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Reevaluating Programming Language Concepts

An Independent Qualifying Project Report:
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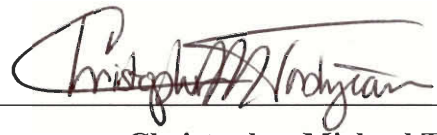
Degree of Bachelor of Science

by



Christopher Michael Tashjian

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Approved:

Professor **Michael Gennert,** Major Advisor

I. Abstract

Currently CS2135, "Programming Language Concepts," takes an "over-the-hood" approach to the Scheme programming language. This report shows, through both quantitative and qualitative methods, that a new "under-the-hood" version of this course taught in C-Term 2000, developed by an MQP team here at WPI, was successful from academic, student, and teaching standpoints. There was a significant increase in the mean final grade and a lower drop rate in C-Term 2000 as compared to the previous run of this course in C-Term 1999. Results from the students' bluesheets were about the same. And finally, the Professor (Michael Gennert) was very happy with the new course upon is completion.

II. Table of Contents

1 Introduction

In reevaluating the approach to CS2135 -- Programming Language Concepts, the MQP team formulated a new class that took on the subject matter from an "under-the-hood" approach. In doing so they focused less on the Scheme programming language for assignments, and more on Scheme concepts. Another difference in the methods used is that the team went for a more active classroom/learning environment. Their goal was to take some class time during every lecture for some group work to stimulate the interest of the students. This IQP will be looking at the overall success of this new approach, as opposed to the old via student surveys, bluesheets, grade reports and focus groups.

2 Background Information

2.1 Previous CS2135 Courses

Professor Gennert previously taught this course during C-Term 1999. I took a look at the bluesheets from that course and have compiled a list of the most common comments/suggestions from the students. They are as follows:

- Practice exams weak/misleading, not accurate representations of real exams
- More student participation in class, group work, etc. to keep students interested/awake
- Don't focus so much on Scheme in the class
- Working in groups on homework was a plus
- Use the microphone in fuller, keeps students awake, and makes the professor easier to hear

2.2 Education

2.2.1 Learning Theory

Many current trends in education such as cooperative learning, integrated curriculum, peer review work, and project based learning can all be traced back to ideas presented by Piaget, Bruner, Ausubel, and Gardner. The theories of these four education psychologists lay the foundations for recent developments in education, and are essential to understanding how and why concepts such as cooperative, or discovery, learning are beneficial in any classroom.

2.2.1.1 Piaget

Piaget described two basic tendencies of human nature: adaptation and organization. The basic unit of organization that Piaget identified was a Scheme. He defined a Scheme as an organized pattern of behavior or thought which is developed from experience. Adaptation is the goal of receiving information that is not easily organized into any of the current Schemes.

Adaptation, according to Piaget, is a two-stage process of assimilation and accommodation. The purpose of adaptation is to fit new knowledge and information into a Scheme or create a new concept of reality to adapt to the new knowledge. Assimilation is adaptation by fitting new knowledge or experiences into current models of reality (current Schemes). Accommodation is the creation of a new Scheme to organize the new information or experiences. "Imagine a six-year-old who goes to an aquarium for the first time and calls the minnows 'little fish' and the whales 'big fish.' In both cases the child is assimilating—attempting to fit a new experience into an existing Scheme (in this case, the conception that all creatures that live in the water are fish)" (Biehler, 51). If the child were to learn, however, that whales are not truly fish, then the child would have to accommodate this knowledge into a new scheme to reconcile the knowledge that not all things that live in the water are fish. The ability to create new Schemes for new knowledge indicates the need for people to organize knowledge.

In order to achieve the best possible adaptation to a situation, Piaget believed that people organized their knowledge and that the process of organization is closely tied to the

understanding of information. He called the process of gaining organization over a concept "equilibration". However, to reach a state of equilibrium, disequilibration must have already taken place. Piaget defined disequilibration as a discrepancy or perceived discrepancy between the new situation or new knowledge and current Schemes. The cycle of disequilibration and equilibration, through accommodation and assimilation, is Piaget's statement on how learning takes place, and how understanding comes about.

2.2.1.2 Bruner

In 1960, Jerome Bruner published *The Process of Education*. Almost instantly, it became a classic statement on education and the theory of education. One of the key points discussed in *The Process of Education* was the notion of what Bruner called structure.

Structure is composed of the basic and fundamental ideas of a subject and how they relate to one another. Not all knowledge in a subject area is fundamental, and therefore, the structure of a subject is generally a smaller subset of the concepts involved in that subject area (Biehler, 360). For a concept to truly be fundamental, it must be able to be represented simply "as a diagram, picture, verbal statement, or formula…." Also required is that the concept is able to be "represented in more than one sensory modality; and they are applicable to a wide range of new problems." (Biehler, 360) Bruner's assertion that what students need to understand is the structure that creates the subject area allows for a more creative curriculum. While the fundamentals are going to stay the same, the representation of these fundamentals can, and by definition, must be able to be dynamic. So the same concept of variables, for example, can be taught using several sensory modes, and learned using different representations.

The concept of structure lends itself well to Discovery Learning - learning that takes place when the student discovers fundamental concepts in an activity. Bruner also advocated using Discovery Learning. He thought that too much learning takes the form of step-by-step instructions or formulas that students could reproduce on demand, and yet not apply outside the classroom. Discovery Learning stresses activity on the part of the student. Instead of prepared steps and prearranged materials, teachers should confront students with a problem and help the students solve the problem. The students will find what knowledge is valuable while attempting to solve the problem. The application of knowledge will be integrated into learning, and the structure will become clear as the students practice the subject by solving the puzzle before them. However, Bruner does not suggest that student be made to discover every fact and every principle needed, but rather that the interconnections between knowledge becomes clearer in Discovery Learning. Making students learn all the pieces on their own, can cause too much confusion on the part of the students, and can also be very time inefficient.

Using project based learning and hands on activities not only give students the opportunity to apply knowledge, but it is also effective in helping students learn the knowledge better. "Research at the elementary, middle and high school levels has produced mostly positive findings. On average, students in activity-based science programs scored at the 70^{th} percentile on tests of science processes, whereas students in traditional science classes scored at the 50^{th} percentile" (Biehler, 362). By teaching knowledge and information as a tool, students have a better grasp of what is important

and why it is important.

2.2.1.3 Ausubel

Ausubel, like Bruner, stresses the importance of linking old knowledge to new knowledge. Ausubel states, on the flyleaf for *Educational Psychology: A Cognitive View*, "If I had to reduce all of educational psychology to just one principle, I would say this: the most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly." But while Bruner calls for Discovery Learning, Ausubel emphasized the importance of high-quality expository teaching. Ausubel does not however, simply advocate lecturing, but underscores the requirement that any lecture or reading passage should lead the learner from what he knows into new knowledge.

The main goal Ausubel's ideas strive to meet is that of ease of learning. Material to be taught must be taught in such a manner and organization so as to relate it to known facts and concepts. Ausubel called this integration of ideas and information meaningful receptive learning, which is the integration of new ideas into current knowledge schemes.

Though the teacher may try to promote all learning as meaningful receptive learning, this cannot be achieved in all cases. Ausubel noted that whether meaningful receptive learning takes place is a function of two things: the nature of the task involved and the learner's attention to the task (Biehler, 363). Ausubel's theory also suggests using Advanced Organizers, which are introductory materials to information that provide a structure for the information. This approach helps the learners see where the information

fits into their knowledge Scheme. "Studies of advanced organizers show that they have their strongest positive effects on measurements of comprehension and problem solving rather than on measures of retention." (Biehler, 364)

2.2.1.4 Gardner

Howard Gardner theorized that there are multiple types of intelligence a person can possess. He identified seven distinct areas of intelligence: linguistic, logical-mathematical, spatial, musical, bodily kinesthetic, interpersonal and intrapersonal, and recently identified and eighth, the naturalist. Since each intelligence is separate from the others, the skills exhibited by someone gifted in one area will necessarily be different from those exhibited by another individual gifted in another intelligence. To prove Gardner's theory, several programs have been set up. These programs attempt to teach information using different intelligences to maximize comprehension and retention by the learners.

Information on Gardner's Multiple Intelligence theory is relevant mainly because the theory has become so widely accepted and incorporated into curriculums. Gardner's theory also works well in conjunction with Bruner's ideas concerning structure. Bruner stated that something that is part of the structure of a subject must be represented in more than one sensory modality. Multiple Intelligence implies that the structure of a subject can be taught effectively to learners who are strong in different 'intelligence areas,' since structure must inherently be represented in different sensory modalities. Gardner provides more specific areas into which to fit different representations of an idea, and so makes practical application of other theories more practical.

2.2.1.5 Bloom

Beginning in 1948 and completing the work in 1956, Benjamin Bloom developed a

taxonomy to categorize the cognitive levels achieved during learning. He identified six levels of increasing cognitive complexity involved in learning. Initially, he found that over 95% of the questions on tests fell within the lowest levels that he had identified (http://officeport.com/edu/blooms.htm). He identified the following (see Table 1 below) six levels of cognitive processing, listed here with verbs associated with the types of thinking performed at each level. They are listed below from the simplest levels to the most complex

Table 1:

1. Knowledge:	Arrange, Define, Duplicate, Label, List, Memorize, Name, Order, Recognize, Relate, Recall, Repeat, Reproduce State.
2. Comprehension:	Classify, Describe, Discuss, Explain, Express, Identify, Indicate, Locate, Recognize, Report, Restate, Review, Select, Translate,
3. Application:	Apply, Choose, Demonstrate, Dramatize, Employ, Illustrate, Interpret, Operate, Practice, Schedule, Sketch, Solve, Use, Write.
4. Analysis:	Analyze, Appraise, Calculate, Categorize, Compare, Contrast, Criticize, Differentiate, Discriminate, Distinguish, Examine, Experiment, Question, Test.
5. Synthesis:	Arrange, Assemble, Collect, Compose, Construct, Create, Design, Develop, Formulate, Manage,

	Organize, Plan, Prepare, Propose, Set Up, Write
6. Evaluation:	Appraise, Argue, Assess, Attach, Choose Compare, Defend Estimate, Judge, Predict, Rate, Core, Select, Support, Value, Evaluate.

2.3 Previous IQPs

The search for previous IQPs was a bit discouraging. Through the use of the online search engine/catalog and the Interactions magazines, I was able to find a handful of IQPs from years past that I felt may offer some insight into my project. Here are brief summaries:

97D241I: Information Literacy: Making it Happen

Information Literacy is the ability to use computers, the Internet, and other technological tools to extract valid information relevant to your area of study. The Internet is filled with great information, but most of it is buried under a large amount of useless "background noise", as this paper referred to it. The purpose of the project was to design an "Information Literacy" course for some fourth graders at one of the Worcester elementary schools. This IQP team wanted to develop a course that would help the students develop some necessary IL skills. The only real correlation to my project is that they developed the lesson plans one-by-one and would look at the success of each one before planning the next. The focus groups in my project served somewhat of a similar

purpose. The feedback I received about the course and assignments was later conveyed to Professor Gennert who used the information to help the class progress.

97D037I: Sound of Technology: An STS Curriculum Development Project

STS stands for science, technology and society, a teaching method that approaches a subject with these three areas in mind. Students are conceptually presented with a social question and they build their knowledge of science and technology around it. This IQP made a "database" of musical knowledge that music teachers could pull lessons from. It addresses the issue of how music classes are taught rarely showing the correlation between the type of music and the times it was popular, and the technology available to those musicians.

97D020I: Planning of the Frontier ROBTL/JAVA Program

Of all the projects I looked at, this was one of the most related to mine. The purpose was to design a Frontier's OO (object-oriented) programming course. Previously the course was taught with ROBTL and then progressed to C++. This IQP moved towards Java instead of C++ because "Java is newer technology and more marketable skill." The new course went about Java by teaching the students the Java equivalents for ROBTL commands that they were previously familiar with. This way the concept is the same, just the syntax has changed. The student who did this project wanted to make sure that the course he developed looked the same (conceptually) in both Java and ROBTL. One of the tools he used to accomplish this was a Java based ROBTL simulator. In the CS2135 class, which my IQP is based upon, the students used a Java based Scheme

evaluator to understand Scheme and its concepts. The course developed for the Frontiers was made to allow for "faster" students. Students that grasped the material quickly could take a look at the ROBTL simulator code and begin to break it down further. The Scheme class did not have this problem, since they designed their own evaluators.

96B025I: Introducing Web Page Languages to Frontiers CS Students

For this project, the IQP team had to design and implement (by serving as TAs) a two-week web design class for the Frontiers students. The project team had to first decide what topics it would cover in such a short period of time. After careful consideration, they decided on VRML, Java, JavaScript, advanced HTML, and CGI programming. Things like VRML were put into the curriculum to maintain the "fun-factor", to keep the students interested in the material. This proved to be a great success, as the students were very receptive to, and interested in, the material covered during the two-week course.

97A021I: Frontiers in Java

This project designed a curriculum to teach the Frontiers students the essentials of Internet communications and the basics of object-orientated programming. The IQP team wrote a course textbook and taught lessons on HTML and Java. This project team used student surveys, like I did, to help them get an idea of how the course was going. They ran into a few problems, mostly due to the different backgrounds of the students, but adjusted well by modifying the schedule and curriculum where needed. They realized that if they had surveyed the students at the beginning of the class, like I did, they would have had a better feel for the students' backgrounds and could have possibly avoided

some problems. The biggest of which was the fact that the students just did not have enough time and background to pick-up Java as well as the team would have hoped. Overall though, the IQP team viewed their project as a success because not only did the students develop new skills, they enjoyed the course.

97D275I: Experiments in MA2051

The purpose of this project was to develop a couple of experiments to be used in the teaching of the Ordinary Differential Equations class here at WPI. The purpose of these experiments was to help the students gain a better handle on the sometimes-difficult material covered in the course. One good thing this IQP team did was they went through the experiments many times themselves and discovered common sources of error and mistakes. They then wrote these things up in the instructions for each lab in the hopes of reducing human/student error. As far as methodology and procedures, this IQP team used the survey method like I did. They surveyed thirty students from a previous run of the course to see what they could improve. I accomplished this via the use of the bluesheets. In addition to student surveys, they also surveyed the TAs on the students' overall performance.

The one thing this report was lacking was a conclusions section, so I unfortunately could not find out how the experiments went over. However, based upon their careful and thorough planning, I would have to guess it was a success.

3 Methodology

3.1 Methods of Comparison

3.1.1 Quantitative

Quantitative/statistical analysis was done with data from the following:

- Student surveys (first and last days of class)
- Bluesheets
- Student grades

The following statistical methods were used:

- Mean
- Median
- Standard Deviation
- Z-Test (hypothesis testing)

These statistical tools were used to analyze and compare the student surveys and the grades students received during the course. The student grades from C-Term 99 were compared with the new approach of C-Term 2000. For consistency purposes, it should be noted that Professor Michael Gennert of the WPI Computer Science department instructed both courses.

The mean, or average, can be computed as follows:

$$\bar{y} = \frac{1}{n}(y_1 + y_2 + \ldots + y_n) = \frac{1}{n}\sum_{i=1}^{n} y_i$$

Where y_i represents the data (in this case the student grades and survey data) and n represents the number of pieces of data (Petrucelli, et al., 44).

The standard deviation is another good tool for statistical analysis. The formula for standard deviation is $+\sqrt{s^2}$ where s is variance:

$$s = \frac{\sum_{i=1}^{n} (y_i - \bar{y})^2}{n-1}$$

The standard deviation is the +/- distance between the mean and the values where approximately 60% of all values fall. (Petrucelli, et al., 48)

Another very useful statistical tool used was hypothesis testing, or the z-test. The z-test is the testing of two population means to determine statistical accuracy. The result one is concerned with is the p-value returned by the test. The smaller the p-value, the stronger the evidence is against the null (or initial) hypothesis. When doing this calculation one must first formulate a null and alternate hypothesis. The null hypothesis is what is attempting to be disproved. For this IQP the null hypothesis is that the mean final grade in C-Term 1999 is equal to the mean final grade from C-Term 2000. The alternate hypothesis is what is believed to be true. So for this project the alternate is that the mean final grade in C-Term 2000 is greater than that from C-Term 1999. The following are needed to compute the p-value:

- null and alternate hypotheses

- the sample size of both populations
- the mean from both populations
- the mean difference
- the variance of both populations

Once all of the above data is gathered and the p-value has been calculated a comparison is made between the p-value returned on the null hypothesis and that of the alternate hypothesis. (Kitchens, 482-490)

3.1.2 Qualitative

Another important aspect of any course is the feelings of the students and the professor. The following were taken into consideration for this part of the analysis:

- Student focus groups
- Bluesheets (student comments)
- Professor interview/survey

These are more opinion based and harder to quantify, but their information was still useful to the IQP.

On the first day of class all the students filled out and hand in the survey I developed (see appendix). I went through the answers and used some statistical tools to compare and understand them. At the end of the term, a very similar survey went out and the results were compared to those of the first day surveys.

Another aspect of my project was the focus groups. During the course of the term I conducted four meetings with a focus group made up of five students from the class. The point of these groups was to gain a better understanding of the students' wants/desires in the course and their feelings on how the course was running. These were more qualitative than quantitative, but proved to be very helpful over the course of the class. The information gathered during these meetings was conveyed to the professor who changed the course at times to better accommodate the students. The possibility of me keeping all focus group discussions and findings to myself was presented, but ruled out due to the fact that I felt it would hinder the performance of the students and overall success of the new course.

4 Procedure

For this IQP many different methods of evaluation and analysis are used. The solid quantitative data come from student grades, student surveys, and the front side of the student bluesheets. From a qualitative standpoint, analysis is done via focus groups, professor interviews/meetings, and the back side of the bluesheets.

Statistical analysis was done via means, medians, standard deviations, variances, percentages, and hypothesis testing as specified in the methodology, above, and results, below. Additional statistical data, not found in the aforementioned sections can be found in the appendix at the end of this report.

Surveys went out to the class in C-Term 2000 on the first and last days of lecture. The two surveys all had quantifiable answers (1 - 5) that were later tallied and analyzed. In addition to these surveys the results of the students' bluesheets from C-Term 2000 were compared to those from C-Term 1999. The purposes of these two sets of data are to understand the views of the students on the course, as are the results from the focus groups.

In addition to looking at the students' views on the course this project takes a look at their grades as well. Anonymous grade reports from both terms were compared via the same statistical means as mentioned above. To prove statistical significance and accuracy, hypothesis testing is conducted.

Once the grades and student views are analyzed the only things left to look at are the opinions and impressions of the professor himself. This work was done on a weekly basis via project meetings. At these meetings the project's progress, as well as the course's progress was discussed in great detail.

5 Results

5.1 Survey Results

5.1.1 First Day

One can see in table 2 below, and the graph (First Day Survey Results) on the next page, that there are some very obvious trends in the survey results (for a copy of the survey see the appendix).

Table 2:

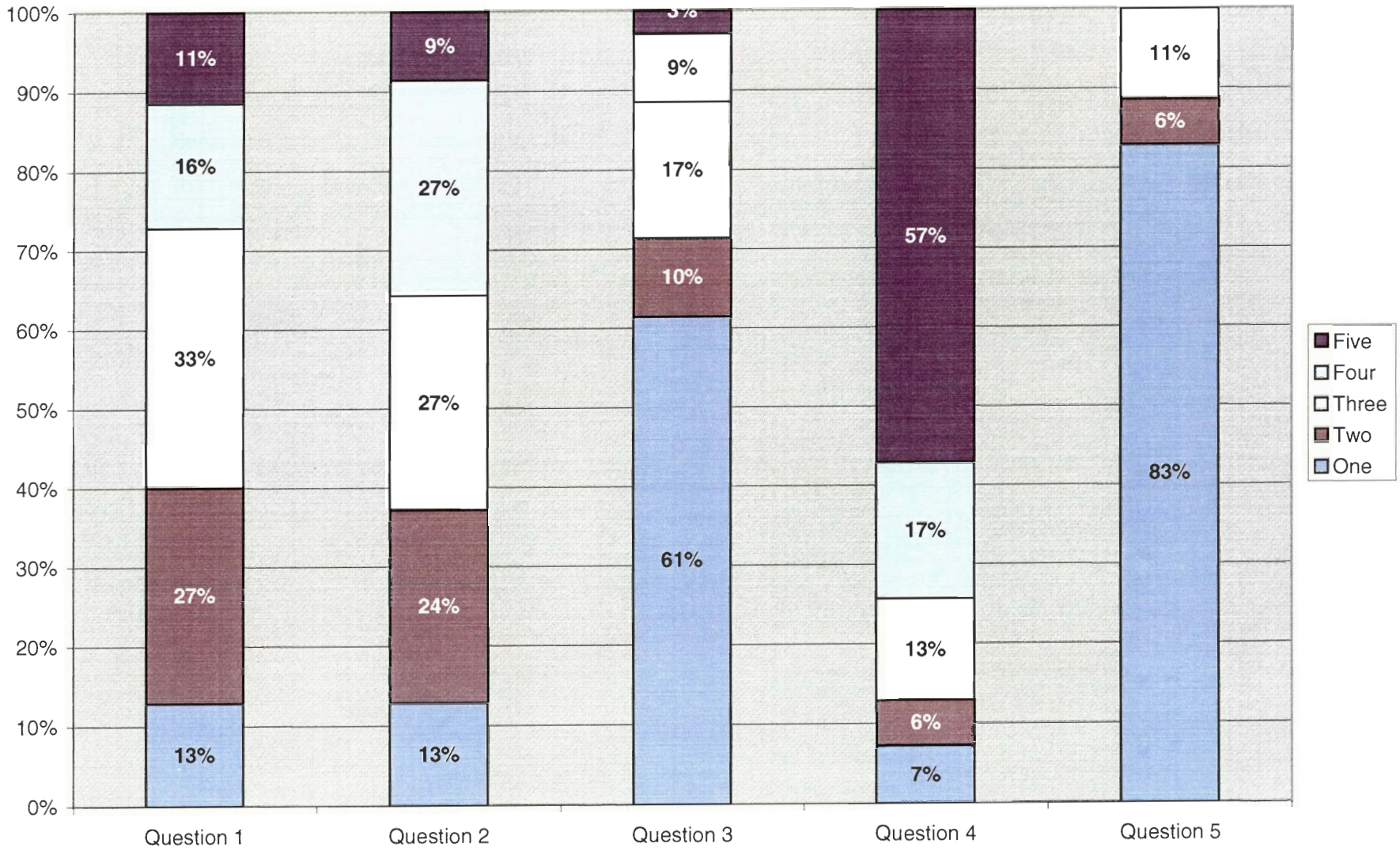
	One	Two	Three	Four	Five
Question 1	13%	27%	33%	16%	11%
Question 2	13%	24%	27%	27%	9%
Question 3	61%	10%	17%	9%	3%
Question 4	7%	6%	13%	17%	57%
Question 5	83%	6%	11%	0%	0%

I was slightly surprised on the results from question 1. Students seemed to be in the middle on the individual vs. group work question, with a slight preference for individual work. I personally expected the results to go in the other direction towards group work.

Based upon the results from question 2 I felt that students would like/benefit from a short group activity during each lecture to stimulate interest in the subject matter, and to break up the monotony of a lecture.

The results on questions 3 and 4 were quite overwhelming and easily interpreted. It appears that most students had never even used Java and would definitely benefit from a crash course in it. In addition no one really knew Scheme, as expected.

First Day Survey Results



5.1.2 Last Day

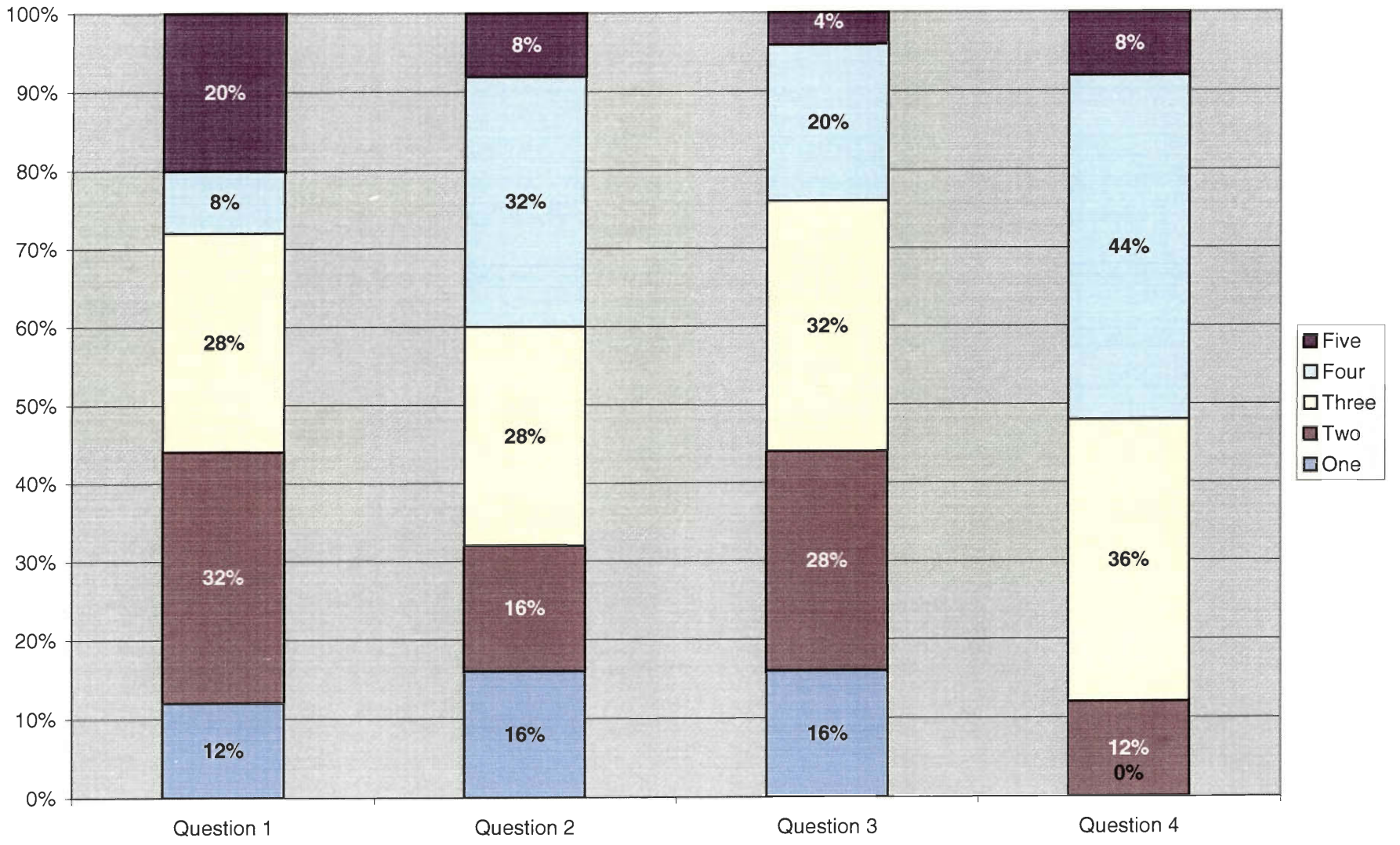
In table 3 below, and the graph (Last Day Survey Results), one can see the successes of the new course.

Table 3:

	One	Two	Three	Four	Five
Question 1	12%	32%	28%	8%	20%
Question 2	16%	16%	28%	32%	8%
Question 3	16%	28%	32%	20%	4%
Question 4	0%	12%	36%	44%	8%

As expected, the students' knowledge of both Scheme and Java increased significantly (questions 3 and 4). Also a slight shift on question 2 can be seen, more students seem to feel that they benefited from the in class group activities in the end. The question of whether or not the students prefer group or individual work does not show a significant change, so the course really did change peoples' minds on that. It simply comes down to what type of person/worker someone is.

Last Day Survey Results



5.2 Bluesheets (multiple choice)

The data from the front side of the bluesheets (see appendix for a sample) can be seen below in tables 4 and 5. For this part of the analysis only certain questions were considered. Part 1 (table 4) is the most important section when looking at the success of the class. From the results below it can be said that there really was not a significant change in student opinions between C-Term 1999 and C-Term 2000. The fluctuations in the values are not very large in Part 1, and even Part 2 for the most part. To calculate the mean values of 1 – 4 were assigned to "strongly disagree" – "strongly agree", respectfully. The calculated means of 3.15 and 3.11 fall in the "agree" range, which overall is positive.

Table 4:

C 1999 Bluesheets (mean for Part 1)						C 2000 Bluesheets (mean for Part 1)					
	SD	D	A	SA	MEAN		SD	D	A	SA	MEAN
P1-Q1	0%	13%	69%	19%	3.06		2%	18%	55%	25%	3.03
P1-Q2	1%	7%	60%	31%	3.21		5%	20%	51%	25%	2.95
P1-Q3	0%	3%	53%	44%	3.41		0%	0%	64%	36%	3.36
P1-Q4	1%	17%	49%	32%	3.12		2%	18%	57%	23%	3.02
P1-Q5	0%	0%	33%	67%	3.67		0%	3%	43%	53%	3.50
P1-Q6	1%	9%	47%	43%	3.31		2%	10%	55%	33%	3.20
P1-Q7	1%	6%	61%	31%	3.23		2%	12%	63%	23%	3.08
P1-Q8	9%	13%	49%	30%	3.00		8%	8%	54%	29%	3.03
P1-Q9	10%	18%	48%	24%	2.85		3%	19%	55%	22%	2.97
P1-Q10	0%	15%	67%	18%	3.03		2%	6%	66%	26%	3.16
P1-Q11	9%	35%	40%	16%	2.63		5%	20%	58%	17%	2.87
P1-Q12	3%	7%	63%	27%	3.14		2%	15%	63%	20%	3.02
P1-Q13	1%	9%	62%	28%	3.16		2%	9%	60%	30%	3.18
P1-Q14	0%	9%	57%	34%	3.25		2%	15%	52%	32%	3.13
TOTAL:	**3%**	**11%**	**54%**	**32%**	**3.15**		**3%**	**12%**	**57%**	**28%**	**3.11**

Part 2 of the student bluesheet is more general. The only significant difference in the scores to be noted would be that of the textbook question (P2-Q1). The textbook used in C-Term 2000 was not as good as that of years past. These results concur with those of the open-ended questions on the back of the bluesheets. Professor Gennert did not intend for the book used in the class to be a "textbook", it was more for reference purposes.

Table 5:

C 1999 Bluesheets (mean for Part 2)						C 2000 Bluesheets (mean for Part 2)					
	SD	D	A	SA	MEAN		SD	D	A	SA	MEAN
P2-Q1	11%	23%	56%	10%	2.64		37%	34%	29%	0%	1.92
P2-Q2	1%	11%	50%	37%	3.23		0%	12%	52%	37%	3.25
P2-Q5	1%	21%	59%	19%	2.96		2%	10%	69%	19%	3.05
P2-Q6	3%	10%	64%	23%	3.07		3%	17%	58%	22%	2.98
P2-Q7	1%	17%	59%	22%	3.01		3%	14%	66%	17%	2.97
TOTAL:	**4%**	**16%**	**58%**	**22%**	**2.98**		**9%**	**17%**	**55%**	**19%**	**2.83**

5.3 Student Grades

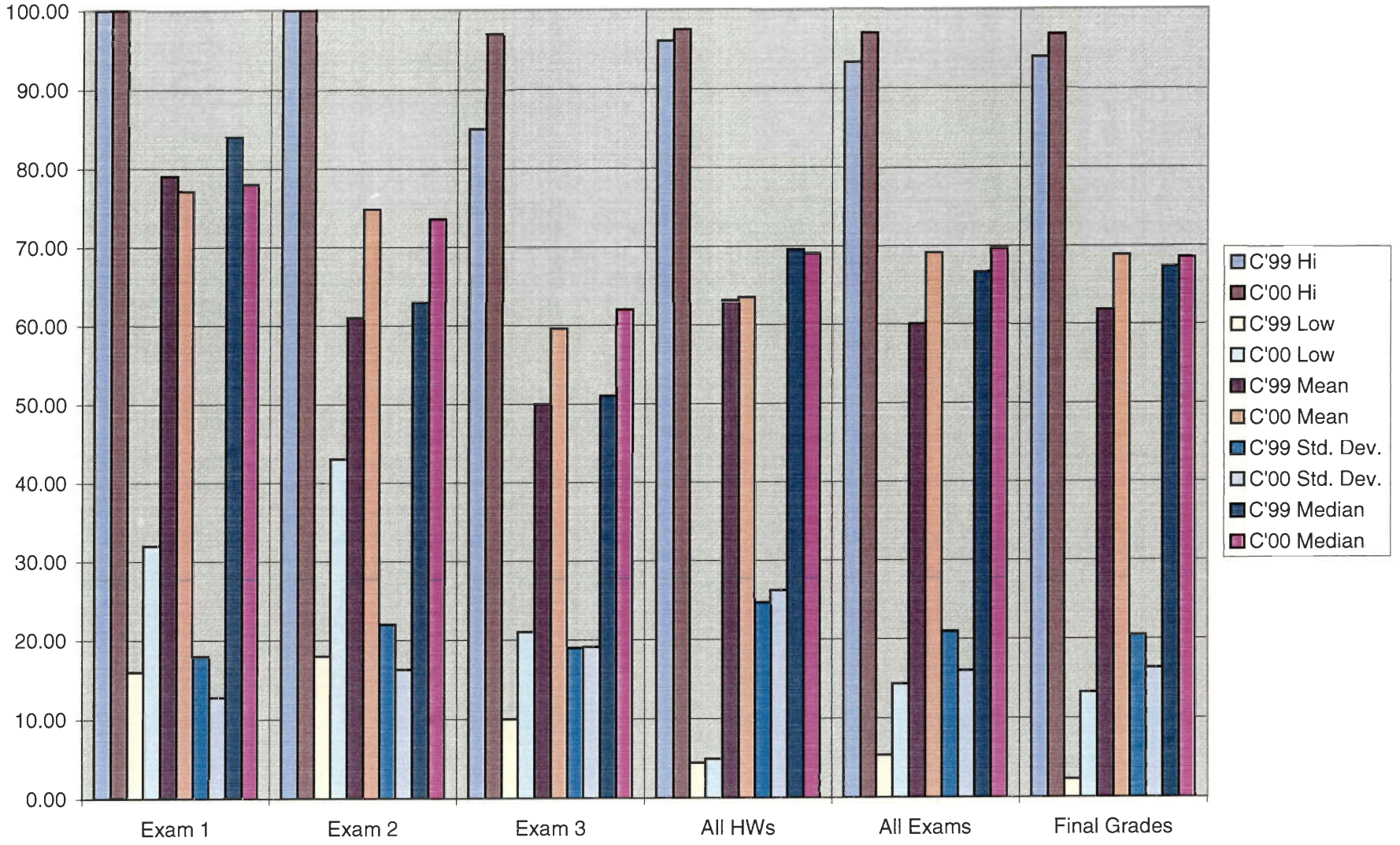
Of all the data collected for this IQP, the students' grades show the biggest change, and success. Below in table 6, and in the graph (Student Grades) on the next page, one can see the significant increase in all mean and median grades for C-Term 2000 as compared to C-Term 1999.

Table 6:

	Exam 1	*Exam 2*	*Exam 3*	*All HWs*	*All Exams*	*Final Grades*
C'99 Hi	100.00	100.00	85.00	96.11	93.33	94.00
C'00 Hi	100.00	100.00	97.00	97.54	97.00	96.85
C'99 Low	16.00	18.00	10.00	4.44	5.33	2.27
C'00 Low	32.00	43.00	21.00	4.92	14.33	13.24
C'99 Mean	79.00	61.00	50.00	63.15	60.00	61.81
C'00 Mean	77.10	74.80	59.60	63.52	69.13	68.84
C'99 Std. Dev.	18.00	22.00	19.00	24.67	20.96	20.47
C'00 Std. Dev.	12.80	16.30	19.10	26.20	16.00	16.32
C'99 Median	84.00	63.00	51.00	69.58	66.67	67.30
C'00 Median	78.00	73.50	62.00	69.10	69.67	68.50
C'99 Count	104	99	96	106	106	106
C'00 Count	97	94	94	97	97	97

The above table also offers some insight into the student drop rate. In C-Term 1999, ten students (9.5%) dropped, or "punted", the course between the first day and the final exam. In C-Term 2000, one can see that the drop rate is significantly lower, only 3.1%. More students stuck with the course, most likely because of their increased interest in the subject matter (as seen in bluesheet results above – P1Q2) and the fact that the mean grade was higher.

Grade Summary



Hypothesis testing was also conducted to show the statistical significance and accuracy of the above results. The null hypothesis, that is disproved, is that the mean final grade in C-Term 1999 is equal to that of C-Term 2000. The alternate hypothesis is that the mean final grade in C-Term 2000 significantly increased. In tables 7 and 8, one can see that the p-value for the alternate hypothesis is significantly lower than that of the null hypothesis, therefore the alternate hypothesis is said to be true. These results strengthen the conclusion that the course was successful.

Table 7 (z-test results – null hypothesis):

	C'99	*C'00*
Mean	61.80557	68.83887
Known Variance	418.9437	266.4
Observations	106	97
Hypothesized Mean Difference	0	
z	-2.71747	
P(Z<=z) one-tail	0.003289	
z Critical one-tail	1.644853	
P(Z<=z) two-tail	0.006578	
z Critical two-tail	1.959961	

Table 8 (z-test results – alternate hypothesis):

	C'99	*C'00*
Mean	61.80557	68.83887
Known Variance	418.9437	266.4
Observations	106	97
Hypothesized Mean Difference	7.03	
z	-5.43366	
P(Z<=z) one-tail	2.77E-08	
z Critical one-tail	1.644853	
P(Z<=z) two-tail	5.53E-08	
z Critical two-tail	1.959961	

5.4 Focus Groups

5.4.1 January 20, 2000

Getting volunteers for the focus group was very easy. Seven students volunteered and I took five of them. Our first meeting went a little slow, but I was definitely able to get a feel for the course and the students by the end of it. The most overwhelming theme in the group was that they [the students] were lost on Java. They felt as though they were not properly prepared in their previous coursework for it and were highly discouraged and frustrated by it. I attempted to explain that Java was not a huge part of the course and that their worries would all come to a rest upon the completion of the first exam. Perhaps a three-hour crash course during the first week of class, as suggested by the MQP team, would have benefited the students. After the meeting, I conveyed the students concerns to Professor Gennert for him to address as he saw fit.

5.4.2 February 2, 2000

By now the students had taken, and gotten back their first exams as well as a couple homework assignments. The mood seemed a little lighter with them now that they had adjusted to Java a little better. The learning curve should not be as steep in the future; more students should have taken CS100X (CS1006) by the time they take this course. One thing that really helped the current batch of students has been the labs. In speaking with them there was an overwhelmingly positive response to the labs. They felt that the labs really help them to grasp the different concepts in a highly effective manner. Another thing that helped was the practice exam. The members of the focus group felt that it was a pretty good representation of the material covered on the actual exam. Professor Gennert had previously expressed some concern on this matter, and was pleased to hear the students' opinions. Professor Gennert also felt that the students had understood the new material a little better now that they had gotten passed the initial scare of Java, in particular, the environment model. I spoke with the students on this during the focus group and they agreed that they understood the material better, but were still confused on environments. They felt that had it at first, but on the second day of lecturing, they got confused. I am sure that they will work through this with little difficulty.

5.4.3 February 17, 2000

By now the students have really formed their opinions on the class and they are consistent with the last meeting we had. They are more comfortable with Java, but not as comfortable as they would like, and feel that the course is going well. They reiterated the fact that they think it should have been be more clearly spelled out beforehand that the course would rely heavily on Java. Aside from this, they feel that the labs are still probably the best aspect of this course. Because of the hands-on nature of, and the clearly laid out instructions for, the labs the students seem to pick up a lot of solid understanding of the subject matter.

I asked the group what they thought of the lecture given by John Schutt. The students all agreed that John definitely knows his stuff, but he has a real hard time conveying ideas to the students. They said that he was very quiet and lacked structure to his lecture. The first fifteen minutes of the lecture was okay, but after that John went too deeply into things and went over the students' heads. One student suggested that John take a public speaking class, because this would help to make him the excellent professor that he has the potential to be.

5.4.4 March 3, 2000

This was the final meeting with the focus group. I asked the group their overall feelings on the course as it was run. For the most part, the students liked the course and felt that the subject matter was covered effectively. Below are some of the points the group brought up:

- Textbook was weak, there were better online references
- Online notes weren't as printer friendly and complete as they might have liked
- Group work was great, but solutions to the in-class group problems would have been a great help for exam prep.
- Metacircular evaluator code needs more comments/instructions
- Not enough time was spent on the Metacircular evaluator for what was asked of the students on the exam

Overall, they really liked the course and the professor. The group, as a whole felt that Professor Gennert was one of the most caring professors they had encountered to date. They felt that with some more Java background the course would have been close to perfect. That was the only major hang-up/flaw that they saw in this method of approaching the subject matter.

5.5 Bluesheets (student comments)

The following were the most prominent comments on the back of the bluesheets collected at the end of the course:

- Course really helped the students to understand how languages work and evaluate things
- Liked the new format of the class…the use of Java to build a new language was great
- Start homeworks early
- Not enough time to complete homeworks, extremely difficult assignments
- Book was terrible/useless, don't waste the money
- Ask questions in class and during office hours
- Java was hard to learn, a crash course would have been real beneficial
- Make note of Java use in course description
- The fact that labs were used as a learning experience and not a grade was good
- Professor Gennert is an excellent professor. He has a great knowledge of the material and is real concerned about the students.

These results concur with the conclusions this report draws. The fact that the textbook was weak came as no surprise to Professor Gennert. The book was only intended to be used as a reference, not as a lecture substitute.

5.6 Professor's view

In speaking with Professor Gennert over the course of C-Term 2000, and once again at the end of the term, the overall feeling from him is that this new approach to CS2135 was a great success. Not only was he impressed by the increased academic performance, and lower drop rate, but he feels that the students left the course with a much better understanding of the material than those students of years past, and this is the most important measure of any course's success.

6 Conclusions

In looking at all the data in this report one can safely come to the conclusion that this new approach to CS2135 was a success. Based upon the student surveys and grades it can be said that it was successful from their [the students] standpoint. From a teaching standpoint, as noted above, the professor was extremely satisfied. The only real problem encountered during the course of C-Term 2000 was the lack of Java knowledge amongst the students. If this course is to be taught in the same manner in the future, this should not be as much of a problem since Java is becoming a larger part of the CS curriculum at WPI.

7 Bibliography

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8 Appendix

- First and last day surveys
- Blank bluesheet
- Other data tables and graphs

Student Survey (first day of lecture):

- Do you feel that you are more productive/learn more from individual or group work?

Individual	1	2	3	4	5	Group

- How beneficial do you feel a short group activity/problem during each lecture could be to you and your lecture experience?

Not at All	1	2	3	4	5	Very Beneficial

- Have well do you know Java?

Never Used It	1	2	3	4	5	Very Well

- Do you feel that you could benefit from a few "crash courses" in Java developed for people who have previous C/C++ experience?

Definitely Not	1	2	3	4	5	Definitely

- How well do you know Scheme/Lisp?

Never Used It	1	2	3	4	5	Very Well

Student Survey (last day of lecture):

- Do you feel that you are more productive/learn more from individual or group work?

Individual	1	2	3	4	5	Group

- How beneficial do you feel a short group activity/problem during each lecture could be to you and your lecture experience in future classes?

Not at All	1	2	3	4	5	Very Beneficial

- How well do you know Java?

Never Used It	1	2	3	4	5	Very Well

- How well do you know Scheme?

Barely	1	2	3	4	5	Very Well

WPI Worcester Polytechnic Institute

STUDENT EVALUATION OF COURSE/LAB OR CONFERENCE INSTRUCTOR

INSTRUCTOR'S NAME	TERM	DATE	COURSE NUMBER

By providing your perceptions of the effectiveness of your teacher on this evaluation form, you can help to improve the overall quality of teaching at WPI. Therefore, please take time to consider each reply thoughtfully. These evaluations are used by the teacher for self-improvement and by members of the administration and faculty committees as one important factor in determining salary, promotion and tenure.

Your response will remain anonymous. The evaluation form will be returned to your teacher after you have received a grade for the course.

Please circle the number to indicate your feeling of disagree/agree with each statement using the range from STRONGLY DISAGREE to STRONGLY AGREE. Circle NOT APPLICABLE if the particular statement does not apply to your instructor.

NA - NOT APPLICABLE
SD - STRONGLY DISAGREE D - DISAGREE A - AGREE SA - STRONGLY AGREE

	RANGE OF AGREEMENT				
	NA	SD	D	A	SA
PART I - YOUR SPECIFIC PERCEPTIONS					
1. The instructor established clear objectives for the course.	0	1	2	3	4
2. The instructor organized the course well.	0	1	2	3	4
3. The instructor was well prepared to teach each class.	0	1	2	3	4
4. The instructor communicated well.	0	1	2	3	4
5. The instructor demonstrated a good understanding of the material being taught.	0	1	2	3	4
6. The instructor used the blackboard/visual aids in an effective manner.	0	1	2	3	4
7. The instructor used class time effectively.	0	1	2	3	4
8. The instructor assigned homework that aided my learning.	0	1	2	3	4
9. The instructor used evaluations that were good measures of the material covered.	0	1	2	3	4
10. The instructor provided adequate assistance outside the classroom.	0	1	2	3	4
11. The instructor stimulated my interest in the subject matter.	0	1	2	3	4
12. The instructor challenged me to extend my capabilities.	0	1	2	3	4
13. The instructor seemed really concerned about the students.	0	1	2	3	4
14. The instructor was well above average.	0	1	2	3	4
FOR LABORATORY COURSE					
15. The instructor showed me how to use laboratory equipment properly.	0	1	2	3	4
16. The instructor provided adequate time to complete experiments.	0	1	2	3	4
17. The instructor clearly defined the requirements for preparing lab reports.	0	1	2	3	4
PART II - SOME GENERAL PERCEPTIONS					
1. The textbook(s) helped me learn the subject matter.	0	1	2	3	4
2. The material to be learned in this course was difficult.	0	1	2	3	4
3. The room used for the course was acceptable.	0	1	2	3	4
4. The lab and/or computer equipment was in good operating condition.	0	1	2	3	4
5. I rate myself in general as an excellent student.	0	1	2	3	4
6. I had a good understanding of material that was prerequisite for the course/lab.	0	1	2	3	4
7. I learned a lot in this course.	0	1	2	3	4

PART III - BACKGROUND INFORMATION

1. My current student year classification is (circle one)

1 - 1st YEAR 2 - 2nd YEAR 3 - 3rd YEAR 4 - 4th YEAR 5 - 5th YEAR 6 - GRADUATE STUDENT

2. My major field is (circle one)

01 - Chemical Engineering
02 - Civil Engineering
03 - Electrical Engineering
04 - Mechanical Engineering
05 - Chemistry
06 - Computer Science
07 - Biology
08 - Management
09 - Mathematical Sciences
10 - Physics
11 - Interdisciplinary
12 - Consortium
13 - Other

PART IV - WRITTEN COMMENTS

1. What did you particularly like about this course/lab?

2. What did you particularly dislike about this course/lab?

3. Can you suggest anything that the instructor can do to improve the quality of teaching?

4. What strategy would you advise a friend to use to benefit from this course?

5. Other Comments?

C'99 Final Grades	C'00 Final Grades
75.44	89.94
79.73	82.77
72.64	61.31
79.78	85.19
83.31	90.50
59.19	64.52
31.72	68.50
86.92	83.32
67.06	64.41
78.89	60.38
37.67	49.82
50.12	59.88
35.17	83.98
88.97	59.57
47.06	66.56
50.32	69.31
60.36	77.67
60.98	81.95
41.97	46.45
7.82	76.17
59.50	71.68
77.39	61.22
43.83	96.85
86.25	71.80
76.75	66.64
58.25	39.95
70.67	79.07
77.97	77.91
54.68	82.45
12.29	92.95
71.64	63.75
51.84	75.38
37.67	91.53
83.03	81.69
15.65	36.09
43.74	80.43
77.02	61.54
86.22	50.27
78.86	54.22
64.84	77.21
49.36	67.07
94.00	40.70
70.14	57.78
34.32	77.07
60.53	68.82
73.75	54.39
85.18	77.72
78.67	87.88
33.25	64.14
87.50	64.56
79.27	66.38
61.03	13.24
76.42	68.76
80.31	72.22
29.76	75.65
73.39	95.20
61.73	50.36

	76.73	84.74
	79.47	70.33
	67.92	52.83
	62.69	74.99
	72.09	76.24
	64.22	76.68
	90.83	64.78
	71.44	94.10
	35.19	71.63
	79.17	59.09
	53.62	58.82
	73.86	59.84
	50.58	86.68
	23.36	92.54
	40.94	88.55
	63.44	96.59
	67.54	83.61
	78.19	78.86
	57.12	59.38
	4.65	61.78
	35.81	59.77
	48.98	74.50
	74.19	59.77
	57.67	56.01
	76.67	61.97
	66.92	62.10
	34.03	27.52
	52.97	57.60
	73.00	86.63
	77.72	91.37
	70.33	80.84
	49.51	61.88
	2.27	62.42
	34.28	65.47
	33.14	54.45
	90.53	62.13
	78.50	92.26
	75.21	58.18
	88.58	55.25
	66.28	18.42
	71.97	
	53.24	
	70.03	
	71.67	
	50.58	
	58.33	
	77.56	
	76.50	
	70.05	
Count	106	97
Max	100.00	100.00
High	94.00	96.85
Low	2.27	13.24
Mean	61.81	68.84
Std. Dev.	20.47	16.32
Median	67.30	68.50
Variance	418.9437373	266.40

C 1999 Bluesheets (Part 1)

	NA	SD	D	A	SA
P1-Q1	0	0	9	48	13
P1-Q2	0	1	5	42	22
P1-Q3	0	0	2	37	31
P1-Q4	1	1	12	34	22
P1-Q5	0	0	0	23	47
P1-Q6	0	1	6	33	30
P1-Q7	0	1	4	43	22
P1-Q8	0	6	9	34	21
P1-Q9	3	7	12	32	16
P1-Q10	10	0	9	40	11
P1-Q11	2	6	24	27	11
P1-Q12	0	2	5	44	19
P1-Q13	1	1	6	43	19
P1-Q14	3	0	6	38	23
TOTAL:	20	26	109	518	307

C 1999 Bluesheets (Part 2)

	NA	SD	D	A	SA
P2-Q1	0	8	16	39	7
P2-Q2	0	1	8	35	26
P2-Q5	2	1	14	40	13
P2-Q6	0	2	7	45	16
P2-Q7	1	1	12	41	15
TOTAL:	3	13	57	200	77

C 1999 Bluesheets (% for Part 1)

	SD	D	A	SA
P1-Q1	0%	13%	69%	19%
P1-Q2	1%	7%	60%	31%
P1-Q3	0%	3%	53%	44%
P1-Q4	1%	17%	49%	32%
P1-Q5	0%	0%	33%	67%
P1-Q6	1%	9%	47%	43%
P1-Q7	1%	6%	61%	31%
P1-Q8	9%	13%	49%	30%
P1-Q9	10%	18%	48%	24%
P1-Q10	0%	15%	67%	18%
P1-Q11	9%	35%	40%	16%
P1-Q12	3%	7%	63%	27%
P1-Q13	1%	9%	62%	28%
P1-Q14	0%	9%	57%	34%
TOTAL:	3%	11%	54%	32%

C 1999 Bluesheets (% for Part 2)

	SD	D	A	SA
P2-Q1	11%	23%	56%	10%
P2-Q2	1%	11%	50%	37%
P2-Q5	1%	21%	59%	19%
P2-Q6	3%	10%	64%	23%
P2-Q7	1%	17%	59%	22%
TOTAL:	4%	16%	58%	22%

C 2000 Bluesheets (Part 1)

	NA	SD	D	A	SA
P1-Q1	2	1	11	33	15
P1-Q2	1	3	12	31	15
P1-Q3	1	0	0	39	22
P1-Q4	1	1	11	35	14
P1-Q5	2	0	2	26	32
P1-Q6	2	1	6	33	20
P1-Q7	2	1	7	38	14
P1-Q8	3	5	5	32	17
P1-Q9	4	2	11	32	13
P1-Q10	12	1	3	33	13
P1-Q11	2	3	12	35	10
P1-Q12	2	1	9	38	12
P1-Q13	5	1	5	34	17
P1-Q14	2	1	9	31	19
TOTAL:	41	21	103	470	233

C 2000 Bluesheets (Part 2)

	NA	SD	D	A	SA
P2-Q1	3	22	20	17	0
P2-Q2	2	0	7	31	22
P2-Q5	3	1	6	41	11
P2-Q6	3	2	10	34	13
P2-Q7	3	2	8	39	10
TOTAL:	14	27	51	162	56

C 2000 Bluesheets (% for Part 1)

	SD	D	A	SA
P1-Q1	2%	18%	55%	25%
P1-Q2	5%	20%	51%	25%
P1-Q3	0%	0%	64%	36%
P1-Q4	2%	18%	57%	23%
P1-Q5	0%	3%	43%	53%
P1-Q6	2%	10%	55%	33%
P1-Q7	2%	12%	63%	23%
P1-Q8	8%	8%	54%	29%
P1-Q9	3%	19%	55%	22%
P1-Q10	2%	6%	66%	26%
P1-Q11	5%	20%	58%	17%
P1-Q12	2%	15%	63%	20%
P1-Q13	2%	9%	60%	30%
P1-Q14	2%	15%	52%	32%
TOTAL:	3%	12%	57%	28%

C 2000 Bluesheets (% for Part 2)

	SD	D	A	SA
P2-Q1	37%	34%	29%	0%
P2-Q2	0%	12%	52%	37%
P2-Q5	2%	10%	69%	19%
P2-Q6	3%	17%	58%	22%
P2-Q7	3%	14%	66%	17%
TOTAL:	9%	17%	55%	19%

C 1999 Bluesheets (mean for Part 1)

	SD = 1	D = 2	A = 3	SA = 4	TOTAL:	COUNT	MEAN
P1-Q1	0	18	144	52	**214**	70	3.06
P1-Q2	1	10	126	88	**225**	70	3.21
P1-Q3	0	4	111	124	**239**	70	3.41
P1-Q4	1	24	102	88	**215**	69	3.12
P1-Q5	0	0	69	188	**257**	70	3.67
P1-Q6	1	12	99	120	**232**	70	3.31
P1-Q7	1	8	129	88	**226**	70	3.23
P1-Q8	6	18	102	84	**210**	70	3.00
P1-Q9	7	24	96	64	**191**	67	2.85
P1-Q10	0	18	120	44	**182**	60	3.03
P1-Q11	6	48	81	44	**179**	68	2.63
P1-Q12	2	10	132	76	**220**	70	3.14
P1-Q13	1	12	129	76	**218**	69	3.16
P1-Q14	0	12	114	92	**218**	67	3.25
TOTAL:	**26**	**218**	**1554**	**1228**	**3026**	**960**	**3.15**

C 1999 Bluesheets (mean for Part 2)

	SD = 1	D = 2	A = 3	SA = 4	TOTAL:	COUNT	MEAN
P2-Q1	8	32	117	28	**185**	70	2.64
P2-Q2	1	16	105	104	**226**	70	3.23
P2-Q5	1	28	120	52	**201**	68	2.96
P2-Q6	2	14	135	64	**215**	70	3.07
P2-Q7	1	24	123	60	**208**	69	3.01
TOTAL:	**13**	**114**	**600**	**308**	**1035**	**347**	**2.98**

C 2000 Bluesheets (mean for Part 1)

	SD = 1	D = 2	A = 3	SA = 4	TOTAL:	COUNT	MEAN
P1-Q1	1	22	99	60	**182**	60	3.03
P1-Q2	3	24	93	60	**180**	61	2.95
P1-Q3	0	0	117	88	**205**	61	3.36
P1-Q4	1	22	105	56	**184**	61	3.02
P1-Q5	0	4	78	128	**210**	60	3.50
P1-Q6	1	12	99	80	**192**	60	3.20
P1-Q7	1	14	114	56	**185**	60	3.08
P1-Q8	5	10	96	68	**179**	59	3.03
P1-Q9	2	22	96	52	**172**	58	2.97
P1-Q10	1	6	99	52	**158**	50	3.16
P1-Q11	3	24	105	40	**172**	60	2.87
P1-Q12	1	18	114	48	**181**	60	3.02
P1-Q13	1	10	102	68	**181**	57	3.18
P1-Q14	1	18	93	76	**188**	60	3.13
TOTAL:	**21**	**206**	**1410**	**932**	**2569**	**827**	**3.11**

C 2000 Bluesheets (mean for Part 2)

	SD = 1	D = 2	A = 3	SA = 4	TOTAL:	COUNT	MEAN
P2-Q1	22	40	51	0	**113**	59	1.92
P2-Q2	0	14	93	88	**195**	60	3.25
P2-Q5	1	12	123	44	**180**	59	3.05
P2-Q6	2	20	102	52	**176**	59	2.98
P2-Q7	2	16	117	40	**175**	59	2.97
TOTAL:	**27**	**102**	**486**	**224**	**839**	**296**	**2.83**