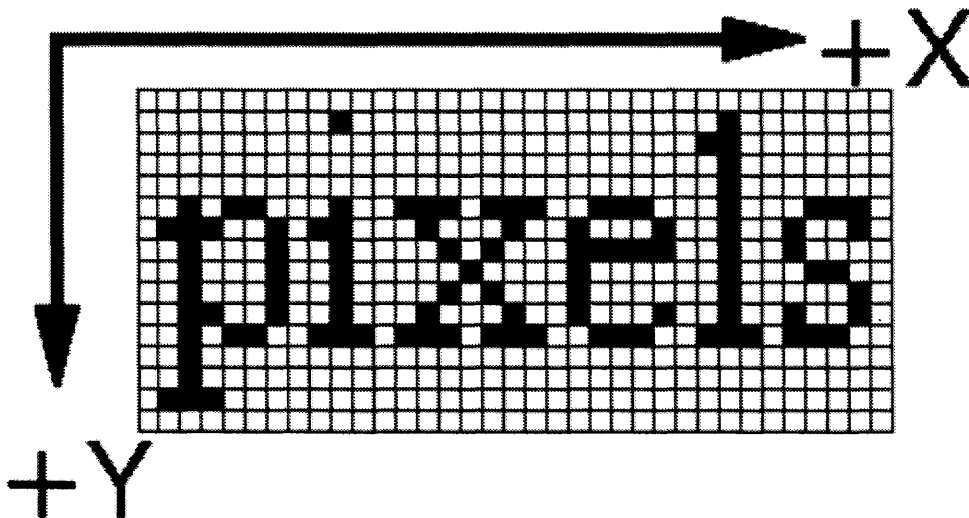


Figure 3: Coordinate System

If we know the width (in pixels) of the bitmap, we can find the index of any given (x, y) pair using the formula  $(y * \text{width}) + x$ . This allows us to address any pixel in the bitmap knowing its (x, y) coordinates.

## Color

As mentioned earlier, color is represented by a number, interpreted in a certain way. What the values in the bitmap mean depend on the bitmap's **surface format**. The surface format defines the **color space** and **bits-per-pixel** (bpp) for the bitmap. The bitmaps we are dealing with are all in the RGB color space, that is **Red, Green, Blue**. All colors can be made from combinations of red, green, and blue shades.

We still need one more piece of information to understand how pixels are stored, and that is the bits-per-pixel information. This determines how many colors can be displayed on the screen at once, and the format of a pixel. We will deal with 32-bit pixels set-up in an ARGB8888 format. This means that the pixel is stored in the following way:

First byte	Second byte	Third byte	Fourth byte
Alpha (8-bits) 0-255	Red (8-bits) 0-255	Green (8-bits) 0-255	Blue (8-bits) 0-255

For now, just ignore the Alpha component; we will just deal with the Red, Green, and Blue components. What this means is that each pixel is composed of 4-bytes, the first byte is the Alpha component (which we will ignore), the second byte is the Red component, third is Green, and fourth is Blue. So if you wanted the brightest blue shade possible, you would use the byte sequence (0,0,0,255) as your pixel value. Colors can also be mixed; for example, to obtain a bright purple color, you would use red and blue at their maximum intensity to get (0,255,0,255). Red and green make yellow, blue and green make cyan. Shades of gray are made up of equal portions of red, green and blue. White is made with the maximum intensity of red, green, and blue (0, 255, 255, 255). To learn more about color, please go [here](#) to read about the RGB color cube and see the demo applet.

## Drawing Lines

Lines are a very useful drawing primitive. Almost all graphics software uses lines in some way. In CAD (Computer Aided Drafting) applications, wireframe models are drawn with lines. Many other shapes can also be made using lines, so it is important to understand how lines are drawn.

## Goals

After you have completed this project, you will understand two-dimensional bitmapped graphics. You will also understand a common line-drawing algorithm (Bresenham's algorithm) and you will provide an implementation.

Bresenham's line drawing algorithm is discussed in depth on the following pages:

- [Bresenham's Line and Circle Algorithms](#)
- [Line drawing algorithms](#)
- [On-Line Computer Graphics Notes](#)

You will write a Line class that has a public Draw() method. The line will be stored as two points (x1, y1), (x2, y2) represented by ints, and a color, represented by an int. Your Draw() method should accept 4 parameters and use the following prototype:

```
void Draw(int bitmap[], int width, int height, int color);
```

```
bitmap[]           - The bitmap array.
width, height      - The dimensions of the bitmap.
color              - The color to draw the line.
```

## Requirements

You will be using a slightly modified version of the [TinyPTC](#) frame buffer library for Java applets. This is a very simple and basic library that allows you to draw to your applet's window. TinyPTC allows you to maintain your own bitmap representing the screen. With a single function call (update()) you can copy this bitmap to your applet's display window. Download the TinyPTC class file [here](#).

Once you have completed your Line class, write an applet that uses it. You can do anything you want; draw a stick figure made of lines, for example. Be creative! Can you figure out how to achieve animation? Make something cool!

## Getting Started

First you should play around with the [sample program](#) to familiarize yourself with drawing to the screen. Once you feel comfortable with how it works, move on to writing your line drawing code. Remember, I will be around for assistance if you need any, so don't hesitate to ask!

# Dictionary-based Jumble Solver

Project Advisor: John Baduini

## Overview

In this project you will design and build a jumble solver using a word dictionary. Jumbles are a collection of letters that, when properly rearranged, will form an English word (or possibly several). Here are some examples of jumbles and their solutions:

- "drwo" → "word"
- "ecrav" → "carve" or "crave"
- "oacduetni" → "education"

## Goals

Building a jumble solver is a simple, yet potentially deep problem. In its simplest form, the completed project will solve jumbles. However, adding additional constraints may require several different approaches. What if your solver is not fast enough? You will learn about algorithm design and complexity, and finding performance bottlenecks.

Are there any other areas where character-based string matching is applicable? It turns out there is. Anagrams are words (or phrases) formed by rearranging letters of other words (or phrases), and can be viewed as a generalization of jumbles. The solving of crossword puzzles can also benefit from these techniques.

## Requirements

Your program will be invoked with a jumble as a command line parameter. Output of matches should be one per line. Your program must find all possible word matches. If no matches are found, an appropriate message should be displayed. At the completion of the program, the running time of the search should be displayed. This will serve as a benchmark to compare your improvements.

## Getting Started

Download the (large!) [dictionary file](#), which is formatted with one word per line. We recommend first building what is called a naïve jumble solver. The naïve jumble solver will serve as a platform for further work and improvements. The basic idea for the naïve solver is to search through every word in the dictionary and examine if our jumble can be rearranged into that particular word. If so, then that word is reported as a match, and we move on to the next word. The program completes when it has checked every word in the dictionary. Note that in order to find all possible matches, the whole dictionary must be searched.

## Helpful Java Classes

Here are some Java classes that you will find useful for this project. The Java 2 SDK Documentation can be found [here](#).

Reading the dictionary:

- [java.io.File](#)
- [java.io.FileReader](#)
- [java.io.StreamTokenizer](#)

Helpful functions that operate on arrays:

- [java.util.Arrays](#)

Measuring how long the search takes:

- [java.util.Date](#)

Reformatting the dictionary file:

- [java.io.RandomAccessFile](#)

## Algorithm

So how do you determine if our jumble can be rearranged into a particular dictionary word? There are many ways this can be done, and it's your job to find one and try it. Spend some time thinking about potential solutions, because there are both good and bad ways to do this. The worst way will be very slow, and there may be some neat (although potentially tricky) ways to solve this problem that result in a nice speedup. If you need any assistance do not hesitate to ask for hints. We want you to come up with your own answer, but a push in the right direction will be given if you desire. Hint: To determine if there is any permutation of a jumble that equals a given word, it is enough to show that the jumble contains exactly the same letters as the word.

## Speed Improvements

After completing the naïve solver, it is time to improve it. The first thing you will want to do is improve the speed, as you will find that the naïve algorithm will perform relatively poorly (especially for a large dictionary). Again, there are many ways to do this, and it is your choice. Without giving away any answers, here are some things you may wish to think about:

- Algorithmic optimizations have the potential to give you much higher speed increases than lower-level optimization (e.g. moving unnecessary work outside of a loop), but may also require rewriting a large portion of your solver. Think about what variables impact the running time of the algorithm. Does word size affect runtime? What about dictionary size?
- Profiling is a technique for identifying the bottlenecks of your program. Bottlenecks are the limiting factors of your program, the sections of code that take the most time to execute. When you have identified the bottlenecks, you know what needs to be improved. Bottlenecks should be the first part of your program you try to speed up. If you need help identifying bottlenecks, please ask.
- Hint and potential spoiler: When profiling the naïve solver, you will probably identify two bottlenecks, 1) disk IO, and 2) your routine that determines if a jumble can be rearranged into a dictionary word. You are allowed to change the dictionary file format if you wish. You may write a program that converts it to the format of your choice.

## Functional Enhancements

Speed improvements are not the only thing of interest; so if that bores you, worry not. This section deals with functional improvements. The naïve jumble solver can be adapted into something that also solves partial crossword puzzle words. You will specify missing letters with a question mark ('?') character. For example, your input to the program may be "comp??er" and the solver will return "computer".

Other possible extensions include adding support to build anagrams from phrases. This can go several ways; supporting phrases in both input and output (phrases are converted into other phrases), supporting phrase input and single-word output, or supporting single-word input and phrase output. This is potentially difficult.

# Writing a Network Client

Project Advisor: Dave LaPointe

## Introduction

This project will introduce you to the concepts behind one of the biggest industries in the country: networking. The scheme behind networks is that a number of computers are able to communicate using a standardized protocol, which is essentially a language they have all previously agreed to understand. In the case of the Internet, this protocol is known as IP (Internet protocol). You will be working with the basic structures and methods that dictate the way networks work by sending and receiving messages, using IP, over the WPI network.

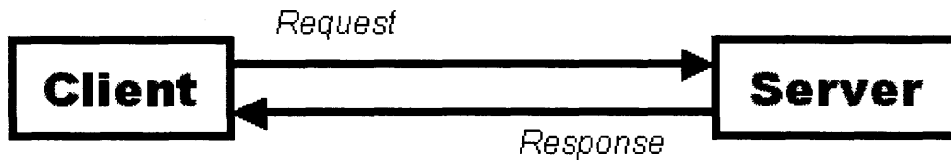
## Goals

Supplied with a framework of a client/server model, you will write the code needed to allow your client to connect to a server, exchange a few messages, and learn a few things about how the Internet functions in the process. In addition, you'll see the differences between TCP (Transmission Control Protocol) and UDP (User Datagram Protocol), the two major protocols that sit on top of IP. TCP and UDP provide the services that enable you to view web pages, stream video and audio from across the world, and chat or play games over the Internet.

## Network Concepts

- **Sockets** - Try to think of a socket as one end of a wire running from your piece of software to someone else's. All of a program's communication over a network is delivered through a socket, and arrives at another program's socket. This system was designed around the client/server model, in which client applications connect to a remote server in order to request services, which are then provided by the server. Sounds simple, right? Well, the socket system was also designed to hide underlying network details. If you want an idea of how complex these details are, the specification for the IP protocol suite, printed onto 8 ½ X 11 inch paper, piles into a stack about three feet high!
- **Packets** - These are data structures (information), plain and simple. When one of our protocols sends information, it first breaks this information into packets, which are reassembled on the other side of the transmission. Packets are useful because if one is lost in transmission (say a lightning bolt hits the line it's on), the machine that sent it does not have to resend the entire transmission, just the lost packet.
- **Client/Server model** - Using sockets, one machine acts as a server, and the other acts as a client. The client connects to the server, requests services, and the server

responds accordingly. You will find that, after programming the client, the rationale behind having these roles becomes rather clear, and that there are a myriad of applications for this model. For example, your web browser is a client. Telnet is a client. Ever heard of Napster? The part that you download is also a client.



- **TCP and UDP** - TCP provides connection-oriented, reliable data transmission. This simply means that the protocol guarantees that information sent is delivered intact. It also ensures that the packets are delivered in the proper order, and that they are sent only as quickly as the network can handle (flow control). UDP, on the other hand, does not do any of this. Packets are simply fired off, and if they don't make it to their destination, too bad. So why does it even exist? Without the overhead needed to provide the services of TCP, UDP transmissions are generally much faster. In addition, there are circumstances where connection-oriented, reliable service is a bad thing. For example, think about a video stream (an online movie, for example) traveling to your machine. If a packet (containing a few frames of video) is lost, do you want to have to wait for that packet to be resent before you can continue watching (thus causing the movie to pause), or would it be better to ignore that packet and keep the stream going? In cases like these, UDP is the preferred protocol. Your client, however, will find reliable delivery necessary, so it will use TCP.

## Server Services

Now that you have a general idea of what the structure of this client/server thing is, you may wonder what kind of server your client will be talking to. The server will have a number of services that you may choose through simple text message exchanges. This makes the overall goal of your client pretty concrete. It must be able to receive and transmit text. Once your client has formed a connection to the server (remember, TCP is connection-oriented, not UDP), it will receive some text from the server, accept input from the keyboard, transmit your input to the server, and repeat. When you break a problem into steps like these, the problem becomes simpler. Remember that, it's a big part of this area of study.

**Ending a session:** Your client knows that it needs only pass Strings between the server and the client's user. However, it does not know when the conversation is over, so we're going to tell it. When the user has finished interacting with the server, he/she will say so, and the server will respond with the phrase "See you later". When your client encounters this phrase (coming from the server), it sends it to the user, closes the connection, and exits.



## Procedure

Pop open the source files for your client and you'll find that part of the code has already been written (you're welcome). The places that need work are clearly described in the code itself. If you need a hint or two, you might want to try a few of the references below, or simply ask (yell for Dave, I'll be around). Once your client is working, you can find cool things to add onto it by using it to talk to my server! The steps involved in creating any client are simple. While you're working, try to identify these steps in your own code (it should be pretty easy). These steps apply specifically to clients written in Java, but the overall idea remains the same in other languages.

1. Open a socket.
2. Create handlers for writing to and reading from the socket. In Java, these are input and output stream objects that are assigned to this job.
3. Write to and read from the socket using the handlers (stream objects) according to rules set by the server. A client must know what kind of server it is dealing with beforehand, so they can communicate properly. For example, an HTTP client knows how to structure requests for web material in a format the HTTP server understands. Similarly, the client can interpret the server's responses because it was programmed specifically for dealing with them. The same idea applies here, but with a much simpler protocol. Your client will transmit and receive text to and from the server, in that order, until the server ends the conversation (see "Ending a Session" above).
4. Once the communication is done, clean up. First, close the socket handlers.
5. Finally, close the socket.

## References

Java 1.3 API Specification - This is the API (Application Programming Interface) document that describes all of the classes included in the official Java 1.3 language specification. For help in finding useful classes and methods for your own projects, look here first. Hint: you will probably find Java.net and Java.io handy for this project.

Java Tutorials | Custom Networking - A little tutorial on sockets, including code examples. You should definitely look at "What Is a Socket?" first.

Java Tutorials | Getting Started | The Main method - This section of the javadocs explains the "main" function. Read this if you are interested in knowing more about its purpose, and a few related details.

# Object-Oriented Design

Advisor: Dave LaPointe

## Introduction

In this project, you will learn the fundamentals of software engineering by designing and implementing the objects (see below) of a simple card game applet. You may be surprised at the myriad of ways in which this kind of problem can be approached, and you certainly may find that some are easier to understand than others. The important concept in this project is that you will grow to understand the rationale behind object-oriented design.

## Design Concepts

Object-oriented design applies to a process known simply in the world of software engineering as the design stage of the software development cycle. The whole cycle includes phases where you define your problem's core requirements, analyze and gather data, design your program, implement your program, possibly integrate your work into something else, and then maintain the whole thing with software fixes and updates. This, however, is a very long process, so we will concentrate on the design phase. But first, there are a few terms with which you must be acquainted.

**Objects** - These are the pieces of your program that interact and perform various tasks required to run the game. With object oriented programming, the key is that every job performed in the program is performed by an object. The decisions regarding what the objects are, as well as what kinds of information they will maintain, are up to you. As an example of what objects do, think of the parts of a car. The battery provides power, the engine turns the drive shaft, the transmission changes gears, the axels hold the wheels, the steering column steers, the fuel injector gives gas to the engine, etc... Each of these parts of the car must work together for the car, itself, to function normally. The same idea applies with objects.

**Responsibilities** - This applet will contain a number of little tasks to be performed by its object parts. In order for your applet to function correctly, you will have to determine what constitutes a task, and which objects are responsible for each task. Thus, objects have responsibilities, and these responsibilities should be assigned to an appropriate object. In our car example, responsibilities would include turning the car, starting the engine, giving gas to the engine, giving the driver something to sit on, providing the driver with controls (interacting with the driver), cooling the engine, etc...

**Associations** - Associations dictate the information objects communicate. Typical associations are simply a statement of how two objects interact. For example, a fuel injector object would give gas to the engine object, thus forming an association. This particular association would be represented in a simplified Static Structure Diagram (explained later).

## Goals

Here is the actual problem for which you are going to design a piece of software. Look carefully at the following paragraph, and pay particular attention to words that sound like candidates for objects.

**Problem Statement** In this game of blackjack, the player places a bet, and is then dealt two cards, both facing up (the values of both are visible). The dealer is also dealt two cards, one face up and one facing down (the player does not know the value of the face down card). The goal of the game is to have a combined card value higher than that of the dealer, using the cards in the player's hand. If the total value exceeds 21, then the player has busted, and loses his or her bet. The player may request additional cards (hit) until he or she is satisfied with their combined value or the hand has busted. The dealer, however, must play by consistent rules. If the dealer's hand is less than 17, it must hit until it reaches 17 or higher. If the player's hand is higher than the dealer's, the player wins twice his or her bet. Otherwise, the player loses the bet. Cards are valued by number, except face cards, which are worth 10, and aces, which can be worth 1 or 11. Additional rules will be ignored for the express purpose of the time limit on this project, but may be implemented at a later time.

**Creating Your Objects** Look at the problem statement, the rules of the game, and underline all nouns. From these words, you will form your objects. Not every noun deserves to be an object, but a general rule to follow is that if you are not sure whether you can intuitively make a particular noun an object, do it, and you will see whether or not it works later. If this process is not entirely clear as to its purpose, do not hesitate to ask for help.

**Interaction Diagrams** In order to illustrate the way your objects interact, you will create an interaction diagram (a.k.a Static Structure Diagram), which clearly shows your objects, the objects' responsibilities, and associations between objects. The diagram is simple to construct; once you've reached this part of the document, call me over (Dave) and we'll run through an example.

**Creating Your Diagram** The Unified Modeling Language (UML) defines a number of artifacts (visual structures) to illustrate your objects' associations and responsibilities. There are a number of rules to follow in the process of creating these artifacts, but we're going to slim the process down to better deal with time constraints. The rules are then simple. For each object, draw a box, and put the name of the object at the top.

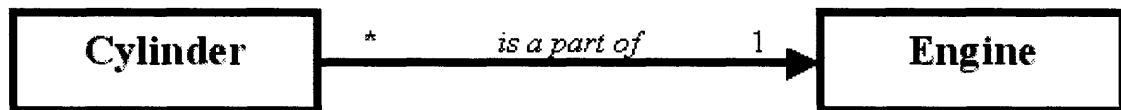


Next, for each association you've determined, draw a line between the associated objects and label it.



These associations generally read from left to right and top-down (it's an unspoken UML rule), but you may add arrows to indicate the direction of the association (from the affector to the affected). Arrows are also necessary when you simply don't have room to arrange them otherwise. Once you've drawn all of your associations, call me (Dave) over to discuss your design decisions. Do not proceed further until I've seen your model.

From here, you'll be adding simple ratios to your associations. The diagram above is a one to one ratio, as there is only one ignition per engine. However, there are a number of cylinders in an engine, and this number is not the same for every engine. Therefore, this ratio is one to many. "Many" is denoted by an asterisk.



Now take a look at your diagram, and try to picture your objects as classes in Java. What will be their methods and data structures? This is the part of the process in which we figure that out, and design begins to meet implementatino. Determine the data your objects must maintain in order to serve their respective purposes, and lay them out for each object. In addition, determine the methods that can be called on these objects in order to use them. This is a part of the project in which you should work closely with an advisor (like me, Dave).

## Extending the Game

This is a basic addendum to your work. Add some of the rules we have, until now, ignored for simplicity. These rules are doubling down, insurance, and splitting pairs. Determine where and how they should be implemented.

## The Prisoners' Dilemma

**Advisor:** Josh Winslow

**Introduction:** You and your best friend are arrested by the police for writing bad code. They place you both in different rooms with no way to contact each other. They offer you both the same deal: if you rat on your friend, you will do less jail time than you would otherwise. There's a catch though. If you both stay quiet, the total jail time will be the least. What do you do?

**Background:** The prisoners' dilemma is an oft studied computer science problem. There is a small rule set, a clear goal (minimize jail time), and a small number of possible outcomes. It has been used in artificial life simulations and there have been several competitions over the years to try to create the best prisoner.

Below is the values assigned to each action. You want to try to minimize your points.

Your Jail Time:		
	Partner's Action:	
Your Action:	Rat:	Not Rat:
Rat:	2	0
Not Rat:	3	1

Partner's Jail Time:		
	Partner's Action:	
Your Action:	Rat:	Not Rat:
Rat:	2	3
Not Rat:	0	1

As you can see, it would appear that it is always advantageous to rat on your friend. You will always do less time that way. However, if your friend comes to the same conclusion, you'll both do more time than you would have if you had both remained silent.

### Goals:

- 1) Write at least 2 PrisonerBot classes and run them against each other.
- 2) Run the PrisonerBots against each other several times and record how well they perform.
- 3) Determine the most effective PrisonerBot

### Requirements:

- 1) You will need to create at the very least 2 classes that make up the AI of your prisoner bots. The classes will need to implement the PrisBot interface that has 1 method of the following form:

boolean decide(); true is returned if the bot decides to rat and false otherwise.

2) The provided class Warden needs to have its constructor edited to call your classes instead of the default classes that are provided.

3) The provided source must be compiled.

### **Further Work:**

1) Write new PrisonerBots that look at the history of how their opponent acted and then base their decisions off of that data. (Look at Warden2 for hints)

2) Compare how the new bots compete against the old bots and against each other.

3) Write a program that can graphically display: 1 round of decisions and sentencing, 5 rounds (as a graph), 10 rounds (as a graph), and 100 rounds (as a graph).

## XML Parsing

**Advisor:** Josh Winslow

**Introduction:** You have been put in charge of maintaining the Billboard system for ranking album sales. Currently, once the data is entered into the system, there is no way to change it. The person who held your job previously was sacked for entering false data about his favorite band into the system and your superiors had to remove the entire database. Your job is to rewrite the system so that records can be added and deleted. The data is all stored in a file in XML format and needs to stay that way (sales applications also use that file).

**Background:** XML or eXtensible Markup Language is a revolutionary way of storing data. Sun, Microsoft, and IBM have all made XML part of their core IT strategy and with good reason. XML and its predecessor SGML are two of the first markup languages that keep data separate from presentation. This allows multiple pieces of software to use the exact same data and display it to the screen in radically different fashions. However, in order to do this, the XML needs to be "parsed" (have its structure examined and interpreted) into a machine understandable format.

Below is an example of an XML document:

```
<!DOCTYPE Billboard100>
<BestSellers>
  <Album>
    <Artist>Rolling Stones</Artist>
    <AlbumName>Bridges To Babalyon</AlbumName>
    <Rank>1</Rank>
    <Year>1999</Year>
    <CopiesSold>1734000</CopiesSold>
  </Album>
  <Album>
    <Artist>AC/DC</Artist>
    <AlbumName>Highway To Hell</AlbumName>
    <Rank>3</Rank>
    <Year>1979</Year>
    <CopiesSold>899999</CopiesSold>
  </Album>
  <Album>
    <Artist>Tool</Artist>
    <AlbumName>Undertow</AlbumName>
    <Rank>2</Rank>
    <Year>1993</Year>
    <CopiesSold>999999</CopiesSold>
```

```
</Album>  
</BestSellers>
```

If you'll note, it looks somewhat similar to HTML as both are markup languages. Markup languages use tags to delineate the start and end of statements, as opposed to using semicolons to delineate the end of statements as java does. The second line is the doctype, in this case Billboard100. The doctype tag lets the program reading the XML know what kind of document it is dealing with. doctypes are important because someone may change the data in the XML document you have been working with and not tell you. In this case, checking doctypes can save you from the costly process of parsing a document that is not useful to you. The first two lines in this document make up the header. The header information may be longer or even non-existent in other documents and the document will still comply with the XML standard.

After the header, all tags must have a closing tag paired with them. Like and or and . These tags may have character data as (CDATA) like or may have other nodes as children like . For our purposes, those are the only two types of tags we will need to know, but there are about 10 others. Their description can be found [here](#).

The most important thing to note about an XML document is the fact that it describes its own data. By using this meta-data, well-formed XML documents can greatly decrease search time. Each document knows what it is about and contains its own hierarchical structure. Instead of searching by keyword through the entire document, a search engine can look for a well know tag name.

## **PARSING**

In order to get your program to understand XML as something other than a big strangely formatted string, you will need to parse it using an XML parser. Fortunately Sun has done much of the work with their Java API(Application Program Interface) for XML Parsing or JAXP library. Contained within the JAXP libraries are two different parsers: a SAX parser and a DOM parser.

### **SAX**

The SAX parser is basically like a big for loop that runs through the entire document looking for tags. When it finds a tag, it will call a method you give it when you load it. You can check the tag to see if it is a tag you are looking for and if it is, you can process it. If it isn't, you just return and the SAX parser will call your method again when it finds another tag. A SAX parser is reasonably fast and has very little overhead because the only things that are being loaded into memory are a couple comparison routines. However, you have to store all of the parent/child node information yourself.

### **DOM**

DOM stands for Document Object Model. In a DOM parser, the parser takes the document and converts each tag pair () into a Node class. Each node class has a list of child nodes (for Album this would be Artist, AlbumName, Rank, Year, and CopiesSold) and a link to its parent node (for Album this would be BestSellers). So, given any node in



the tree and some information about another node anywhere in the tree, you could find it. This model makes searching and organization of information very easy but comes with a substantial cost in memory and processor usage.

### **XMLUtils**

The XMLUtils adds easy searching and initialization to the DOM system. However, you will still need to carefully review the following JavaDoc entries: Node, NodeList, and Document as they contain many useful methods.

**Ethics:** Most of the usefulness of XML is in its meta-data. What happens when someone includes false meta-data in a document? This might lead to Wal-Mart coming up as the cheapest price for a CD on a search if they use as a dummy tag and as the actual price. Can you think of other implications? Is this wrong? Why or why not?

### **Goals:**

- 1) Write a program that reads in an XML file from disk. (A file will be provided.)
- 2) Use the provided XMLUtils to parse the document using a DOM
- 3) Display the records to the screen in an organized fashion.
- 4) Allow the user to add or delete records. Pick some of your favorite albums that aren't in the XML document and add them then remove some you hate.
- 5) Write the modified XML document back to disk.

### **Requirements:**

- 1) The XML file must be selected by the first command line argument. I.E.  
java billboard /home/jwinslow/public\_html/BillBoard.XML
- 2) The 3 jaxp jar files must be added to your classpath.
- 3) XMLUtils must be used for searching and initialization.

### **Further Work:**

- 1a) The DOM parser takes a very long time to load and has a large memory footprint. The SAX parser is fast and uses little memory, but does not store the document in any sort of meaningful hierarchy. Convert your program to use the SAX parser.
- 1b) Do time trials to see which parser is faster and by how much. Do this on a variety of different sized documents.
- 2) Write an extension to XMLUtils that uses a SAX parser to create a Document Model similar to what the DOM uses but only has links to sections of the document that the user specifies. Modify your program to use these new methods.

# Database Project - Oracle Front-End

Project Advisor: Matthew Toczek

## Introduction

Some of the most powerful and extensive databases today are run on Oracle database management systems (DBMSs). Visa, MasterCard, Fidelity Investments, NASA and the American government all use Oracle databases in some form or another, due to its power, flexibility, and scalability. The single largest drawback of Oracle, as you will see, is its not-too-friendly user interface. Many Oracle databases have only a text-line interface that is difficult for anyone but a database administrator (DBA) to understand and use effectively. (To put this in perspective, a DBA with about two years' experience can easily command a salary of over \$150,000 per year, while the average American salary is around \$30,000 per year.) Your mission in this project is to alleviate some of the user's burden when using an Oracle database by building a user-friendly front-end program.

## Background

You'll be given an account to WPI's Oracle programming environment, and a database schema will be provided for you. Your first task should be to familiarize yourself with some basic Oracle commands. Inserting records into the database, executing queries, and displaying query results are all operations that should be supported by your front-end program.

The schema is a simple method of organizing musical artists groups, their members, songs and albums released, etc. The schema contains six tables, with field names in parentheses. Unless otherwise noted, all variable types are character datatypes:

- **Album** - (AlbumName, ReleaseDate [date], GroupName)
- **Artist** - (ArtistName, Proficiency, GroupName)
- **Band** - (GroupName)
- **Playlist** - (PlaylistName, SongName)
- **Records** - (ArtistName, SongName)
- **Song** - (SongName, SongLength [int], Genre, AlbumName)

You'll probably notice that each field name is in at least two tables, except "Genre." This is an important concept in database schema design. If you like, you can read more about this, and other issues about database design, at an excellent tutorial site called [webmonkey](#), in the "backend" section.

To run Oracle at WPI, you'll have to telnet to wpi.wpi.edu. At the UNIX prompt, type in "ln -s ~koeller/oracle/coraenv" and hit enter, then type "source ~/coraenv" and hit enter, and finally, "sqlplus" and enter. Oracle will ask you for a login and password, which will be provided. (For those wanting to learn a bit more about UNIX, a more detailed description of the above instructions is available, courtesy of Professor Rundensteiner, [here](#).)

Go ahead and insert a few records (also called "tuples" by some) into the database: your favorite artist, albums, or just some random music industry-type information. Use the "insert record" command for this purpose. (See [Stanford University's database page](#) for some help on how to do this.)

Once you have a small sample size of data to play with, execute a couple of queries from the Oracle command line. (Try "Select albumname From album Where albumname =

Once you've met your opponent, it's time to conquer it with a good dose of Java. Take a look at the sample Java source code provided. You'll realize that a Java front-end can pretty easily be built by encapsulating Oracle commands and sending them to the database. Of course, if this were all that would be done, there'd be almost no point. However, as the programmer, you have the power to manipulate those statements any way you wish. (Imagine you were hired to build a front-end program for a credit card company, or perhaps a bank. No one but you knows exactly how you're manipulating the Oracle statements, so it wouldn't be too hard to increase your bank balance by, say, a few million bucks.) Use this power wisely.

## Glossary

- **Back-end** - The workhorse of any front-end/back-end divided system. In the world of Internet businesses, many back-ends are databases used for processing e-commerce transactions, keeping track of "for sale" items or otherwise collecting and sorting information of nearly any type.
- **Char** - One of many standard datatypes supported by Oracle. Chars are similar to strings in Java.
- **Create Table** - One of many Oracle commands. Create Table creates a structured area of memory (structured off of a given schema) where data can be stored, and later accessed (usually by some SQL statement) in a logical and useful fashion.
- **Date** - Oracle standard datatype, available in a number of formats for variable precision.
- **Field** - One section of a record. Typical fields have names such as "first name," "last name," "address," etc.
- **Front-end** - A relatively user-friendly program that interfaces with some back-end program (an Oracle database, for example). In its simplest form, a front-end usually provides simple error checking and instructions/advice to the user. More

extensive front-ends can provide graphical user interfaces and entire subsystems to make any operation the user might perform much easier to understand and execute.

- **DBMS - DataBase Management System.** Oracle, Microsoft Access, Sybase, and MySQL are all DBMSes. The function of a DBMS is, largely, to manage large amounts of data. Large amounts of data may very well mean hundreds of gigabytes, or more.
- **Query -** Formal request for information from a database. Queries are usually written in SQL, and must be coded logically and consistently.
- **Record -** One complete set of data in a table, with entries for each field in that table.
- **Schema -** Think of this as "database design." A database's schema determines what kind of data is stored (names, addresses, account balances), how it is stored (integer type, date, financials, etc), and how each piece of data relates to all the other pieces of data.
- **SQL -** Sequential Query Language. The industry standard language for building and executing query statements within a database.
- **Table -** Standard analogy for the use of database schemas. Used as "There are three fields in the Album table."
- **Tuple -** Formal for record.

## **Goal**

Build a front-end program in Java that will interface with the Oracle back-end database given. Your front-end should allow the user to:

- 1) Insert records into each table in the database
- 2) See all of the information in a given table
- 3) Execute some standard, hard-coded queries
- 4) Execute a user-given query

## **Requirements**

The front-end can be relatively simple, a text menu displaying the options available is just fine. Don't worry too much about formatting the output for the screen; concentrate first on linking to the database from your Java program and successfully passing requests to the database, having them execute properly, having the results returned to your program, and displaying the results. You should provide some good error-handling techniques, as the

potential for users to foul-up is pretty high. Messages such as "Table name invalid; try again." and "Error executing query" are examples of the error-handling your front-end should support. Displaying a short introduction (what the program is, what it does, perhaps a paragraph or two) upon the program's execution is also a good idea. This will help orient the user as to what the heck he or she should be doing.

Remember that you're trying to make the user's database experience as painless as possible. If you'd like some constructive criticism and feedback on how your front-end interface is progressing, feel free to ask one of the advisors or a neighbor to try it out.

## **Improvements and Extensions**

There are at least two significant improvements you can make on this project. The first is replacing the text-line interface with a graphic user interface with windows, menus, and user-assistance messages and functions.

The second method of improvement is allowing more extensive user control of the database. This could be something as simple as adding in "Create Table" functionality, or could be as all-encompassing as giving the user 'superuser' status within the database. Database superusers (DBAs) have the power to do pretty much anything to the database: deleting records, changing account balances or addresses, or all the contents of the database, for example. If you do decide on this route, perhaps it'd be best if you added in some security measures (password access for certain commands, perhaps) just to be sure no one lets their newfound authority go to their heads.

# Cryptography Project - Ciphertext Decryption

Project Advisor: Matthew Toczek

## Introduction

The FBI's Carnivore "email snooping system" is only one of many concerns regarding the integrity and privacy of personal electronic communications today. The popular use of electronic communications (email, instant messaging services, web-based financial transactions, etc) makes it easier than ever for an outsider to intercept supposedly private communications between individuals, organizations, businesses and governments.

One method of securing electronic communications is encryption. Many styles of encryption exist, dating back to the beginning of human history: the Julian shift cipher (used by Julius Caesar himself) and the Enigma system (used extensively by the German military, and cracked by the Allies, in World War II) are just two examples of encryption systems. However, one encryption system that is most readily applicable to electronic communications is asymmetric-key encryption.

Probably the most well-known asymmetric-key encryption system is Pretty Good Privacy (PGP), written by Phil Zimmerman, and published online (for free, yeah!) in the early 1990s. The underlying mathematical equations and mechanisms of PGP are so strong that the system was classified as a national security concern. Because PGP was available all over the world via the Internet, Zimmerman was charged with violation of national security by the American government. In some places "violation of national security" is called treason, and is punishable by death. (If you're still unconvinced of the seriousness of encryption export law, check out [www.cryptography.org](http://www.cryptography.org).)

Good encryption systems, when used properly, make communications more difficult to be read by a third party. However, as the German military learned in World War II, no encryption system is unbreakable. Your task in this project, should you choose to accept it, is to play the "unauthorized observer" role. Given an intercepted message, you must crack the code and steal your opponent's secrets. (Note: the US government's National Security Agency [NSA] handles this sort of role all the time. The NSA handles the majority of the American government's intelligence workload, is the world's largest employer of theoretical mathematicians and cryptologists, and measures its computing power in terms of "How many acres of NSA basement floor space are filled with supercomputers.")

## Background

[Author's note: It would be beneficial to refer to the glossary given below while reading through the background material.]

Suppose Alice wants to send a message to Bob over an insecure network (the Internet, for example), while Oscar is listening in. Alice strongly encrypts her message to prevent

Oscar from reading the contents, but Alice must make it relatively easy for Bob to decrypt the message. One way that this can be done easily over the Internet is by using an asymmetric-key encryption system.

*Here's how asymmetric-key encryption works:* Bob has two "keys," which are really just small collections of numbers. Bob has a public key (consisting of a very large number:  $z$ , and another smaller number called the encryption key:  $n$ ).

$$k[\text{pub}] = (z, n)$$

Bob also has a private key that consists of three numbers.  $p$ ,  $q$ , and  $s$ .  $p$  and  $q$  are both prime numbers, and have the property  $p \cdot q = z$ .  $s$  is another number, called the decryption key.

$$k[\text{prv}] = (p, q, s)$$

[Please note: the encryption and decryption keys,  $n$  and  $s$ , are not just "some random numbers." There is more to it than that. However, the mathematics is a bit complicated to discuss here. A more mathematically detailed description of asymmetric-key encryption is available at Professor Koeller's [algorithms page](#).]

When Alice wants to send an encrypted message to Bob, she gets his public key (containing  $z$  and  $n$ ) from Bob's website. Alice also has her plaintext message,  $m$ . Alice encrypts her plaintext message,  $m$ , into ciphertext,  $c$ , with the following equation:

$$c = m^n \bmod z$$

Alice then sends her encrypted message over the Internet to Bob. Bob receives the encrypted message,  $c$ , and turns it back into the original plaintext with the equation:

$$m = c^s \bmod z$$

Notice that this equation uses information available only in Bob's private key:  $s$ . For the unauthorized observer to obtain  $s$ , two things are required:  $p$  and  $q$ .  $p$  and  $q$  are plainly available in Bob's private key (which you don't have access to), but they can be obtained by factorizing  $z$ , which is available from Bob's public key (which you do have). [Note: Getting  $s$  from  $p$  and  $q$  is surprisingly simple. A process called the Extended Euclidean Algorithm does this quite nicely. Don't worry about the specifics of the Extended Euclidean Algorithm. A function called "exteuclid" will be provided for you. It will take two integer arguments,  $p$  and  $q$ , and will return  $s$ .]

The strength of asymmetric-key encryption systems rests mostly on properties surrounding prime numbers. Go ahead and solve the following two problems on your calculator:

- 1) What is  $13 \times 7$ ?
- 2) What are the prime factors of 133?

The numbers 7, 13, and 19 are relatively small, as prime numbers go. The next two problems use numbers that are a bit larger. If you'd like to attempt them, go ahead, but don't spend too much time on #4.

- 3) What's  $421 \times 509$ ?
- 4) What are the prime factors of 317461?

Notice that multiplying two prime numbers together is relatively simple, but finding the prime factors of a number (that is, "factorizing" the number) proves to be quite difficult. While multiplication is a simple mathematical and computational process, factorization is far more difficult.

Consider this: factorizing a standard PGP public key (which is a number about 200 digits long) takes about one year of constant processing power (almost 9000 hours of nonstop processor operations) on a computer a few hundred times as powerful as your home computer. And PGP is weak, compared to the cryptographic systems used by businesses and, especially, governments and their agencies.

As you'll be playing the unauthorized observer role in this project, you'll be given the ciphertext of Alice's message to Bob (which can be easily "snooped" from the Internet), and Bob's public key (which he freely posts on his website, so people can send him encrypted messages). With these two pieces of information, and plenty of programming skill, you'll crack the message.

In this case, cracking an encrypted message involves three steps.

- **Step1** Factorize Bob's public key. The public key will be some large number, which has two prime factors. You must find the two prime factors of Bob's public key by writing a factorization program. For example: Say Bob's public key is the number 713. Your program's output might look something like this:

$$713 \% 2 \neq 0$$

$$713 \% 3 \neq 0 \dots$$

$$713 \% 23 = 0, \text{ so } 23 \text{ is one prime factor of the public key. The other factor must be } 713 / 23 = 31.$$

Bob's public key has successfully been cracked!

- **Step2** Compute the decryption key,  $s$ , by using the Extended Euclidean Algorithm. The Extended Euclidean Algorithm solves the equation  $n*s \bmod \theta = 1$  for the variable  $s$ . Here,  $\theta = (p-1)(q-1)$ . Again, this might seem a bit complicated, but don't worry too much about the specifics of how the equations work out. You can take my word for it, or you can read through the "lecture slides" part of Professor Koeller's [algorithms page](#) and convince yourself (learning some pretty cool number theory in the process.)



- **Step3** Decrypt the ciphertext message,  $c$ . The equation governing this process is  $m = c^s \text{ mod } z$ , where:

$m$  = Alice's plaintext message

$c$  = Alice's ciphertext message, given in the file cipher.txt

$z$  = the larger number of Bob's public key. Note that this is the number you're already cracked by this point.

Don't worry too much about the interrelations of the above equations. Just realize that your goal is to compute 'm' from the first equation. To do that, you need 4 things:  $c$ ,  $s$ ,  $p$  and  $q$ . The ciphertext,  $c$ , is given to you. You find  $s$  from the Extended Euclidean Algorithm, and you've already found  $p$  and  $q$  by cracking  $z$ .

## Glossary

- Asymmetric-key encryption system - Any encryption system that uses two keys, like a public and private key. PGP is one such asymmetric-key encryption system.
- Brute-force attack - Cracking an encrypted message by using nothing more than raw computing power. Other ways of cracking encrypted communications involve the use of espionage and reverse engineering poorly designed encrypted systems. As you have no spies inside Alice and Bob's organization, and public-key encryption is a good method of securing transmissions, you're only option is to attempt a brute-force attack on the ciphertext.
- Ciphertext - Ciphertext is the encrypted (encoded) message that is sent to your associate. Alice sends her ciphertext to Bob over an insecure communications channel.
- Cracking - Informal for "factoring."
- Encrypt - To convert plaintext to ciphertext.
- Extended Euclidean Algorithm - A relatively simple algorithm, used to compute the decryption key " $s$ " from the components of " $z$ ." A function called `exteuclid` will be provided for you. `exteuclid` will take two integer parameters ( $p$  and  $q$ ) and will return  $s$ . (Recall that  $z = p * q$ )
- Factoring - Reducing some non-prime number to its prime factors. For example:  
Factoring 12543 yields  $111 * 113$   
Factoring 96 yields  $2 * 2 * 2 * 2 * 2 * 3$   
Factoring 510510 yields  $2 * 3 * 5 * 7 * 11 * 13 * 17$
- Factorizing - Same as "factoring"

- **Linked List** - A data structure often used in various programs for its relative simplicity and extraordinarily large size. The linked list has a "head" node, which connects to another node, and so on, until the tail node is reached. Each node in a linked list can hold some amount of the same type of information. Thus, you can have a linked list of any single datatype (a linked list of integers, perhaps, for your BigInt).
- **Mod** - Short for modular arithmetic. Also denotes the mathematical operation "modulus." (Ex: "7 modulus 3" is the same as "7 mod 3" is the same as  $7 \% 3$ ) In integer division (where we don't concern ourselves with decimals)  $7 / 3 = 2$ , while  $7 \% 3 = 1$ .  $100 / 2 = 50$ , while  $100 \% 2 = 0$ .  $x \text{ mod } y$  equals the remainder of  $x$  divided by  $y$ .
- **Plaintext** - Plain text message. This is the message you write and want to send to your friend, associate, partner-in-crime, etc. Plaintext is not encrypted. This document, for example, can be considered a plaintext document.
- **Public Key** - Part of an asymmetric-key encryption system. The public key is what someone uses to encrypt a message, so public keys are usually posted on websites, printed on business cards, etc. Asymmetric-key encryption systems are designed so that if an unauthorized observer knows the public key the system is still very difficult to crack. Public keys consist of two numbers,  $z$  and  $n$ .
- **Prime Factors** - Any positive integer is either a prime number (5, 37, and 101, for example), or can be broken down into a string of prime factors ( $125 = 5 * 5 * 5$ ,  $2701 = 37 * 73$ , for example).
- **Prime Number** - (sometimes referred to just as a "Prime") An integer that is divisible only by itself and one.
- **Private Key** - Part of an asymmetric-key encryption system. Only one unique private key can decrypt the messages from its associated public key. The private key is just like your computer password: if it falls into the wrong hands, it spells disaster. Private keys consist of three numbers:  $p$ ,  $q$ , and  $s$ , where  $p * q = z$ , from the public key.

## Goal

Given a ciphertext file, encrypted by a public-key encryption system, build a brute-force attack program to decrypt the ciphertext.

## Requirements

1 - The program will take user-input of the ciphertext filename from the program command prompt, and will display the plaintext to the screen.

2 - As the program may take some time to execute (perhaps a few minutes at most) it would be useful to display some sort of progress report for each iteration of the 'cracking' loop. This doesn't have to be anything fancy; a simple line of text should suffice. One example of this progress report format is:

```
"Cracking 1431000479; 1431000479 % 2 != 0"
```

```
"Cracking 1431000479; 1431000479 % 3 != 0"
```

...and so on, until you determine the number's prime factors.

## **Improvements/Extensions**

The scope of your program's ability is limited by the largest built-in integer value available in Java. In reality, public-key encryption systems have a target number to crack of more than 200 digits (and in some cases far larger) in length. Your new mission, should you choose to accept it, is to create a new type of integer class called `BigInt`. This new class will be a linked list, with each node in the list holding one digit of the entire number. As nodes in a linked list are dynamically allocated, the theoretical size of a `BigInt` is hindered only by the amount of memory of the computer system on which it is running. To be of use in attacking encrypted messages, you must overload the operators / (division) % (modulus), and = (equality).

Once your new integer type is up and running, you should use it in the cracking program you've already written. You can test your `BigInt` on numbers as small as four or five digits. Once you know the `BigInt` works for these relatively simple cases, go ahead and try "recracking" the given ciphertext. You'll probably note the speed difference with which the ciphertext is cracked by using default variable types, versus the `BigInt` variable type.

## **Appendix B: Pretest**

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 01	I have written a Java program that plays sounds.	FALSE
Student 01	What modules did you start with this morning	Java
Student 01	Using the simple class you just wrote, create another class that is a sub-class of it,	
Student 01	I consider myself an advanced Java programmer.	FALSE
Student 01	In C++, the cout stream can be used to output	any combination of above
Student 01	Create a simple class definition with two class variables and one class method.	i don't know
Student 01	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	int x;for (x=0; x<10; x++)if (list[x]!=0) thenlist[x]++;
Student 01	Have you ever written a Java Applet? If so, describe one you have written?	
Student 01	I have written Java program that handles mouse events.	FALSE
Student 01	I have written a Java program that displays graphics.	FALSE
Student 01	Describe the largest Java program you have written. How many lines of code (estimated) does it contain?	
Student 01	How did you learn to program in Java?	I don't know how to program in Java
Student 01	I have Java programming experience.	FALSE
Student 01	Using inheritance	You can define classes that include methods and variables of other classes
Student 01	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x directly? (Hint: functions)	create a function with the value as a parameter. the variable will be global with respect to the function, and the variable will be changed within the function.
Student 01	Common programming languages are built upon the ability to access a data value using a _____?	Variable

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 01	How much programming experience have you had? (Your answer should include the number of years you've been programming, the languages you've worked with, and the highest degree of complexity of your most advanced program.)	I've been programming for 3 years. I can program in C++, VB, and Pascal. I got a five on the APCS exam. I do not know the highest degree of complexity that I have worked with.
Student 01	Describe the most complex piece of Java code you have written?	
Student 01	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 01	With which programming languages are you familiar?	Pascal
Student 01	With which programming languages are you familiar?	Visual Basic
Student 01	How did you gain your programming experience? (check all that apply)	I taught myself from programming books.
Student 01	With which programming languages are you familiar?	C++
Student 01	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 01	Looking at the following pseudo-code, what is the value of x when the program is finished:	10
Student 01	Looking at the following pseudo-code, what is the value of x when the program has finished:	0
Student 01	When you program, do you tend to lump everything into one main function, or separate your program into different functions/subroutines?	I use functions.
Student 01	With which object-oriented language (if any) are you most familiar?	C++
Student 01	In object-oriented languages, a class _____	Is a general template that is used to create objects with similar features.
Student 01	How did you gain your programming experience? (check all that apply)	I learned from high-school programming class(es).
Student 02	What modules did you start with this morning	JavaBOTL
Student 02	In C++, the cout stream can be used to output	any combination of above
Student 02	With which programming languages are you familiar?	Basic

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 02	Looking at the following pseudo-code, what is the value of x when the program is finished:	10
Student 02	What modules did you start with this morning	Java
Student 02	How much programming experience have you had? (Your answer should include the number of years you've been programming, the languages you've worked with, and the highest degree of complexity of your most advanced program.)	1 yr C++ (kinda fuzzy) 2 years HTML 2 years BASIC
Student 02	With which programming languages are you familiar?	C++
Student 02	With which programming languages are you familiar?	HTML
Student 02	With which programming languages are you familiar?	Javascript/VBScript
Student 02	How did you gain your programming experience? (check all that apply)	I learned from high-school programming class(es).
Student 02	How did you gain your programming experience? (check all that apply)	I taught myself from programming books.
Student 02	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 02	I consider myself an advanced Java programmer.	FALSE
Student 02	I have written a Java program that displays graphics.	FALSE
Student 02	Common programming languages are built upon the ability to access a data value using a _____?	Reference
Student 02	In object-oriented languages, a class _____	Is a general template that is used to create objects with similar features.
Student 02	Looking at the following pseudo-code, what is the value of x when the program has finished:	1
Student 02	I have written Java program that handles mouse events.	FALSE
Student 02	With which object-oriented language (if any) are you most familiar?	C++
Student 02	Using the simple class you just wrote, create another class that is a sub-class of it,	

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 02	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	I'm not sure
Student 02	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x directly? (Hint: functions)	?
Student 02	Using inheritance	I'm not sure
Student 02	I have Java programming experience.	FALSE
Student 02	Describe the largest Java program you have written. How many lines of code (estimated) does it contain?	
Student 02	I have written a Java program that plays sounds.	FALSE
Student 02	Describe the most complex piece of Java code you have written?	
Student 02	Have you ever written a Java Applet? If so, describe one you have written?	
Student 02	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	<pre>void ArrayLoop(apvector&amp; array1){int x;for(x= 0; x&lt;10; x++){ if array1[x]&gt; 0 array[x]++;}}</pre>
Student 02	Create a simple class definition with two class variables and one class method.	
Student 02	How did you learn to program in Java?	I don't know how to program in Java
Student 02	When you program, do you tend to lump everything into one main function, or separate your program into different functions/subroutines?	I use functions.
Student 03	How much programming experience have you had? (Your answer should include the number of years you've been programming, the languages you've worked with, and the highest degree of complexity of your most advanced program.)	About 2-3 years, i've taken a class in Pascal, Visual Basic, and taught myself HTML, some javascript/VBScript
Student 03	Looking at the following pseudo-code, what is the value of x when the program is finished:	10
Student 03	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array



<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 03	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 03	How did you gain your programming experience? (check all that apply)	I taught myself from programming books.
Student 03	How did you gain your programming experience? (check all that apply)	I learned from high-school programming class(es).
Student 03	How did you gain your programming experience? (check all that apply)	I taught myself using Web-based material.
Student 03	With which programming languages are you familiar?	Visual Basic
Student 03	With which programming languages are you familiar?	Pascal
Student 03	With which programming languages are you familiar?	HTML
Student 03	What modules did you start with this morning	JavaBOTL
Student 03	Looking at the following pseudo-code, what is the value of x when the program has finished:	0
Student 03	Have you ever written a Java Applet? If so, describe one you have written?	-
Student 03	With which programming languages are you familiar?	Javascript/VBScript
Student 03	Create a simple class definition with two class variables and one class method.	Public Class MyClass { int x = 0; int y;}
Student 03	In C++, the cout stream can be used to output	any combination of above
Student 03	I have written Java program that handles mouse events.	FALSE
Student 03	Using the simple class you just wrote, create another class that is a sub-class of it,	Public Class AnotherClass Extends MyClass { int z = 0; int x2;}
Student 03	When you program, do you tend to lump everything into one main function, or separate your program into different functions/subroutines?	I use functions.
Student 03	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	x = 0 For x = 0 to 9 If MyArray(x) > 0 Then MyArray(x) = MyArray(x) + 1 End If Next x
Student 03	Describe the most complex piece of Java code you have written?	-
Student 03	I have written a Java program that plays sounds.	FALSE

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 03	I have written a Java program that displays graphics.	FALSE
Student 03	How did you learn to program in Java?	I don't know how to program in Java
Student 03	I have Java programming experience.	FALSE
Student 03	I consider myself an advanced Java programmer.	FALSE
Student 03	Describe the largest Java program you have written. How many lines of code (estimated) does it contain?	-
Student 03	With which object-oriented language (if any) are you most familiar?	-
Student 03	In object-oriented languages, a class _____	is a general template that is used to create objects with similar features.
Student 03	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	I'm not sure
Student 03	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x directly? (Hint: functions)	??
Student 03	Using inheritance	Sub-classes only need to define differences from, and/or additions to, the parent class
Student 04	I have written a Java program that displays graphics.	FALSE
Student 04	Using inheritance	It is possible to create a hierarchy of classes
Student 04	Using inheritance	You can define classes that include methods and variables of other classes
Student 04	Using inheritance	Sub-classes only need to define differences from, and/or additions to, the parent class
Student 04	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x directly? (Hint: functions)	create a method that allows the user to set the value of x
Student 04	How did you learn to program in Java?	
Student 04	Looking at the following pseudo-code, what is the value of x when the program has finished:	0
Student 04	I have written a Java program that plays sounds.	FALSE
Student 04	I have written Java program that handles mouse events.	FALSE

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 04	Describe the most complex piece of Java code you have written?	
Student 04	Have you ever written a Java Applet? If so, describe one you have written?	
Student 04	In C++, the cout stream can be used to output	any combination of above
Student 04	I consider myself an advanced Java programmer.	FALSE
Student 04	Using the simple class you just wrote, create another class that is a sub-class of it,	don't remember how to do this
Student 04	Create a simple class definition with two class variables and one class method.	don't remember how to do this
Student 04	I have Java programming experience.	FALSE
Student 04	How much programming experience have you had? (Your answer should include the number of years you've been programming, the languages you've worked with, and the highest degree of complexity of your most advanced program.)	I had to learn HTML and write a webpage in my networking class. I have taken a full year of C++ class, starting in fall of 2000. I have also written a variety of classes.
Student 04	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	<pre>{ for (i=0 ; i&lt;10 ; i++) { if (array(i) != 0) { array(i) = array(i) + 1; } }}</pre>
Student 04	Looking at the following pseudo-code, what is the value of x when the program is finished:	10
Student 04	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 04	Common programming languages are built upon the ability to access a data value using a _____?	Reference
Student 04	How did you gain your programming experience? (check all that apply)	I learned from high-school programming class(es).
Student 04	When you program, do you tend to lump everything into one main function, or separate your program into different functions/subroutines?	I use functions.
Student 04	With which programming languages are you familiar?	C++
Student 04	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 04	What modules did you start with this morning	Java
Student 04	Describe the largest Java program you have written. How many lines of code (estimated) does it contain?	
Student 04	When you program, do you tend to lump everything into one main function, or separate your program into different functions/subroutines?	I lump things together.
Student 04	With which object-oriented language (if any) are you most familiar?	C++
Student 04	In object-oriented languages, a class _____	Is a general template that is used to create objects with similar features.
Student 04	With which programming languages are you familiar?	HTML
Student 05	In object-oriented languages, a class _____	Is used to sort object based on their type.
Student 05	How much programming experience have you had? (Your answer should include the number of years you've been programming, the languages you've worked with, and the highest degree of complexity of your most advanced program.)	I have experience working in HTML. Also, as of this morning RobotL.
Student 05	When you program, do you tend to lump everything into one main function, or separate your program into different functions/subroutines?	What's a function?
Student 05	I have written a Java program that plays sounds.	FALSE
Student 05	I have written Java program that handles mouse events.	FALSE
Student 05	Describe the most complex piece of Java code you have written?	N/A
Student 05	Have you ever written a Java Applet? If so, describe one you have written?	No
Student 05	With which programming languages are you familiar?	HTML
Student 05	What modules did you start with this morning	RoBOTL
Student 05	I have written a Java program that displays graphics.	FALSE
Student 05	Describe the largest Java program you have written. How many lines of code (estimated) does it contain?	N/A
Student 05	How did you learn to program in Java?	I don't know how to program in Java
Student 05	I have Java programming experience.	FALSE

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 05	Using inheritance	Sub-classes only need to define differences from, and/or additions to, the parent class
Student 05	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 05	How did you gain your programming experience? (check all that apply)	I taught myself using Web-based material.
Student 05	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x directly? (Hint: functions)	functions
Student 05	Using the simple class you just wrote, create another class that is a sub-class of it,	N/A
Student 05	In C++, the cout stream can be used to output	integer values
Student 05	Create a simple class definition with two class variables and one class method.	N/A
Student 05	I consider myself an advanced Java programmer.	FALSE
Student 05	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Reference
Student 05	Looking at the following pseudo-code, what is the value of x when the program is finished:	1
Student 05	Looking at the following pseudo-code, what is the value of x when the program has finished:	1
Student 05	With which object-oriented language (if any) are you most familiar?	None
Student 05	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	N/A
Student 05	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 06	Using inheritance	I'm not sure
Student 06	How did you learn to program in Java?	I don't know how to program in Java

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 06	Describe the largest Java program you have written. How many lines of code (estimated) does it contain?	
Student 06	I have written a Java program that displays graphics.	FALSE
Student 06	I have written Java program that handles mouse events.	FALSE
Student 06	I have Java programming experience.	FALSE
Student 06	Have you ever written a Java Applet? If so, describe one you have written?	
Student 06	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	
Student 06	Create a simple class definition with two class variables and one class method.	<code>public class test {myvar1.domethod() myvar2.domethod();}</code>
Student 06	Using the simple class you just wrote, create another class that is a sub-class of it,	<code>public class test2 extends test {myvar3="this is a string"myvar4="this is another string"}</code>
Student 06	In C++, the cout stream can be used to output	any combination of above
Student 06	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x directly? (Hint: functions)	
Student 06	I have written a Java program that plays sounds.	FALSE
Student 06	I consider myself an advanced Java programmer.	FALSE
Student 06	How much programming experience have you had? (Your answer should include the number of years you've been programming, the languages you've worked with, and the highest degree of complexity of your most advanced program.)	I have been programming for about 3 years, I have done HTML FLASH, and Javascript, also I have studied and worked with, but not fully comprehend PERL, small amounts of JAVA visual basic, and C++
Student 06	Describe the most complex piece of Java code you have written?	
Student 06	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	I'm not sure
Student 06	What modules did you start with this morning	JavaBOTL

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 06	With which programming languages are you familiar?	C++
Student 06	With which programming languages are you familiar?	HTML
Student 06	With which programming languages are you familiar?	Javascript/VBScript
Student 06	With which programming languages are you familiar?	Perl
Student 06	With which programming languages are you familiar?	Visual Basic
Student 06	How did you gain your programming experience? (check all that apply)	I taught myself using Web-based material.
Student 06	When you program, do you tend to lump everything into one main function, or separate your program into different functions/subroutines?	I use functions.
Student 06	How did you gain your programming experience? (check all that apply)	I taught myself from programming books.
Student 06	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 06	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 06	In object-oriented languages, a class _____	Is a general template that is used to create objects with similar features.
Student 06	Looking at the following pseudo-code, what is the value of x when the program is finished:	1
Student 06	Looking at the following pseudo-code, what is the value of x when the program has finished:	0
Student 06	With which object-oriented language (if any) are you most familiar?	C++, which I studied in high school for about a semester, and I have a little knowledge of VB.
Student 06	How did you gain your programming experience? (check all that apply)	I learned from high-school programming class(es).
Student 07	I have written a Java program that displays graphics.	FALSE
Student 07	Describe the largest Java program you have written. How many lines of code (estimated) does it contain?	N/A
Student 07	How did you learn to program in Java?	I don't know how to program in Java
Student 07	I have Java programming experience.	FALSE

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 07	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x directly? (Hint: functions)	Send the user to a function to choose a value, and then send it back to assign it to x
Student 07	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	C++for(int x=0;x<10;x++){if(array[x] != 0)array[x]++; }
Student 07	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 07	Using inheritance	You can define classes that include methods and variables of other classes
Student 07	I have written a Java program that plays sounds.	FALSE
Student 07	I have written Java program that handles mouse events.	FALSE
Student 07	I consider myself an advanced Java programmer.	FALSE
Student 07	Have you ever written a Java Applet? If so, describe one you have written?	I've tried to modify them, only looking at the sample way it compiled. I must have missed something because I had disastrous results.
Student 07	Create a simple class definition with two class variables and one class method.	PegClass L(4), R(4);L.Showall();
Student 07	Using the simple class you just wrote, create another class that is a sub-class of it,	I'm kind of guessing now, since I've never created classes, just used them
Student 07	In object-oriented languages, a class _____	Is a general template that is used to create objects with similar features.
Student 07	With which programming languages are you familiar?	C++
Student 07	In C++, the cout stream can be used to output	any combination of above
Student 07	Describe the most complex piece of Java code you have written?	N/A
Student 07	With which programming languages are you familiar?	HTML
Student 07	How did you gain your programming experience? (check all that apply)	I learned from high-school programming class(es).



<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 07	How much programming experience have you had? (Your answer should include the number of years you've been programming, the languages you've worked with, and the highest degree of complexity of your most advanced program.)	I've worked a little with Basic for a few months (long ago). I've spent approximately a year doing c++, 2-8 in Lawrence View Press Book (from school). My most complex program was probably life. I've also worked with HTML, and see <a href="http://www.pagerealm.c">http://www.pagerealm.c</a>
Student 07	With which object-oriented language (if any) are you most familiar?	c++
Student 07	How did you gain your programming experience? (check all that apply)	I taught myself from programming books.
Student 07	How did you gain your programming experience? (check all that apply)	Other
Student 07	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 07	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 07	Looking at the following pseudo-code, what is the value of x when the program is finished:	10
Student 07	Looking at the following pseudo-code, what is the value of x when the program has finished:	0
Student 07	When you program, do you tend to lump everything into one main function, or separate your program into different functions/subroutines?	I use functions.
Student 07	What modules did you start with this morning	JavaBOTL
Student 08	What modules did you start with this morning	JavaBOTL
Student 08	How much programming experience have you had? (Your answer should include the number of years you've been programming, the languages you've worked with, and the highest degree of complexity of your most advanced program.)	I've been programming HTML since 1996. I have progressed to ASP (VB & VBScript) web programming and the use of SQL Server with Microsoft's Active Data Objects (ADO). I've manipulated JavaScript already written but have not programed in a C or Java langu
Student 08	With which programming languages are you familiar?	HTML
Student 08	With which programming languages are you familiar?	Javascript/VBScript
Student 08	I have written a Java program that plays sounds.	FALSE
Student 08	What modules did you start with this morning	RoBOTL

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 08	Using the simple class you just wrote, create another class that is a sub-class of it,	
Student 08	In object-oriented languages, a class _____	Is a general template that is used to create objects with similar features.
Student 08	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 08	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x directly? (Hint: functions)	Not sure
Student 08	Using inheritance	I'm not sure
Student 08	I have Java programming experience.	FALSE
Student 08	How did you learn to program in Java?	I don't know how to program in Java
Student 08	Describe the largest Java program you have written. How many lines of code (estimated) does it contain?	
Student 08	I have written a Java program that displays graphics.	FALSE
Student 08	I have written Java program that handles mouse events.	FALSE
Student 08	With which programming languages are you familiar?	Visual Basic
Student 08	Have you ever written a Java Applet? If so, describe one you have written?	
Student 08	Describe the most complex piece of Java code you have written?	
Student 08	Create a simple class definition with two class variables and one class method.	
Student 08	Looking at the following pseudo-code, what is the value of x when the program is finished:	9
Student 08	How did you gain your programming experience? (check all that apply)	I taught myself using Web-based material.
Student 08	How did you gain your programming experience? (check all that apply)	I taught myself from programming books.
Student 08	With which object-oriented language (if any) are you most familiar?	SQL
Student 08	How did you gain your programming experience? (check all that apply)	I learned at a job.
Student 08	How did you gain your programming experience? (check all that apply)	Other

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 08	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	
Student 08	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 08	With which programming languages are you familiar?	XML
Student 08	Looking at the following pseudo-code, what is the value of x when the program has finished:	1
Student 08	When you program, do you tend to lump everything into one main function, or separate your program into different functions/subroutines?	I lump things together.
Student 08	When you program, do you tend to lump everything into one main function, or separate your program into different functions/subroutines?	I use functions.
Student 08	In C++, the cout stream can be used to output	any combination of above
Student 08	I consider myself an advanced Java programmer.	FALSE
Student 08	Common programming languages are built upon the ability to access a data value using a _____?	Reference
Student 09	How did you gain your programming experience? (check all that apply)	Other
Student 09	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x directly? (Hint: functions)	
Student 09	In C++, the cout stream can be used to output	
Student 09	I consider myself an advanced Java programmer.	FALSE
Student 09	Using the simple class you just wrote, create another class that is a sub-class of it,	
Student 09	Create a simple class definition with two class variables and one class method.	

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 09	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	
Student 09	Have you ever written a Java Applet? If so, describe one you have written?	no
Student 09	Describe the most complex piece of Java code you have written?	
Student 09	I have written Java program that handles mouse events.	FALSE
Student 09	I have written a Java program that plays sounds.	FALSE
Student 09	I have written a Java program that displays graphics.	FALSE
Student 09	Describe the largest Java program you have written. How many lines of code (estimated) does it contain?	
Student 09	How did you learn to program in Java?	I don't know how to program in Java
Student 09	With which programming languages are you familiar?	Javascript/VBScript
Student 09	Using inheritance	Sub-classes only need to define differences from, and/or additions to, the parent class
Student 09	What modules did you start with this morning	RoBOTL
Student 09	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 09	In object-oriented languages, a class _____	Is used to sort object based on their type.
Student 09	With which object-oriented language (if any) are you most familiar?	
Student 09	When you program, do you tend to lump everything into one main function, or separate your program into different functions/subroutines?	What's a function?
Student 09	Looking at the following pseudo-code, what is the value of x when the program has finished:	0
Student 09	Looking at the following pseudo-code, what is the value of x when the program is finished:	

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 09	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 09	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 09	How did you gain your programming experience? (check all that apply)	I taught myself using Web-based material.
Student 09	With which programming languages are you familiar?	HTML
Student 09	How much programming experience have you had? (Your answer should include the number of years you've been programming, the languages you've worked with, and the highest degree of complexity of your most advanced program.)	I have worked with HTML, and very little true basic. I am also familiar with JavaScript. I have known HTML for about 3 or 4 years.
Student 09	I have Java programming experience.	FALSE
Student 10	Looking at the following pseudo-code, what is the value of x when the program has finished:	0
Student 10	I have Java programming experience.	FALSE
Student 10	With which programming languages are you familiar?	C
Student 10	With which programming languages are you familiar?	C++
Student 10	How did you gain your programming experience? (check all that apply)	I learned from high-school programming class(es).
Student 10	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 10	Looking at the following pseudo-code, what is the value of x when the program is finished:	10
Student 10	When you program, do you tend to lump everything into one main function, or separate your program into different functions/subroutines?	I use functions.
Student 10	With which object-oriented language (if any) are you most familiar?	C++
Student 10	In object-oriented languages, a class _____	Is a template that can only be used to create one specific type of object.
Student 10	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 10	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x directly? (Hint: functions)	a modifier member function where a value is sent and stored in the variable of the class
Student 10	Using inheritance	It is possible to create a hierarchy of classes
Student 10	How much programming experience have you had? (Your answer should include the number of years you've been programming, the languages you've worked with, and the highest degree of complexity of your most advanced program.)	one year C/C++ hardest project: car racing game where a group worked on parts that had to interact and work
Student 10	Using inheritance	Sub-classes only need to define differences from, and/or additions to, the parent class
Student 10	I consider myself an advanced Java programmer.	FALSE
Student 10	How did you learn to program in Java?	I don't know how to program in Java
Student 10	Describe the largest Java program you have written. How many lines of code (estimated) does it contain?	i don't know how to program in java
Student 10	I have written a Java program that displays graphics.	FALSE
Student 10	I have written a Java program that plays sounds.	FALSE
Student 10	I have written Java program that handles mouse events.	FALSE
Student 10	Describe the most complex piece of Java code you have written?	i don't know how to program in java
Student 10	Have you ever written a Java Applet? If so, describe one you have written?	no
Student 10	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	for (int x=0;x<array[last];x++) if (array[x]>0)
Student 10	Create a simple class definition with two class variables and one class method.	class plant { int height; int num_leaves; public: int GetHeight() {return height;}};
Student 10	Using the simple class you just wrote, create another class that is a sub-class of it,	class tree: public plant { int diameter; int circumference;};
Student 10	In C++, the cout stream can be used to output	any combination of above

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 10	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 10	Using inheritance	You can define classes that include methods and variables of other classes
Student 10	What modules did you start with this morning	RoBOTL
Student 11	I have Java programming experience.	FALSE
Student 11	With which programming languages are you familiar?	HTML
Student 11	With which programming languages are you familiar?	Visual Basic
Student 11	How did you gain your programming experience? (check all that apply)	I learned from high-school programming class(es).
Student 11	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 11	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	
Student 11	Looking at the following pseudo-code, what is the value of x when the program is finished:	-1
Student 11	Looking at the following pseudo-code, what is the value of x when the program has finished:	x=-1 y=2
Student 11	When you program, do you tend to lump everything into one main function, or separate your program into different functions/subroutines?	What's a function?
Student 11	With which object-oriented language (if any) are you most familiar?	
Student 11	In object-oriented languages, a class _____	I'm not sure.
Student 11	How much programming experience have you had? (Your answer should include the number of years you've been programming, the languages you've worked with, and the highest degree of complexity of your most advanced program.)	Have not
Student 11	What modules did you start with this morning	RoBOTL

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 11	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	I'm not sure
Student 11	How did you learn to program in Java?	I don't know how to program in Java
Student 11	Describe the largest Java program you have written. How many lines of code (estimated) does it contain?	
Student 11	I have written a Java program that displays graphics.	FALSE
Student 11	I have written a Java program that plays sounds.	FALSE
Student 11	I have written Java program that handles mouse events.	FALSE
Student 11	Describe the most complex piece of Java code you have written?	
Student 11	Have you ever written a Java Applet? If so, describe one you have written?	
Student 11	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	
Student 11	Create a simple class definition with two class variables and one class method.	
Student 11	Using the simple class you just wrote, create another class that is a sub-class of it,	
Student 11	I consider myself an advanced Java programmer.	FALSE
Student 11	In C++, the cout stream can be used to output	
Student 11	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x directly? (Hint: functions)	
Student 11	Using inheritance	Sub-classes only need to define differences from, and/or additions to, the parent class
Student 12	I consider myself an advanced Java programmer.	FALSE
Student 12	In C++, the cout stream can be used to output	strings



<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 12	How much programming experience have you had? (Your answer should include the number of years you've been programming, the languages you've worked with, and the highest degree of complexity of your most advanced program.)	None.
Student 12	Using the simple class you just wrote, create another class that is a sub-class of it,	
Student 12	Create a simple class definition with two class variables and one class method.	
Student 12	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	
Student 12	Have you ever written a Java Applet? If so, describe one you have written?	
Student 12	Describe the most complex piece of Java code you have written?	
Student 12	I have written Java program that handles mouse events.	FALSE
Student 12	I have written a Java program that plays sounds.	FALSE
Student 12	I have written a Java program that displays graphics.	FALSE
Student 12	Describe the largest Java program you have written. How many lines of code (estimated) does it contain?	
Student 12	How did you learn to program in Java?	I don't know how to program in Java
Student 12	How did you gain your programming experience? (check all that apply)	I have no programming experience.
Student 12	I have Java programming experience.	FALSE
Student 12	What modules did you start with this morning	RoBOTL
Student 12	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 12	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 12	Looking at the following pseudo-code, what is the value of x when the program is finished:	x=1 or 11

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 12	Looking at the following pseudo-code, what is the value of x when the program has finished:	x=1 or y=0
Student 12	With which object-oriented language (if any) are you most familiar?	
Student 12	In object-oriented languages, a class _____	Is a general template that is used to create objects with similar features.
Student 12	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 12	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x directly? (Hint: functions)	
Student 12	When you program, do you tend to lump everything into one main function, or separate your program into different functions/subroutines?	I have never programmed before.
Student 12	With which programming languages are you familiar?	
Student 12	Using inheritance	Sub-classes only need to define differences from, and/or additions to, the parent class
Student 13	With which programming languages are you familiar?	
Student 13	Have you ever written a Java Applet? If so, describe one you have written?	none
Student 13	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	??
Student 13	Create a simple class definition with two class variables and one class method.	
Student 13	Using the simple class you just wrote, create another class that is a sub-class of it,	
Student 13	I consider myself an advanced Java programmer.	FALSE
Student 13	In C++, the cout stream can be used to output	integer values

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 13	How much programming experience have you had? (Your answer should include the number of years you've been programming, the languages you've worked with, and the highest degree of complexity of your most advanced program.)	I haven't had any programming experience..
Student 13	How did you gain your programming experience? (check all that apply)	I have no programming experience.
Student 13	Describe the most complex piece of Java code you have written?	none
Student 13	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	
Student 13	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 13	What modules did you start with this morning	RoBOTL
Student 13	I have written Java program that handles mouse events.	FALSE
Student 13	I have written a Java program that plays sounds.	FALSE
Student 13	I have written a Java program that displays graphics.	FALSE
Student 13	Describe the largest Java program you have written. How many lines of code (estimated) does it contain?	haven't work with java
Student 13	How did you learn to program in Java?	I don't know how to program in Java
Student 13	I have Java programming experience.	FALSE
Student 13	Looking at the following pseudo-code, what is the value of x when the program is finished:	-1
Student 13	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x directly? (Hint: functions)	
Student 13	In object-oriented languages, a class _____	I'm not sure.
Student 13	With which object-oriented language (if any) are you most familiar?	none
Student 13	When you program, do you tend to lump everything into one main function, or separate your program into different functions/subroutines?	

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 13	Looking at the following pseudo-code, what is the value of x when the program has finished:	
Student 13	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Struct
Student 13	Using inheritance	You can define classes that include methods and variables of other classes

## **Appendix C: Posttest**

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 01	Create a simple class definition with two class variables and one class method.	
Student 01	I have written a Java program that handles mouse events.	TRUE
Student 01	I have copied down the directions for accessing the Frontiers CS site as a guest when Frontiers is over.	TRUE
Student 01	I have written a Java program that plays sounds.	TRUE
Student 01	I have written a Java program that displays graphics.	TRUE
Student 01	Using the simple class you just wrote, create another class that is a sub-class of it,	
Student 01	How has your overall level of programming experience changed since you participated in the Frontiers program?	I learned several differences between java and c++. I have also learned how to navigate and operate in a variety of different operating systems and programming languages.
Student 01	Using inheritance	Sub-classes only need to define differences from, and/or additions to, the parent class
Student 01	Using inheritance	You can define classes that include methods and variables of other classes
Student 01	Using inheritance	It is possible to create a hierarchy of classes
Student 01	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 01	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 01	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x	create a member function with the value as a parameter, and change the value of x in the procedure to the value passed in.
Student 01	What modules did you start with?	Java
Student 01	In object-oriented languages, a class _____	Is a general template that is used to create objects with similar features.
Student 01	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 01	Looking at the following pseudo-code, what is the value of x when the program has finished:	0

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 01	Looking at the following pseudo-code, what is the value of x when the program is finished:	1
Student 01	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	for (int x=0; x<10; x++)if (list[x]!=0)list[x]++;
Student 01	The study of the limitations of algorithmic computation (computer programs) is called	computability
Student 01	The study of the time and space consumed by a computer program is called:	complexity
Student 01	List at least two advantages/characteristics of an object-oriented program.	data with similar characteristics can be easily related to each other.functions can be created to serve specific types of data, which makes for less confusion.
Student 02	I have written a Java program that displays graphics.	TRUE
Student 02	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 02	Using inheritance	It is possible to create a hierarchy of classes
Student 02	Using inheritance	Sub-classes only need to define differences from, and/or additions to, the parent class
Student 02	Using inheritance	You can change the internal variables of the class
Student 02	Create a simple class definition with two class variables and one class method.	?
Student 02	I have written a Java program that plays sounds.	TRUE
Student 02	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x	have x passed through a function into the main program
Student 02	In object-oriented languages, a class _____	describes an object's attribute values.
Student 02	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 02	Using the simple class you just wrote, create another class that is a sub-class of it,	?
Student 02	How has your overall level of programming experience changed since you participated in the Frontiers program?	I can now program in Java

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 02	I have copied down the directions for accessing the Frontiers CS site as a guest when Frontiers is over.	TRUE
Student 02	Looking at the following pseudo-code, what is the value of x when the program is finished:	10
Student 02	What modules did you start with?	Java
Student 02	List at least two advantages/characteristics of an object-oriented program.	functions can be reused, and user does not need to see code to use it.
Student 02	Using inheritance	You can define classes that include methods and variables of other classes
Student 02	Looking at the following pseudo-code, what is the value of x when the program has finished:	0
Student 02	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	for(i=0,i<10,i++){if (array[i]>0)i++;}
Student 02	The study of the limitations of algorithmic computation (computer programs) is called	computability
Student 02	The study of the time and space consumed by a computer program is called:	complexity
Student 02	I have written a Java program that handles mouse events.	TRUE
Student 02	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 03	I have written a Java program that displays graphics.	TRUE
Student 03	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	for (x=0; x<11; x++) { if (myArray[x] > 0) { myArray[x] = myArray[x] + 1 } }
Student 03	How has your overall level of programming experience changed since you participated in the Frontiers program?	I have learned a lot about how java works, as well as an introduction to several "web" languages, and I have learned alot about io functions in java through my network project
Student 03	What modules did you start with?	JavaBOTL, but then went right on to Java
Student 03	Common programming languages are built upon the ability to access a data value using a _____?	Variable



<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 03	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 03	Looking at the following pseudo-code, what is the value of x when the program has finished:	0
Student 03	Looking at the following pseudo-code, what is the value of x when the program is finished:	10
Student 03	I have written a Java program that plays sounds.	FALSE
Student 03	Using the simple class you just wrote, create another class that is a sub-class of it,	<pre>public class anotherClass extends myClass { char aChar; int z = 0;}</pre>
Student 03	The study of the limitations of algorithmic computation (computer programs) is called	computability
Student 03	I have copied down the directions for accessing the Frontiers CS site as a guest when Frontiers is over.	TRUE
Student 03	I have written a Java program that handles mouse events.	TRUE
Student 03	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x	use a function
Student 03	In object-oriented languages, a class _____	Is a template that can only be used to create one specific type of object.
Student 03	Using inheritance	It is possible to create a hierarchy of classes
Student 03	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 03	The study of the time and space consumed by a computer program is called:	complexity
Student 03	Create a simple class definition with two class variables and one class method.	<pre>public class MyClass { int x = 0; int y = 1; public void addInt() { int z = x + y; }}</pre>
Student 03	List at least two advantages/characteristics of an object-oriented program.	inheritance, in which one class can inherit methods etc. from another class, 2) use of functions to change variables values
Student 04	Using inheritance	You can define classes that include methods and variables of other classes
Student 04	Using inheritance	Sub-classes only need to define differences from, and/or additions to, the parent class
Student 04	Create a simple class definition with two class variables and one class method.	<pre>public class Rect{ int l,w;}public int area(){ return l*w; }public SetSides( int a, int b){ l=a; w=b;}</pre>

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 04	I have copied down the directions for accessing the Frontiers CS site as a guest when Frontiers is over.	TRUE
Student 04	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x	Create a method, preferably with an intuitive name, that will accept a variable of the same type as x, then assign that value to x.
Student 04	Using the simple class you just wrote, create another class that is a sub-class of it,	public class Square{ Rect square;}public Square() { square.w=square.l; }
Student 04	Using inheritance	It is possible to create a hierarchy of classes
Student 04	Looking at the following pseudo-code, what is the value of x when the program has finished:	0
Student 04	I have written a Java program that displays graphics.	TRUE
Student 04	I have written a Java program that plays sounds.	FALSE
Student 04	I have written a Java program that handles mouse events.	TRUE
Student 04	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 04	In object-oriented languages, a class _____	Is a general template that is used to create objects with similar features.
Student 04	List at least two advantages/characteristics of an object-oriented program.	The pieces(objects) of an object-oriented program can be reused in other programs.Encapsulation: users can use the methods of an object without knowing how they
Student 04	The study of the time and space consumed by a computer program is called:	complexity
Student 04	The study of the limitations of algorithmic computation (computer programs) is called	computability
Student 04	Looking at the following pseudo-code, what is the value of x when the program is finished:	10
Student 04	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 04	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 04	How has your overall level of programming experience changed since you participated in the Frontiers program?	I have expanded my ability to manipulate objects and their methods. I have learned to do in Java almost everything I can do in C++(short leap). I have also learned to use HTML frames in the creation of a web page.

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 04	What modules did you start with?	Java
Student 04	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	<pre>for (int i=0; i&lt;10 ; i++) { if (Numbers[i] &gt; 0) { Numbers[i]++; } }</pre>
Student 05	The study of the time and space consumed by a computer program is called:	computability
Student 05	How has your overall level of programming experience changed since you participated in the Frontiers program?	Initially, I had never programmed before. Now, although my knowledge may not be as extensive as some due to their prior experience, I feel I have a much better understanding of how programming and Computer Science works.
Student 05	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	<pre>int Numbers[];Numbers = new int[10];for (int x=0, x&lt;10, x++){ Numbers[x]=x=1}</pre>
Student 05	I have written a Java program that handles mouse events.	TRUE
Student 05	I have written a Java program that plays sounds.	FALSE
Student 05	I have written a Java program that displays graphics.	TRUE
Student 05	What modules did you start with?	RoBOTL, but then went right on to javaBOTL
Student 05	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 05	Create a simple class definition with two class variables and one class method.	<pre>public class Example{ int foobar; int frontiers; public void init() { foobar = 100; frontiers = 500; resize (foobar, frontiers); } }</pre>
Student 05	Using inheritance	Sub-classes only need to define differences from, and/or additions to, the parent class
Student 05	Looking at the following pseudo-code, what is the value of x when the program has finished:	0
Student 05	Using the simple class you just wrote, create another class that is a sub-class of it,	NA
Student 05	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x	You could write a function that allows the user to input their value for x and have that function change x.

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 05	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 05	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 05	Looking at the following pseudo-code, what is the value of x when the program is finished:	1
Student 05	The study of the limitations of algorithmic computation (computer programs) is called	complexity
Student 05	I have copied down the directions for accessing the Frontiers CS site as a guest when Frontiers is over.	FALSE
Student 05	List at least two advantages/characteristics of an object-oriented program.	Object-oriented programs allow for more control of a program and can create useful things such as graphics and utilizes mouse events.
Student 05	In object-oriented languages, a class _____	Is a template that can only be used to create one specific type of object.
Student 06	In object-oriented languages, a class _____	Is a general template that is used to create objects with similar features.
Student 06	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 06	I have written a Java program that handles mouse events.	TRUE
Student 06	I have written a Java program that plays sounds.	FALSE
Student 06	I have written a Java program that displays graphics.	TRUE
Student 06	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x	
Student 06	Using the simple class you just wrote, create another class that is a sub-class of it,	<code>public void main{int test3,test4;}</code>
Student 06	Using inheritance	You can define classes that include methods and variables of other classes
Student 06	I have copied down the directions for accessing the Frontiers CS site as a guest when Frontiers is over.	TRUE
Student 06	How has your overall level of programming experience changed since you participated in the Frontiers program?	I learned more about JAVA, obviously my experience has increased since i have been working with a language i have never worked with before.

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 06	The study of the time and space consumed by a computer program is called:	complexity
Student 06	The study of the limitations of algorithmic computation (computer programs) is called	computability
Student 06	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	for (i=0;i<5;i++);
Student 06	Looking at the following pseudo-code, what is the value of x when the program is finished:	10
Student 06	Looking at the following pseudo-code, what is the value of x when the program has finished:	0
Student 06	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 06	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 06	What modules did you start with?	JavaBOTL
Student 06	Create a simple class definition with two class variables and one class method.	public class test{int test1,test2;test1.toUpperCase;}
Student 06	List at least two advantages/characteristics of an object-oriented program.	It is not line by line and therefore gives the user a more interactive interface. An object oriented programming language has many more capabilities, it doesnt read it line by line.
Student 07	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 07	Using inheritance	You can define classes that include methods and variables of other classes
Student 07	Create a simple class definition with two class variables and one class method.	public class Hand{vector hand;int lengthint score=0;public void findscore(){for(int x=0; x<length; x++){score+=hand[x].value;}}
Student 07	Using the simple class you just wrote, create another class that is a sub-class of it,	public class Card{char suit;char type;int value; public void find_val(){switch(type){case 'A': value=1;break;case 'J': case 'Q':case 'K': value=10;break;default: value=int(type);}}
Student 07	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x	you just have the new value stored to a temp, and that then becomes the new value of x.

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 07	I have written a Java program that displays graphics.	TRUE
Student 07	In object-oriented languages, a class _____	Is a general template that is used to create objects with similar features.
Student 07	I have written a Java program that handles mouse events.	TRUE
Student 07	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 07	I have copied down the directions for accessing the Frontiers CS site as a guest when Frontiers is over.	FALSE
Student 07	I have written a Java program that plays sounds.	FALSE
Student 07	List at least two advantages/characteristics of an object-oriented program.	*It is easy to make a model, and reuse it over and over *It is easier to figure if something is wrong, since the program is visusally doing something
Student 07	The study of the time and space consumed by a computer program is called:	complexity
Student 07	The study of the limitations of algorithmic computation (computer programs) is called	computability
Student 07	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	vector list;for(int x=0; x<10; x++){if(list[x] != 0){ list[x]++;}}
Student 07	Looking at the following pseudo-code, what is the value of x when the program has finished:	0
Student 07	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 07	What modules did you start with?	JavaBOTL
Student 07	How has your overall level of programming experience changed since you participated in the Frontiers program?	Not really. I didn't get indepth enough in any particular subject. It kind of was just exercising my programming mind set
Student 07	Looking at the following pseudo-code, what is the value of x when the program is finished:	10
Student 08	Using inheritance	Sub-classes only need to define differences from, and/or additions to, the parent class
Student 08	How has your overall level of programming experience changed since you participated in the Frontiers program?	I've been able to work with Java and program with cutting-edge internet technologies such as XML.

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 08	The study of the time and space consumed by a computer program is called:	complexity
Student 08	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x	You could create a method in that class which would interact with the variable x. The way some person could change the value without having to deal with x directly would be with the method I created.
Student 08	I have written a Java program that displays graphics.	TRUE
Student 08	I have written a Java program that plays sounds.	FALSE
Student 08	I have written a Java program that handles mouse events.	TRUE
Student 08	I have copied down the directions for accessing the Frontiers CS site as a guest when Frontiers is over.	TRUE
Student 08	Create a simple class definition with two class variables and one class method.	public class simpleclass {int x;int y; public static void main(){ x=0 y=1 if y equals x then { x = x + 1 } else { y = y - 1 }}}
Student 08	Using inheritance	You can define classes that include methods and variables of other classes
Student 08	What modules did you start with?	RoBOTL
Student 08	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 08	Using inheritance	It is possible to create a hierarchy of classes
Student 08	List at least two advantages/characteristics of an object-oriented program.	Two advantages of an object-oriented program are: #NAME?#NAME?
Student 08	What modules did you start with?	JavaBOTL
Student 08	The study of the limitations of algorithmic computation (computer programs) is called	computability
Student 08	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	String[] numbers = {"0","0.2","0.4","0.8","1.0","1.2","2.4","3.8","4","5"};for (int i=0; i<numbers.length(); i++) { if {numbers[i]>0 } numbers[i] = numbers[i] + 1}
Student 08	Looking at the following pseudo-code, what is the value of x when the program is finished:	9
Student 08	Looking at the following pseudo-code, what is the value of x when the program has finished:	0

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 08	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 08	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 08	What modules did you start with?	JavaBOTL, but then went right on to Java
Student 08	Using the simple class you just wrote, create another class that is a sub-class of it,	<pre>public class simpleclass {int x;int y; public static void main() { x=0 y=1 if y equals x then { x = x + 1 } else { y = y - 1 }} class subclass { int a; int b; }}</pre>
Student 08	What modules did you start with?	RoBOTL, but then went right on to javaBOTL
Student 08	What modules did you start with?	Java
Student 08	In object-oriented languages, a class _____	Is a general template that is used to create objects with similar features.
Student 09	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 09	In object-oriented languages, a class _____	Is a general template that is used to create objects with similar features.
Student 09	I have copied down the directions for accessing the Frontiers CS site as a guest when Frontiers is over.	TRUE
Student 09	I have written a Java program that handles mouse events.	TRUE
Student 09	I have written a Java program that plays sounds.	FALSE
Student 09	I have written a Java program that displays graphics.	TRUE
Student 09	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x	
Student 09	Using the simple class you just wrote, create another class that is a sub-class of it,	<pre>import java.awt.*;import java.applet.*;public class Variables extends Applet{int variable1;int variable2; }public void init (){variable1 = 1;variable2 = 2;}</pre>
Student 09	Create a simple class definition with two class variables and one class method.	<pre>import java.awt.*;import java.applet.*;public class Variables extends Applet{int variable1;int variable2; }public void init (){variable1 = 1;variable2 = 2;}</pre>
Student 09	Using inheritance	You can change the internal variables of the class
Student 09	Using inheritance	Sub-classes only need to define differences from, and/or additions to, the parent class



<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 09	What modules did you start with?	Java
Student 09	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 09	How has your overall level of programming experience changed since you participated in the Frontiers program?	I am much more familiar with the basic terms and commands, and also how programs work.
Student 09	List at least two advantages/characteristics of an object-oriented program.	
Student 09	The study of the time and space consumed by a computer program is called:	computability
Student 09	The study of the limitations of algorithmic computation (computer programs) is called	complexity
Student 09	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	
Student 09	Looking at the following pseudo-code, what is the value of x when the program is finished:	10
Student 09	Looking at the following pseudo-code, what is the value of x when the program has finished:	0
Student 09	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 09	What modules did you start with?	JavaBOTL
Student 09	What modules did you start with?	RoBOTL
Student 09	Using inheritance	It is possible to create a hierarchy of classes
Student 10	Looking at the following pseudo-code, what is the value of x when the program has finished:	0
Student 10	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 10	I have copied down the directions for accessing the Frontiers CS site as a guest when Frontiers is over.	TRUE
Student 10	How has your overall level of programming experience changed since you participated in the Frontiers program?	i have gained a great deal of programming knowledge in syntax application and general understanding
Student 10	What modules did you start with?	RoBOTL, but then went right on to javaBOTL

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 10	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 10	Looking at the following pseudo-code, what is the value of x when the program is finished:	10
Student 10	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	public void sortnums (int array[], int numelements){ for (int i=0;int i<numelements;i++) if(array[i]>0) array[i]++;}
Student 10	The study of the limitations of algorithmic computation (computer programs) is called	computability
Student 10	The study of the time and space consumed by a computer program is called:	complexity
Student 10	I have written a Java program that handles mouse events.	TRUE
Student 10	In object-oriented languages, a class _____	describes an object's attribute values.
Student 10	I have written a Java program that displays graphics.	TRUE
Student 10	Using inheritance	It is possible to create a hierarchy of classes
Student 10	Using inheritance	You can define classes that include methods and variables of other classes
Student 10	Using inheritance	Sub-classes only need to define differences from, and/or additions to, the parent class
Student 10	Create a simple class definition with two class variables and one class method.	class book {int num_pages;char bookname[60]; private:int GetPages (void) {return num_pages;}}
Student 10	Using the simple class you just wrote, create another class that is a sub-class of it,	class mystery: public book{char detective[60];char villain[60];};
Student 10	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x	calling a function called SetX which resets the value of x based on user input
Student 10	I have written a Java program that plays sounds.	TRUE
Student 10	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 10	List at least two advantages/characteristics of an object-oriented program.	encapsulation-allowing user to have access but not directlyfunctions of the object that perform tasks

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 11	Using inheritance	It is possible to create a hierarchy of classes
Student 11	What modules did you start with?	RoBOTL
Student 11	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 11	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 11	Looking at the following pseudo-code, what is the value of x when the program has finished:	-1
Student 11	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	for (i+0; i<6; i++)
Student 11	The study of the limitations of algorithmic computation (computer programs) is called	complexity
Student 11	List at least two advantages/characteristics of an object-oriented program.	you have a set thing to make like robots or tic tsc toe
Student 11	How has your overall level of programming experience changed since you participated in the Frontiers program?	i now knojava better andable to learn others with that easier
Student 11	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 11	The study of the time and space consumed by a computer program is called:	computability
Student 11	Using inheritance	Sub-classes only need to define differences from, and/or additions to, the parent class
Student 11	Create a simple class definition with two class variables and one class method.	<pre>public class smiley2 extends Rob{     public void SetWorld() {         left_bot lefty=new left_bot();         lefty.place(World,9,11,"west","blue");         right_bot righty=new right_bot();         righty.place(World,10,11,"east","red");     } }</pre>
Student 11	Using the simple class you just wrote, create another class that is a sub-class of it,	<pre>public class smiley2 extends Rob{     public void SetWorld() {         block(6,13);         block(13,13);         block(14,12);         block(14,5);         block(13,4);         block(9,9);         block(10,9);     } }</pre>
Student 11	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x	X=hiset hi= 14

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 11	I have written a Java program that displays graphics.	TRUE
Student 11	I have written a Java program that plays sounds.	FALSE
Student 11	I have written a Java program that handles mouse events.	TRUE
Student 11	I have copied down the directions for accessing the Frontiers CS site as a guest when Frontiers is over.	FALSE
Student 11	Looking at the following pseudo-code, what is the value of x when the program is finished:	9
Student 11	In object-oriented languages, a class _____	Is a general template that is used to create objects with similar features.
Student 12	I have written a Java program that displays graphics.	FALSE
Student 12	I have written a Java program that plays sounds.	FALSE
Student 12	How has your overall level of programming experience changed since you participated in the Frontiers program?	I went from having no programming experience to having a good start that I can build upon later.
Student 12	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x	
Student 12	Using the simple class you just wrote, create another class that is a sub-class of it,	
Student 12	Create a simple class definition with two class variables and one class method.	
Student 12	Using inheritance	Sub-classes only need to define differences from, and/or additions to, the parent class
Student 12	Using inheritance	You can define classes that include methods and variables of other classes
Student 12	Using inheritance	It is possible to create a hierarchy of classes
Student 12	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 12	What modules did you start with?	RoBOTL
Student 12	I have written a Java program that handles mouse events.	FALSE
Student 12	In object-oriented languages, a class _____	Is a general template that is used to create objects with similar features.
Student 12	Common programming languages are built upon the ability to access a data value using a _____?	Data Type

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 12	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 12	Looking at the following pseudo-code, what is the value of x when the program has finished:	x=1 if y!=0
Student 12	Looking at the following pseudo-code, what is the value of x when the program is finished:	
Student 12	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	
Student 12	The study of the limitations of algorithmic computation (computer programs) is called	computability
Student 12	The study of the time and space consumed by a computer program is called:	complexity
Student 12	List at least two advantages/characteristics of an object-oriented program.	objects can be be reused in other programs.
Student 12	I have copied down the directions for accessing the Frontiers CS site as a guest when Frontiers is over.	FALSE
Student 13	I have written a Java program that handles mouse events.	FALSE
Student 13	When programming, one often wants to store lists of similar data. This can be accomplished through the use of a special collection of locations known as a/an _____.	Array
Student 13	In object-oriented languages, a class _____	Is a general template that is used to create objects with similar features.
Student 13	I have written a Java program that displays graphics.	FALSE
Student 13	Let's say you have a class with a variable x in it. How could you provide a way for someone who wants to use your class to change the value of x without ever having to deal with x	
Student 13	Using the simple class you just wrote, create another class that is a sub-class of it,	
Student 13	Create a simple class definition with two class variables and one class method.	
Student 13	Using inheritance	You can change the internal variables of the class

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 13	Using classes it is possible to create objects that may be used without any knowledge of their inner workings. This technique is called:	Encapsulation
Student 13	I have written a Java program that plays sounds.	FALSE
Student 13	List at least two advantages/characteristics of an object-oriented program.	
Student 13	The study of the time and space consumed by a computer program is called:	computability
Student 13	The study of the limitations of algorithmic computation (computer programs) is called	software engineering
Student 13	Suppose you have an array of 10 Numbers ranging from 0 to 5, write a program or function that will loop through these numbers, adding 1 to each number that is greater than zero. Do it in java if you can; otherwise do it in the programming language (or pse	
Student 13	Looking at the following pseudo-code, what is the value of x when the program has finished:	x = -1
Student 13	Common programming languages are built upon the ability to access a data value using a _____?	Variable
Student 13	What modules did you start with?	RoBOTL
Student 13	How has your overall level of programming experience changed since you participated in the Frontiers program?	yes i learn more about programming in this program. i think i advanced a little about how to work with javaBOLT.but not dat much
Student 13	I have copied down the directions for accessing the Frontiers CS site as a guest when Frontiers is over.	FALSE
Student 13	Looking at the following pseudo-code, what is the value of x when the program is finished:	100

## **Appendix D: Survey**

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 01	Did you work on any of the course materials outside of the scheduled lab hours?	yes
Student 01	How much did JavaBOTL aid in your learning of Java?	None
Student 01	Is there anything else you'd like to say?	thanks
Student 01	What advice would you offer next year's group?	hurry through the modules very quickly, then take the time necessary to become familiar with any and all programming syntax that may prove helpful (such as java swing)
Student 01	How effective was your project advisor in answering your questions?	very effective (most of the time)
Student 01	Did the staff spend too much time with your group, too little time with your group, or just enough time with your group?	just enough
Student 01	In general, how knowledgeable was the staff?	Somewhat knowledgeable
Student 01	Did you feel there were enough teachers/advisors/staff to help you out?	yes
Student 01	Of the features you wanted to add to your project, approximately how many were you able to add?	0.5
Student 01	Did you feel there was enough time to complete your project?	no
Student 01	How interesting was the project you worked on?	Somewhat interesting
Student 01	How interesting were the projects overall?	Interesting
Student 01	Were the subjects of the group projects (networks, databases, etc...) 'too diverse,' 'not diverse enough,' or 'just	just right
Student 01	How would you rate the difficulty of the project you worked on?	Somewhat easy
Student 01	What was your role in the group's accomplishments?	i coded some of the actual linking program from java to oracle, and i coded the applet that was supposed to house the linking program.
Student 01	Which set of modules did you start with? (RoBOTL, JavaBOTL, or Java)	java
Student 01	How can the projects be improved? Please be as specific as possible.	there could be more time to complete the projects. furthermore, there could be more exploration for the projects; people could find out more for themselves instead of getting almost everything that was necessary from the project description.
Student 01	What was your least favorite aspect of working in groups?	there was not enough time for each group member to completely understand everything that went into the project.



<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 01	From which part of the CS Frontiers program did you learn the most? (morning modules, afternoon modules, or group projects)	i learned the most from the afternoon modules, because before coming here i had no idea how to write html, and now i can. Java syntax, which is basically all i learned in the other two, was so similar to c++ that i simply could not learn much from it.
Student 01	From which part of the CS Frontiers program did you learn the least? (morning modules, afternoon modules, or group projects)	i learned the least from the morning modules, because it was the most similar to assignments that i have completed in the past.
Student 01	How would you rate the lab and computer systems?	Fair
Student 01	Which part of the CS Frontiers program was the least enjoyable? (Morning modules, afternoon modules, group projects)	morning modules
Student 01	Which part of the CS Frontiers program did you enjoy the most? (Morning modules, afternoon modules, group projects)	group projects
Student 01	If you did not complete all the modules, which module set did you last work with? (RoBOTL, JavaBOTL, Java)	
Student 01	Which module did you like the most?	java 4
Student 01	How much did RoBOTL aid in your learning of Java?	None
Student 01	How much did you enjoy working in groups?	A little
Student 01	How well do you feel your group worked together?	Fairly well
Student 01	How would you evaluate the variation in skill level among your group members? As "too varied," "not varied enough," or "just right?"	too varied
Student 01	What was your favorite aspect of working in groups?	each group member brought what they knew, and people were able to accomplish more. errors were easier to spot while an outside eye observed your code.
Student 01	If you could have spent more time on any topic (in general), which would it be?	i would spend more time on the group project, because it presents the greatest challenge to me.
Student 02	How would you rate the difficulty of the project you worked on?	Very difficult
Student 02	Of the features you wanted to add to your project, approximately how many were you able to add?	0.75
Student 02	Were the subjects of the group projects (networks, databases, etc...) 'too diverse,' 'not diverse enough,' or 'just	make more interesting/easier projects
Student 02	How interesting were the projects overall?	Somewhat dull
Student 02	How interesting was the project you worked on?	Somewhat dull

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 02	Did you feel there was enough time to complete your project?	yes
Student 02	Did you work on any of the course materials outside of the scheduled lab hours?	no
Student 02	How can the projects be improved? Please be as specific as possible.	make them more interesting
Student 02	Did you feel there were enough teachers/advisors/staff to help you out?	yes
Student 02	In general, how knowledgeable was the staff?	Somewhat knowledgeable
Student 02	Did the staff spend too much time with your group, too little time with your group, or just enough time with your group?	too much, except when we needed him
Student 02	How effective was your project advisor in answering your questions?	somewhat effective
Student 02	Which part of the CS Frontiers program was the least enjoyable? (Morning modules, afternoon modules, group projects)	web programming
Student 02	What was your role in the group's accomplishments?	I debugged.
Student 02	If you did not complete all the modules, which module set did you last work with? (RoBOTL, JavaBOTL, Java)	-
Student 02	What advice would you offer next year's group?	bring a jacket
Student 02	How would you rate the lab and computer systems?	Excellent
Student 02	How much did RoBOTL aid in your learning of Java?	None
Student 02	What was your least favorite aspect of working in groups?	people
Student 02	From which part of the CS Frontiers program did you learn the most? (morning modules, afternoon modules, or group projects)	Morning, since I could already do the HTML in the afternoons.
Student 02	If you could have spent more time on any topic (in general), which would it be?	basics of forms
Student 02	Which part of the CS Frontiers program did you enjoy the most? (Morning modules, afternoon modules, group projects)	afternoon modules
Student 02	Which set of modules did you start with? (RoBOTL, JavaBOTL, or Java)	Java
Student 02	Is there anything else you'd like to say?	no
Student 02	Which module did you like the most?	Java module 3(?)
Student 02	How much did JavaBOTL aid in your learning of Java?	None

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 02	How much did you enjoy working in groups?	Some
Student 02	How well do you feel your group worked together?	Fairly well
Student 02	How would you evaluate the variation in skill level among your group members? As "too varied," "not varied enough," or "just right?"	not much variation
Student 02	What was your favorite aspect of working in groups?	work split
Student 02	From which part of the CS Frontiers program did you learn the least? (morning modules, afternoon modules, or group projects)	<see above>
Student 03	How would you evaluate the variation in skill level among your group members? As "too varied," "not varied enough," or "just right?"	just right
Student 03	If you did not complete all the modules, which module set did you last work with? (RoBOTL, JavaBOTL, Java)	i did complete all
Student 03	How well do you feel your group worked together?	Very well
Student 03	How much did you enjoy working in groups?	Some
Student 03	How much did JavaBOTL aid in your learning of Java?	Some
Student 03	How much did RoBOTL aid in your learning of Java?	None
Student 03	Which module did you like the most?	Java - TicTacToe
Student 03	Which set of modules did you start with? (RoBOTL, JavaBOTL, or Java)	JavaBOTL
Student 03	How would you rate the lab and computer systems?	Good
Student 03	If you could have spent more time on any topic (in general), which would it be?	java - learnign more about the different classes, and then doing work on the project based on what we had learned( i think trying to teach four different languages in two weeks is too much, just focus on one, two at the most(java + HTML).
Student 03	From which part of the CS Frontiers program did you learn the least? (morning modules, afternoon modules, or group projects)	afternoon modules, because i already knew HTML
Student 03	From which part of the CS Frontiers program did you learn the most? (morning modules, afternoon modules, or group projects)	group projects(because the networkign stuff was all new to me, so I learned a lot about how networks function and how to use the java methods to create a working client/server pair.
Student 03	Which part of the CS Frontiers program did you enjoy the most? (Moming modules, afternoon modules, group projects)	morning modules

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 03	What was your favorite aspect of working in groups?	Ability to get different viewpoints, and if one person was having a bad day, the other could pick up the slack
Student 03	Which part of the CS Frontiers program was the least enjoyable? (Morning modules, afternoon modules, group projects)	afternoon modules
Student 03	Did you feel there were enough teachers/advisors/staff to help you out?	yes
Student 03	What advice would you offer next year's group?	plan out the project before starting - gather general information on all classes you might need, and then narrow it down to exactly how you will complete the
Student 03	Is there anything else you'd like to say?	I really liked the network project idea, i just think it would've been better if we could get the code right away, learn how it functions, and then begin adding features to both the server and client to make it more functional, instead of doign all the ni
Student 03	How effective was your project advisor in answering your questions?	very effective - he knew what he was talking about
Student 03	What was your least favorite aspect of working in groups?	we didnt always have an advisor to help us, because he was helping his other group
Student 03	In general, how knowledgeable was the staff?	Somewhat knowledgeable
Student 03	How can the projects be improved? Please be as specific as possible.	Give some introductory code, so the project can get up and running, and then, with appropriate resources available, add to the project through research to make it more functional
Student 03	Of the features you wanted to add to your project, approximately how many were you able to add?	0.75
Student 03	Did you work on any of the course materials outside of the scheduled lab hours?	a little, but not too much - i think we should've had more time for the project, and less for modules(group by skill, so 2 fast learners could start project sooner)
Student 03	Did you feel there was enough time to complete your project?	no
Student 03	How interesting was the project you worked on?	Very interesting
Student 03	How interesting were the projects overall?	Very interesting
Student 03	Were the subjects of the group projects (networks, databases, etc...) 'too diverse,' 'not diverse enough,' or 'just	just right - something for everybody
Student 03	How would you rate the difficulty of the project you worked on?	Very difficult
Student 03	What was your role in the group's accomplishments?	i did some of the coding, worked out some of the logic
Student 03	Did the staff spend too much time with your group, too little time with your group, or just enough time with your group?	to little time
Student 04	How effective was your project advisor in answering your questions?	project advisor was effective

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 04	What was your role in the group's accomplishments?	Made classes Made charts Played with smartboard
Student 04	How would you rate the difficulty of the project you worked on?	Somewhat difficult
Student 04	Were the subjects of the group projects (networks, databases, etc...) 'too diverse,' 'not diverse enough,' or 'just	'just right?'
Student 04	How interesting were the projects overall?	Very interesting
Student 04	How interesting was the project you worked on?	Very interesting
Student 04	Did you feel there was enough time to complete your project?	very close
Student 04	Did you work on any of the course materials outside of the scheduled lab hours?	no
Student 04	Of the features you wanted to add to your project, approximately how many were you able to add?	0.75
Student 04	How can the projects be improved? Please be as specific as possible.	they're perfect
Student 04	Did you feel there were enough teachers/advisors/staff to help you out?	yep
Student 04	In general, how knowledgeable was the staff?	Very knowledgeable
Student 04	What advice would you offer next year's group?	work ;)
Student 04	Is there anything else you'd like to say?	nope
Student 04	Which set of modules did you start with? (RoBOTL, JavaBOTL, or Java)	Java
Student 04	Did the staff spend too much time with your group, too little time with your group, or just enough time with your group?	just enough time with your group?
Student 04	How would you rate the lab and computer systems?	Excellent
Student 04	How much did JavaBOTL aid in your learning of Java?	
Student 04	Which part of the CS Frontiers program did you enjoy the most? (Morning modules, afternoon modules, group projects)	Morning modules
Student 04	Which part of the CS Frontiers program was the least enjoyable? (Morning modules, afternoon modules, group projects)	afternoon modules
Student 04	From which part of the CS Frontiers program did you learn the most? (morning modules, afternoon modules, or group projects)	morning modules or group projects I learned things I may not have known before, because I already had experience with HTML and UNIX.

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 04	Which module did you like the most?	Tic Tac Toe
Student 04	If you could have spent more time on any topic (in general), which would it be?	Making nifty games.
Student 04	What was your least favorite aspect of working in groups?	Got Stuck
Student 04	If you did not complete all the modules, which module set did you last work with? (RoBOTL, JavaBOTL, Java)	
Student 04	How much did RoBOTL aid in your learning of Java?	
Student 04	How much did you enjoy working in groups?	Some
Student 04	How well do you feel your group worked together?	Very well
Student 04	How would you evaluate the variation in skill level among your group members? As "too varied," "not varied enough," or "just right?"	just about right
Student 04	What was your favorite aspect of working in groups?	Blackjack
Student 04	From which part of the CS Frontiers program did you learn the least? (morning modules, afternoon modules, or group projects)	afternoon modules! already had experience with HTML and UNIX.
Student 05	What was your role in the group's accomplishments?	I did all of the database work, wrote a function that converts queries to a certain case(with aid of the UG's) and helped Kevin with his coding of the applet whenever he needed a break or someone to look at it.
Student 05	Of the features you wanted to add to your project, approximately how many were you able to add?	0.75
Student 05	What was your favorite aspect of working in groups?	Working together and assigning different tasks to different members of the group in order to create things succesfully and efficently provided knowledge of a very important aspect of programming that can't be covered in afternoon or morning modules.
Student 05	Is there anything else you'd like to say?	I had a great two weeks. Not only did the UG's teach me a lot about what programming is like, and provide me with information that will allow me to choose the right future, but they also acted in such a natural manner that I was able to get some insight
Student 05	What advice would you offer next year's group?	If you don't understand any material, make sure that you take your time so you can grasp it fully. As much knowledge about Java as possible will come in very handy when you begin work on your projects.
Student 05	How effective was your project advisor in answering your questions?	He was excellent. He was very knowledgeable about Oracle, but made sure not to help us too much when it came to working with the database. He was very helpful with the Java syntax needed and troubleshooting.
Student 05	Did the staff spend too much time with your group, too little time with your group, or just enough time with your group?	just enough. they were there when i needed aid but didn't seem overbearing and made sure I did work on my

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 05	In general, how knowledgeable was the staff?	Very knowledgeable
Student 05	Which part of the CS Frontiers program was the least enjoyable? (Morning modules, afternoon modules, group projects)	none
Student 05	How can the projects be improved? Please be as specific as possible.	I don't think that I can suggest any changes other than giving the students more time, but i think that is pretty much impossible.
Student 05	Did you work on any of the course materials outside of the scheduled lab hours?	yes
Student 05	Did you feel there was enough time to complete your project?	There was enough time to complete the given requirements, however I would have liked to go into a bit more depth.
Student 05	How interesting was the project you worked on?	Very interesting
Student 05	How interesting were the projects overall?	Very interesting
Student 05	Were the subjects of the group projects (networks, databases, etc...) 'too diverse,' 'not diverse enough,' or 'just	I thought they were good, but it would be really interesting if we had more time and could weave the projects together. ie databases and XML would have been feasible.
Student 05	How would you rate the difficulty of the project you worked on?	Somewhat difficult
Student 05	Which set of modules did you start with? (RoBOTL, JavaBOTL, or Java)	RoBOTL (only worked on it for .5 a day)
Student 05	Did you feel there were enough teachers/advisors/staff to help you out?	yes
Student 05	From which part of the CS Frontiers program did you learn the most? (morning modules, afternoon modules, or group projects)	Although the afternoon modules were good, i didnt have to think for myself. There were very strict guidelines to follow. I feel the group projects were the best form of learning because it was an interesting application of the material that forced you to
Student 05	Which part of the CS Frontiers program did you enjoy the most? (Morning modules, afternoon modules, group projects)	group projects
Student 05	From which part of the CS Frontiers program did you learn the least? (morning modules, afternoon modules, or group projects)	Between afternoon modules and morning modules, I think I learned equally, however the morning modules were less applicable and seemed to be rather irrelevant to the material that we were working on in the afternoon modules and group projects.
Student 05	How would you rate the lab and computer systems?	Excellent
Student 05	If you did not complete all the modules, which module set did you last work with? (RoBOTL, JavaBOTL, Java)	Finished all
Student 05	Which module did you like the most?	Java...all of it. It was the most challenging.
Student 05	How much did RoBOTL aid in your learning of Java?	Not much

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 05	How much did JavaBOTL aid in your learning of Java?	Some
Student 05	How much did you enjoy working in groups?	Very much
Student 05	How well do you feel your group worked together?	Very well
Student 05	How would you evaluate the variation in skill level among your group members? As "too varied," "not varied enough," or "just right?"	just right
Student 05	What was your least favorite aspect of working in groups?	I personally enjoyed working in groups, however, groups of three can be a bit tricky because sometimes it is hard to distribute all the work evenly, especially between a variety of skill levels.
Student 05	If you could have spent more time on any topic (in general), which would it be?	I would have liked to have gone a bit more in depth on Java, thus allowing the database project to be more succesfull and advanced.
Student 06	What was your role in the group's accomplishments?	I did all the points in the graphics project. I did all the for loops so I mapped out all the pixels on the screen.
Student 06	Is there anything else you'd like to say?	Thanks :)
Student 06	Did you work on any of the course materials outside of the scheduled lab hours?	yes
Student 06	Were the subjects of the group projects (networks, databases, etc...) 'too diverse,' 'not diverse enough,' or 'just	Just right, but I wish i could have had the chance to work on Cryptography..
Student 06	How interesting were the projects overall?	Interesting
Student 06	How interesting was the project you worked on?	Interesting
Student 06	Did you feel there was enough time to complete your project?	yes
Student 06	Of the features you wanted to add to your project, approximately how many were you able to add?	0.75
Student 06	How can the projects be improved? Please be as specific as possible.	be a little more specific on what to draw? I suppose but Other than that.. nothing
Student 06	Did you feel there were enough teachers/advisors/staff to help you out?	yes
Student 06	In general, how knowledgeable was the staff?	Very knowledgeable
Student 06	Did the staff spend too much time with your group, too little time with your group, or just enough time with your group?	just enough
Student 06	What advice would you offer next year's group?	Have fun!
Student 06	What was your least favorite aspect of working in groups?	Not being able to work with friends
Student 06	How effective was your project advisor in answering your questions?	Very effective, he helped us whenever we needed it.



<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 06	If you could have spent more time on any topic (in general), which would it be?	Java Syntax
Student 06	How would you rate the difficulty of the project you worked on?	Somewhat difficult
Student 06	Which part of the CS Frontiers program was the least enjoyable? (Morning modules, afternoon modules, group projects)	Afternoon modules
Student 06	What was your favorite aspect of working in groups?	being able to throw ideas at each other and see what they think
Student 06	From which part of the CS Frontiers program did you learn the least? (morning modules, afternoon modules, or group projects)	Afternoon modules because I already knew everything in the afternoon modules.
Student 06	Which part of the CS Frontiers program did you enjoy the most? (Morning modules, afternoon modules, group projects)	Morning Modules
Student 06	How would you rate the lab and computer systems?	Excellent
Student 06	Which set of modules did you start with? (RoBOTL, JavaBOTL, or Java)	JavaBOTL
Student 06	If you did not complete all the modules, which module set did you last work with? (RoBOTL, JavaBOTL, Java)	completed all
Student 06	Which module did you like the most?	Tic Tac Toe
Student 06	How much did RoBOTL aid in your learning of Java?	None
Student 06	How much did JavaBOTL aid in your learning of Java?	Not much
Student 06	How much did you enjoy working in groups?	Some
Student 06	How well do you feel your group worked together?	Fairly well
Student 06	How would you evaluate the variation in skill level among your group members? As "too varied," "not varied enough," or "just right?"	just right
Student 06	From which part of the CS Frontiers program did you learn the most? (morning modules, afternoon modules, or group projects)	Morning Modules because I had no prior experience with JAVA
Student 07	Were the subjects of the group projects (networks, databases, etc...) 'too diverse,' 'not diverse enough,' or 'just	Ok, this is a suggestion, if this ever planned to be done again. Each group actually is doing a part of a larger project, which will mysteriously come together at the end. So, some people do graphics, others design, some actual code, and different things
Student 07	How interesting were the projects overall?	Somewhat interesting
Student 07	How interesting was the project you worked on?	Somewhat interesting

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 07	Did you feel there was enough time to complete your project?	No, why did you all delay so long in letting us start?
Student 07	Did you work on any of the course materials outside of the scheduled lab hours?	YES: Morning modules for a while, but mostly project stuff
Student 07	Of the features you wanted to add to your project, approximately how many were you able to add?	0.75
Student 07	How can the projects be improved? Please be as specific as possible.	It working? Also, even when/if it works, I would really like to have had actual pics of cards instead of little
Student 07	Did you feel there were enough teachers/advisors/staff to help you out?	I guess enough, but tried to do stuff alone
Student 07	In general, how knowledgeable was the staff?	Somewhat knowledgeable
Student 07	Did the staff spend too much time with your group, too little time with your group, or just enough time with your group?	I don't know. If we had a better java learning module, we wouldn't have hit so many snags. I'll say middle of the road to be safe
Student 07	How effective was your project advisor in answering your questions?	Effective. A mix of straight out telling, making search, and suggesting
Student 07	How would you rate the difficulty of the project you worked on?	Somewhat difficult
Student 07	Is there anything else you'd like to say?	Can I come again? Ummmm, there should be either a seperation of different levels, or the description should be more clearly defined. I know the module was supposed to acomplish peoples varying levels, but then you slap them together in a group, and it do
Student 07	If you did not complete all the modules, which module set did you last work with? (RoBOTL, JavaBOTL, Java)	web programming
Student 07	What advice would you offer next year's group?	Learn java... experiment before asking questions too. It might lead to bigger problems to fix, but it is more fun
Student 07	Which module did you like the most?	Web programing stuff
Student 07	Which part of the CS Frontiers program did you enjoy the most? (Morning modules, afternoon modules, group projects)	Morning Modules
Student 07	Which part of the CS Frontiers program was the least enjoyable? (Morning modules, afternoon modules, group projects)	afternoon modules
Student 07	From which part of the CS Frontiers program did you learn the most? (morning modules, afternoon modules, or group projects)	Group: because we had learned barely any java, and we had to bumble through writing a program, without much clue of the syntax. It was interesting
Student 07	From which part of the CS Frontiers program did you learn the least? (morning modules, afternoon modules, or group projects)	Afternoon, because I taught myself html and can make a nice professional looking page (if I want to) already
Student 07	If you could have spent more time on any topic (in general), which would it be?	More complex stuff. The modules were really easy and did not challenge me at all.

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 07	How much did RoBOTL aid in your learning of Java?	None
Student 07	Which set of modules did you start with? (RoBOTL, JavaBOTL, or Java)	JavaBOTL
Student 07	What was your role in the group's accomplishments?	A lot of the code/coordination. Recorded information from the planning stage, and did help flesh out the planning concepts. etc?
Student 07	How much did JavaBOTL aid in your learning of Java?	None
Student 07	How much did you enjoy working in groups?	Some
Student 07	How well do you feel your group worked together?	Fairly well
Student 07	How would you evaluate the variation in skill level among your group members? As "too varied," "not varied enough," or "just right?"	too varied
Student 07	What was your favorite aspect of working in groups?	Seeing all the separate parts come together. If it worked also, I would be estatic, but they did fit together. It was like we each made a few jigsaw pieces that fit together, put still didn't have a clear picture
Student 07	What was your least favorite aspect of working in groups?	Either the varriance of ability, or other people copping out. I understand a break once in a while, but I did outside work on this too.
Student 07	How would you rate the lab and computer systems?	Good
Student 08	What was your favorite aspect of working in groups?	Small groups - individualized learning
Student 08	What advice would you offer next year's group?	none - I enjoyed my time here these past two weeks.
Student 08	Did the staff spend too much time with your group, too little time with your group, or just enough time with your group?	Just enough
Student 08	In general, how knowledgeable was the staff?	Very knowledgeable
Student 08	Did you feel there were enough teachers/advisors/staff to help you out?	Yes
Student 08	How can the projects be improved? Please be as specific as possible.	Project outline's are perfect, but sample code and/or tutorials should be appendixed in digital form (e.g. web).
Student 08	Of the features you wanted to add to your project, approximately how many were you able to add?	0.75
Student 08	Did you work on any of the course materials outside of the scheduled lab hours?	Yes, read through CS Frontiers book (very helpful aid)
Student 08	Did you feel there was enough time to complete your project?	Barely enough to do project requirements
Student 08	How interesting was the project you worked on?	Very interesting

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 08	How interesting were the projects overall?	Very interesting
Student 08	Were the subjects of the group projects (networks, databases, etc...) 'too diverse,' 'not diverse enough,' or 'just	JUST RIGHT - I had trouble deciding which one to choose. I did get my first selection.
Student 08	How would you rate the difficulty of the project you worked on?	Very difficult
Student 08	How effective was your project advisor in answering your questions?	Very Effective. His experience with XML in a production environment (IBM Co-Op) made Josh very effective in answering any questions we had.
Student 08	What was your least favorite aspect of working in groups?	Small groups - two members (has it's ups & downs) - object group selection criteria was not disclosed to students (possibly subjective)
Student 08	Which module did you like the most?	Tic-Tac-Toe
Student 08	Which part of the CS Frontiers program was the least enjoyable? (Morning modules, afternoon modules, group projects)	morning modules
Student 08	From which part of the CS Frontiers program did you learn the most? (morning modules, afternoon modules, or group projects)	group projects
Student 08	From which part of the CS Frontiers program did you learn the least? (morning modules, afternoon modules, or group projects)	afternoon modules, I have used HTML for a very long time and the PERL modules are starting to become dated with the arrival of server-side HTML preprocessing, such as (ASP, PHP, ColdFusion, JSP, etc.)
Student 08	If you could have spent more time on any topic (in general), which would it be?	web-programming with XML, Java, & SQL - additional theory lectures may have been fun for some students. I enjoyed the two which were presented.
Student 08	How would you rate the lab and computer systems?	Good
Student 08	What was your role in the group's accomplishments?	Worked with Sun Micro's JAXP and DOM standards to parse XML. Wrote application-logic. Adapted and integrated third-party code to write XML back from memory.
Student 08	If you did not complete all the modules, which module set did you last work with? (RoBOTL, JavaBOTL, Java)	Completed
Student 08	Which part of the CS Frontiers program did you enjoy the most? (Morning modules, afternoon modules, group projects)	group projects
Student 08	How much did RoBOTL aid in your learning of Java?	Some
Student 08	How much did JavaBOTL aid in your learning of Java?	Very much
Student 08	How much did you enjoy working in groups?	Some
Student 08	How well do you feel your group worked together?	Fairly well

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 08	Is there anything else you'd like to say?	I would just like to thank the staff for their effort and time put into this program. It was very successful. I really appreciate the attention in making sure everyone in the program was challenged, and how everyone's Frontiers experience was individual
Student 08	How would you evaluate the variation in skill level among your group members? As "too varied," "not varied enough," or "just right?"	just right
Student 08	Which set of modules did you start with? (RoBOTL, JavaBOTL, or Java)	RoBOTL
Student 09	What was your least favorite aspect of working in groups?	Not being able to contribute a lot due to the lack of programming skill.
Student 09	What was your role in the group's accomplishments?	Helping with the presentation and the coding.
Student 09	Is there anything else you'd like to say?	no
Student 09	What advice would you offer next year's group?	none
Student 09	How effective was your project advisor in answering your questions?	Somewhat effective
Student 09	Did the staff spend too much time with your group, too little time with your group, or just enough time with your group?	too little/just enough
Student 09	In general, how knowledgeable was the staff?	Very knowledgeable
Student 09	Did you feel there were enough teachers/advisors/staff to help you out?	yes
Student 09	How can the projects be improved? Please be as specific as possible.	More preparation
Student 09	Of the features you wanted to add to your project, approximately how many were you able to add?	1
Student 09	Did you work on any of the course materials outside of the scheduled lab hours?	yes
Student 09	Did you feel there was enough time to complete your project?	not really
Student 09	How interesting was the project you worked on?	Somewhat interesting
Student 09	How interesting were the projects overall?	Somewhat interesting
Student 09	Were the subjects of the group projects (networks, databases, etc...) 'too diverse,' 'not diverse enough,' or 'just	just right
Student 09	How would you evaluate the variation in skill level among your group members? As "too varied," "not varied enough," or "just right?"	just right

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 09	If you did not complete all the modules, which module set did you last work with? (RoBOTL, JavaBOTL, Java)	Java
Student 09	Which part of the CS Frontiers program did you enjoy the most? (Morning modules, afternoon modules, group projects)	Morning modules
Student 09	Which part of the CS Frontiers program was the least enjoyable? (Morning modules, afternoon modules, group projects)	afternoon modules
Student 09	From which part of the CS Frontiers program did you learn the most? (morning modules, afternoon modules, or group projects)	I learned the most from the morning modules because all of it (RoBOTL, JavaBOTL, java) is new to me. I already knew the html in the Afternoon labs, and I spent more time on the modules than the group projects.
Student 09	From which part of the CS Frontiers program did you learn the least? (morning modules, afternoon modules, or group projects)	The afternoon modules because I already knew the html that was in the lab.
Student 09	If you could have spent more time on any topic (in general), which would it be?	The morning modules because I am not done them.
Student 09	Which set of modules did you start with? (RoBOTL, JavaBOTL, or Java)	RoBOTL
Student 09	How would you rate the difficulty of the project you worked on?	Very difficult
Student 09	How much did RoBOTL aid in your learning of Java?	Not much
Student 09	How much did JavaBOTL aid in your learning of Java?	Some
Student 09	How much did you enjoy working in groups?	Some
Student 09	How well do you feel your group worked together?	Very well
Student 09	What was your favorite aspect of working in groups?	If one person didn't know it, then the other probably did.
Student 09	Which module did you like the most?	when you had to turn on the computers using JavaBOTL
Student 09	How would you rate the lab and computer systems?	Good
Student 10	What was your role in the group's accomplishments?	research and development
Student 10	What was your least favorite aspect of working in groups?	having to know when to give up on a bad idea and search for a new one
Student 10	What advice would you offer next year's group?	skip to java, its not bad, and read the FQP choices carefully
Student 10	Which part of the CS Frontiers program was the least enjoyable? (Morning modules, afternoon modules, group projects)	morning modules(robotl and javabotl)

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 10	From which part of the CS Frontiers program did you learn the most? (morning modules, afternoon modules, or group projects)	afternoon modules, i've never done any webpage design before and i got a lot out of learning how to do it
Student 10	From which part of the CS Frontiers program did you learn the least? (morning modules, afternoon modules, or group projects)	morning modules, their relevance in programming, aside from syntax and a basic understanding, was minimal
Student 10	If you could have spent more time on any topic (in general), which would it be?	webpage design
Student 10	How would you rate the lab and computer systems?	Good
Student 10	Which set of modules did you start with? (RoBOTL, JavaBOTL, or Java)	robotl
Student 10	If you did not complete all the modules, which module set did you last work with? (RoBOTL, JavaBOTL, Java)	javabotl
Student 10	Which module did you like the most?	all the web page design modules
Student 10	How much did RoBOTL aid in your learning of Java?	Not much
Student 10	How much did JavaBOTL aid in your learning of Java?	Not much
Student 10	How much did you enjoy working in groups?	Some
Student 10	Which part of the CS Frontiers program did you enjoy the most? (Morning modules, afternoon modules, group projects)	afternoon modules
Student 10	How would you evaluate the variation in skill level among your group members? As "too varied," "not varied enough," or "just right?"	just right
Student 10	What was your favorite aspect of working in groups?	different views on how to solve the same problem
Student 10	How would you rate the difficulty of the project you worked on?	Somewhat difficult
Student 10	Were the subjects of the group projects (networks, databases, etc...) 'too diverse,' 'not diverse enough,' or 'just	just right
Student 10	How interesting were the projects overall?	Somewhat interesting
Student 10	How interesting was the project you worked on?	Somewhat interesting
Student 10	Did you feel there was enough time to complete your project?	yes and no, there was time for simple stuff but not for a larger scale example
Student 10	Did you work on any of the course materials outside of the scheduled lab hours?	no

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 10	Of the features you wanted to add to your project, approximately how many were you able to add?	0.5
Student 10	How can the projects be improved? Please be as specific as possible.	more time, more specific instructions
Student 10	Did you feel there were enough teachers/advisors/staff to help you out?	yes
Student 10	In general, how knowledgeable was the staff?	Very knowledgeable
Student 10	Did the staff spend too much time with your group, too little time with your group, or just enough time with your group?	just enough
Student 10	How effective was your project advisor in answering your questions?	he was a great help
Student 10	How well do you feel your group worked together?	Fairly well
Student 10	Is there anything else you'd like to say?	thanks for everything, enjoy the rest of your summer(s)
Student 11	How can the projects be improved? Please be as specific as possible.	more time
Student 11	Which part of the CS Frontiers program did you enjoy the most? (Morning modules, afternoon modules, group projects)	all
Student 11	How interesting were the projects overall?	Somewhat interesting
Student 11	How interesting was the project you worked on?	Somewhat interesting
Student 11	Did you feel there was enough time to complete your project?	no
Student 11	From which part of the CS Frontiers program did you learn the most? (morning modules, afternoon modules, or group projects)	all taught me something i didnt kno
Student 11	Of the features you wanted to add to your project, approximately how many were you able to add?	0.5
Student 11	What was your role in the group's accomplishments?	making the picture setting
Student 11	Did you feel there were enough teachers/advisors/staff to help you out?	yup
Student 11	In general, how knowledgeable was the staff?	Very knowledgeable
Student 11	Did the staff spend too much time with your group, too little time with your group, or just enough time with your group?	just enough
Student 11	How effective was your project advisor in answering your questions?	good
Student 11	What advice would you offer next year's group?	dont pick XML



<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 11	Is there anything else you'd like to say?	nop
Student 11	Did you work on any of the course materials outside of the scheduled lab hours?	yup
Student 11	How would you rate the difficulty of the project you worked on?	Very difficult
Student 11	What was your least favorite aspect of working in groups?	too small
Student 11	What was your favorite aspect of working in groups?	meet people
Student 11	How would you evaluate the variation in skill level among your group members? As "too varied," "not varied enough," or "just right?"	too varied
Student 11	How well do you feel your group worked together?	Fairly well
Student 11	How much did you enjoy working in groups?	Some
Student 11	How much did JavaBOTL aid in your learning of Java?	Very much
Student 11	How much did RoBOTL aid in your learning of Java?	Very much
Student 11	Which module did you like the most?	tictactoe
Student 11	If you did not complete all the modules, which module set did you last work with? (RoBOTL, JavaBOTL, Java)	tictactoe
Student 11	Which set of modules did you start with? (RoBOTL, JavaBOTL, or Java)	robotl
Student 11	How would you rate the lab and computer systems?	Good
Student 11	If you could have spent more time on any topic (in general), which would it be?	java
Student 11	From which part of the CS Frontiers program did you learn the least? (morning modules, afternoon modules, or group projects)	none
Student 11	Were the subjects of the group projects (networks, databases, etc...) 'too diverse,' 'not diverse enough,' or 'just	'just right
Student 11	Which part of the CS Frontiers program was the least enjoyable? (Morning modules, afternoon modules, group projects)	none
Student 12	Which set of modules did you start with? (RoBOTL, JavaBOTL, or Java)	RoBOTL
Student 12	What was your favorite aspect of working in groups?	

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 12	How would you evaluate the variation in skill level among your group members? As "too varied," "not varied enough," or "just right?"	too varied: I had much less skill than the others, although that may be a good thing because I couldn't have done it at all without them.
Student 12	How well do you feel your group worked together?	Very well
Student 12	How much did you enjoy working in groups?	Very much
Student 12	How much did JavaBOTL aid in your learning of Java?	
Student 12	How much did RoBOTL aid in your learning of Java?	
Student 12	What was your least favorite aspect of working in groups?	It was hard for me to contribute to the actual programming in the group.
Student 12	If you did not complete all the modules, which module set did you last work with? (RoBOTL, JavaBOTL, Java)	I had just started JavaBOTL, but didn't really get to working with it.
Student 12	From which part of the CS Frontiers program did you learn the most? (morning modules, afternoon modules, or group projects)	I think I learned the most in the morning modules because it taught programming, which I previously knew nothing about. The web design labs in the afternoon were also helpful.
Student 12	How would you rate the lab and computer systems?	Good
Student 12	If you could have spent more time on any topic (in general), which would it be?	I would have spent more time on the morning modules.
Student 12	From which part of the CS Frontiers program did you learn the least? (morning modules, afternoon modules, or group projects)	I learned the least in the group project because the required work was above my programming ability and I didn't have time to learn it all at once.
Student 12	Which part of the CS Frontiers program did you enjoy the most? (Morning modules, afternoon modules, group projects)	morning modules
Student 12	Which part of the CS Frontiers program was the least enjoyable? (Morning modules, afternoon modules, group projects)	Afternoon modules were good but frustrating because I had to learn to use UNIX.
Student 12	Which module did you like the most?	RoBOTL module 4
Student 12	Did you feel there were enough teachers/advisors/staff to help you out?	yes.
Student 12	What advice would you offer next year's group?	Try to do as many programming modules as possible before you start.
Student 12	How effective was your project advisor in answering your questions?	He was very effective in helping us plan how to do the project. He was less helpful in teaching me the basics of Java, but I was probably supposed to already know some before we started.
Student 12	What was your role in the group's accomplishments?	I contributed in the planning stages and I made the web site for the presentation.
Student 12	In general, how knowledgeable was the staff?	Somewhat knowledgeable

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 12	Is there anything else you'd like to say?	Please contact Nantucket High School and make them offer a CS course. I know you can't just do that, but I wish it were possible.
Student 12	How can the projects be improved? Please be as specific as possible.	See question 19. Also, maybe some of the projects could be designed for specific skill levels.
Student 12	Of the features you wanted to add to your project, approximately how many were you able to add?	0.75
Student 12	Did you work on any of the course materials outside of the scheduled lab hours?	No.
Student 12	Did you feel there was enough time to complete your project?	I'm not sure.
Student 12	How interesting was the project you worked on?	Very interesting
Student 12	How interesting were the projects overall?	Very interesting
Student 12	Were the subjects of the group projects (networks, databases, etc...) 'too diverse,' 'not diverse enough,' or 'just	Diversity was just right, but I think it might be a good idea to have the different projects combine into one big project in the end, with different groups working on different aspects of it.
Student 12	How would you rate the difficulty of the project you worked on?	Very difficult
Student 12	Did the staff spend too much time with your group, too little time with your group, or just enough time with your group?	Possibly too little, but I'm not sure. Maybe enough.
Student 13	How would you rate the difficulty of the project you worked on?	Somewhat difficult
Student 13	Were the subjects of the group projects (networks, databases, etc...) 'too diverse,' 'not diverse enough,' or 'just	just right
Student 13	How interesting were the projects overall?	Somewhat interesting
Student 13	How interesting was the project you worked on?	Very interesting
Student 13	Did you feel there was enough time to complete your project?	yes
Student 13	Did you work on any of the course materials outside of the scheduled lab hours?	yea looking for information for the database
Student 13	Of the features you wanted to add to your project, approximately how many were you able to add?	0.75
Student 13	How can the projects be improved? Please be as specific as possible.	they were fine the way they were in the beginning.
Student 13	Did you feel there were enough teachers/advisors/staff to help you out?	yes
Student 13	In general, how knowledgeable was the staff?	Very knowledgeable

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 13	Did the staff spend too much time with your group, too little time with your group, or just enough time with your group?	just enough
Student 13	What was your role in the group's accomplishments?	i was the one that look for the syntex and all the data we needed to put in our database.
Student 13	What advice would you offer next year's group?	think first before doing anything
Student 13	If you did not complete all the modules, which module set did you last work with? (RoBOTL, JavaBOTL, Java)	JavaBOTL
Student 13	How effective was your project advisor in answering your questions?	they were somewhat accurate. but most of the time they were on point
Student 13	Which module did you like the most?	RoBOTL module 4
Student 13	Is there anything else you'd like to say?	itz was a pleasure workig with al you people
Student 13	Which part of the CS Frontiers program was the least enjoyable? (Morning modules, afternoon modules, group projects)	morning modules
Student 13	From which part of the CS Frontiers program did you learn the most? (morning modules, afternoon modules, or group projects)	i learn more from the afternoon modules because i had to do the thing myself and i got more familiar how to make a webpage.
Student 13	From which part of the CS Frontiers program did you learn the least? (morning modules, afternoon modules, or group projects)	the morning modules were da one i least learn least because it was early in the morning.
Student 13	If you could have spent more time on any topic (in general), which would it be?	It would be on JavaBOLT for the reason that i would get to know the programming system better.
Student 13	How much did RoBOTL aid in your learning of Java?	Some
Student 13	Which set of modules did you start with? (RoBOTL, JavaBOTL, or Java)	RoBOTL
Student 13	What was your least favorite aspect of working in groups?	i had none
Student 13	Which part of the CS Frontiers program did you enjoy the most? (Morning modules, afternoon modules, group projects)	group projrcts
Student 13	How much did JavaBOTL aid in your learning of Java?	Some
Student 13	How much did you enjoy working in groups?	Very much
Student 13	How well do you feel your group worked together?	Very well
Student 13	How would you evaluate the variation in skill level among your group members? As "too varied," "not varied enough," or "just right?"	just righth

<i>User Name</i>	<i>Question</i>	<i>Answer</i>
Student 13	What was your favorite aspect of working in groups?	it was good because i had help from my partner who knew what they were doing so hey help me understanding what to do for the project.
Student 13	How would you rate the lab and computer systems?	Good