Evaluating the Distance Learning Operations Course by Measuring Prolonged Learning and Application

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Introduction

Professional development is commonly defined as “the systematic maintenance, improvement and broadening of knowledge and skills, and the development of personal qualities necessary for execution of professional and technical duties throughout the individual’s working life” (Friedman et al 2000). Professional development, also defined as the continued advancement of knowledge and skill, can come from a variety of resources. Some common ways of achieving professional development include “study, travel, research, workshops or courses, sabbaticals, internships, apprenticeships, residencies or work with a mentor” (Canada Council for the Arts 2005).

One kind of professional development is employee training, or educating specific employees on specific knowledge, skills, or attributes deemed important by the company. The average U.S. company spends between 2 and 10 percent of its total budget on this type of training. This expense results in approximately $820 spent per employee annually on training (ASTD 2004). Options available for training include on-site-based training, distance learning, or a blended approach. While on-site-based training allows more social interaction which can often lead to valuable relationships and networking abilities, distance learning facilitates larger class sizes, easier access to instructional materials, a smaller price tag, and allows for easier data collection when it comes to assessment (Dolezalek 2004).

One of the primary goals of training programs is to improve performance by modifying behaviors to fit a desired standard. In order to modify a behavior, however, learning of the new behavior and the skills to apply it are first required (Kirkpatrick 2005). How does one know if the behaviors and/or skills have been learned? Assessment, or the evaluation of learning, can provide insight into the amount of knowledge gained and/or retained as a result of a training course. Common ways of assessing learning include testing of knowledge, testing of performance, surveys, interviews, or any combination of these (Kirkpatrick 2005).

Testing, with the purpose of measuring and analyzing learning, remains a difficult task for trainers and statisticians alike. The desire of the evaluator is to be able to compare the results of one test to those of subsequent administrations (Hodges 2002). Good test construction is vital to ensure that the results provided by the test are consistent, and able to be used to assess results (Ediger 2001).

Two important characteristics of a good test are reliability and validity. A reliable test is one that is consistent over time, meaning that, if learning has occurred, a reliable test will give the same results (Hodges 2002). Therefore, giving a reliable test over again, at some time later, can give insight into the amount of learning that has taken place. Other ways to ensure reliability in testing include making scoring objective, making the test long enough, and controlling the environment in which the test is given (Hodges 2002).

A test is considered valid if it measures accurately and precisely what it is intended to measure (Hodges 2002). While a test can be reliable without being valid, it cannot be valid unless it is first reliable. Though several types of validations exist, the test used in this study aims for content validation. Content validation assesses whether the items within the test accurately represent the performance domain, behaviors, or skills that are being taught and tested (Crocker and Algina 1986). Two ways to ensure test validity is to prepare the test taking into consideration of the objectives of the course (which must be available to all trainers and students), and analyzation of the test data in order to eliminate or modify tricky or vague multiple-choice items for future test administrations (Ediger 2001).

Online testing, though not the ideal form of test administration, is often the only viable option left to trainers, especially those involved in distance learning. Bringing in students from around the country to take a test or undergo a performance evaluation is certainly cost-prohibitive. Helgeson and Kumar (1993) argued that large scale, hands-on testing in laboratories is too expensive in time, human resources, and equipment. Other deficiencies that occur with online training and assessment include: students varying acceptance and understanding of the technology, lack of personal feedback and interaction, and the inability to monitor cheating and enforce time constraints (Dolezalek 2004; Helgeson and Kumar 1993). Despite these constraints, the improvements in areas such as cost-effectiveness, better record-keeping, and the ease of test taking help to outweigh the negative aspects. Online testing has proven overwhelmingly to be the course of action chosen by distance learning courses.

Distance Learning Operations Course: Background

The Warning Decision Training Branch (WDTB), located in Norman, Oklahoma, develops and delivers training for the National Oceanic and Atmospheric Association’s (NOAA) National Weather Service (NWS). With the goal of increasing expertise of the NWS personnel, it strives to equip forecaster with the tools necessary to make better and more educated warning decisions though its services. One of the services provided by the WDTB is the Distance Learning Operations Course (DLOC), which is a training course offered primarily to entry-level meteorologists in NOAA’s NWS Weather Forecast Offices (WFO’s).

DLOC provides education, training, and instruction on the operation and interpretation of the WSR-88D radar and its outputs, which is one of the primary tools forecasters use to make warning decisions. It is the goal of DLOC to impart the knowledge and understanding of its objectives with the aim of being able to change behaviors and improve performance. The DLOC course, made up of eight separate Instructional Components (ICs), contains multiple-choice tests, to be taken after completing the ICs. Each test covers distinct and detailed learning objectives presented at the beginning of every section. Several of the ICs utilize teletraining, which is an online teaching environment that allows real-time instruction and communication between WDTB trainers and the students. The teletraining sessions supplement other portions of the course such as web-based modules and student guides. In addition, at the conclusion of the course, there is a residence workshop at the WDTB to culminate the course.

With all of the time and resources spent on this important training, it begs the question, "what is the return of investment?" Return on Investment (ROI), which was first introduced by Dr. Jack Phillips and is often referred to level 5 evaluation, measures the monetary value of a training program, usually as a percentage of results and costs (Phillips, 1997). This is no simple calculation, however, and due to the extensive costs in time and money, it is only recommended that only the top 5% of organizations programs should undertake ROI analysis (Kirkpatrick 2005). There are also several steps of evaluation which must be first undertaken before ROI can be accurately calculated, each of which will be discussed in the next section. While an ROI calculation of DLOC would be ideal, the groundwork for such a project must first be laid, which will be attempted in this research.

The purpose of this study is to determine the amount of learning that has taken place, and to what extent this learning is a direct consequence of DLOC training. Proper evaluation of DLOC will allow the NWS to accurately gauge the funding needed for the course and its completion. Specifically, this study aims to answer the following research questions:

1) How much information is retained from the course?
2) What is the reported level of application of the DLOC material in the meteorologist's current position?
3) Is there any correlation between the amount of usage of the material and the retention of the material?
4) Is there any significant difference between the 2004 and the 2005 classes of DLOC?

Theoretical Framework

This study is based on the four level evaluation model presented by Kirkpatrick (2005). The four levels are, in chronological order: *reaction* (how do trainees react to the training program), *learning* (to what extent has learning occurred), *behavior* (how much has on-the-job behavior changed due to the training), and *results* (how have organizational results changed because of the training). Training is typically measured either quantitatively or qualitatively, to evaluate the effectiveness of the learning event. It is appropriate to evaluate first, at levels 1 and 2 before assessing level 3 (behavior). This way the previous levels can be understood as they relate to the training being evaluated. For example, information will not be retained as effectively if the trainees are not accepting and responsive to the training (i.e. level 1 to level 2).

Level 2 evaluation, or the evaluation of learning which has taken place as a result of the training, remains that most common measurement technique for individuals in both academic or business settings. Universities use this type of evaluation in their exams to determine whether learning of the course material has occurred, thus whether you pass or fail. Most businesses, however, rarely evaluate beyond level 1, and when they do test for learning, only do so during the training itself. In order to determine whether learning is extended, level 2 data must be collected at some time after the training has been completed, when the trainees have returned to work. If the material has been effectively learned enough to change workplace behavior, the trainee should be able to recall the course material well after they have returned to work.

Data and Methods

Participants

In this research, level 2 data will be collected (in the form of a test) from two samples of former DLOC students, one which took the course a year and half ago (2004 group), and the other only 6 months removed from the training (2005 group). This sample of former students is representative of students from WFOs all over the country. To facilitate gathering the largest and most representative data set possible, a posttest was provided to every student participating in the FY04 and FY05 DLOC's (~ 160 people). Sixty-six former students (28 in the FY2004 class and 39 in the FY2005 class) accepted to take our assessment and were included in this study. This gives a response rate of just over 40%. Although the sample was self-selected, it represents a significant proportion of our population of interest and sample bias was not expected. The former DLOC students were separated into one of 6 regions; Eastern, Central, Southern, Western, Pacific/Alaskan, and Other (which contained forecasters in national centers such as the National Hurricane Center).

Assessment Instrument

Within the study, the quasi-independent variables are the exam results gathered during the DLOC course, while the quasi-dependent variables will consist of the new test results and the reported level of application recorded in the survey. These variables were measured with a content test and an applicability survey.

In the posttest given to DLOC students, the scoring was made completely objective by making the test a multiple-choice test, in which one and only one answer for each question is correct. The test, which is a 25 item test, was of significant length to properly gauge whether learning of the course objectives had taken place. Since DLOC is a distance learning course, each trainee completed the tests online. To ensure reliability, the test was implemented by a similar online testing system that the students completed during the actual DLOC.

The performance domains for each of the tests in DLOC come from the learning objectives in the course. These objectives are measured directly and objectively, helping to ensure both reliability and content validity. One of the 5 exams in DLOC covers topics in the instruction component entitled, “Convective Storm Structure and Evolution.” This IC contains material which has been tested over in previous years of DLOC. Therefore, the exam on Convective Storm Structure and Evolution was a logical choice for retesting former students for course objective retention.

In addition, a survey was included in the data collection which provided information into the frequency with which the employees used the DLOC materials, so that the amount of level 2 data which can be attributed to the training can be related. In the survey, each student ranked their applicability of eight different aspects of DLOC, one through nine (with one constituting no application and nine as full application). The median of the eight aspects was taken to be the student’s application of DLOC. The median was chosen since it is less sensitive to outliers than the mean. Frequently, a student may not be able to use one or two aspects of DLOC due to their job assignment. So taking the mean to represent application could skew the results. The survey which accompanies the posttest, collects geographical information, and helps to ensure the sample represents all regions of the NWS WFO's (Appendix A).

Data Collection Procedure

The posttest, along with an accompanying survey, was placed on a designated website. An email was then sent to each of the former students to notify them of the nature of the research and ask them for their participation. When taking the exam, the students were instructed to take no more than 60 minutes, and to take the test "closed book", with no help from outside sources. Directions were clear that it was imperative to the research that students take the test with only the knowledge retained from DLOC. They were also assured that their scores would in no way affect their job, and that their individual scores would never be released (See letter: Appendix B). A database containing all former DLOC students from FY04 and FY05 was created. This database contained the name and email address of each student, as well as their current office. The scores from their exam during the original DLOC were also entered into the database.

Once the data on level 2 has been analyzed, and we know to what extent learning has taken place and is available to be transferred to level 3, behavior changes can be predicted based on learning. Since the purpose of this study is to be able to determine the amount of learning which stays over time, which can then be applied to changing behaviors, certain criterion need to be set for acceptable retention. If, after a period of time, the mean for the students is still above a passing 70%, it can be inferred that the knowledge is sufficient enough to be applied to changing workplace behaviors.

Statistical Analysis

To compare the average scores on tests, a Student's t test was used. This test determines whether two means are significantly different from each other. To measure the strength of the correlation between posttest scores and applicability, Pearson correlation coefficients were calculated. An additional test was used to determine whether the correlation coefficient was significantly different from zero. From these tests, we can draw inferences into how much long-term learning has taken place, as well as whether or not we can attribute this learning solely to DLOC, or from continued use of course objectives in the workplace.

To determine if different NWS regions report different levels of applications of the concepts learned through the DLOC course, a Kruskal-Wallis test, a nonparametric version an Analysis of Variance (ANOVA) was used. In addition, Chi-Square tests were performed to determine what specific items were answered significantly different in both test administrations in order to possibly identify weaknesses in DLOC training, as well as questions with a recurring incorrect response, which could point to ambiguity in a certain test question. Making these extra observations will help the WDTB evaluate the effectiveness of DLOC, as well as providing some possible directions in improving it.

Throughout the research, an alpha level (or significance level) of 0.1 was chosen, meaning that only p-values of less than 0.1 would be considered significant. An alpha value of 0.1 was adopted instead of the traditional 0.05 due to the fact that the sample size is rather small and not normally distributed. An alpha value above 0.1, however, becomes too lenient and not strict enough to weed out potential chance errors when using a smaller sample size.

Results

Participants vs. Non-Participants

Figure 1 shows the distribution of scores for each year, with each looking similar to a normal, bell-shaped curve, which is assumed when using parametric tests. A t-test performed to gauge how different the participants in the posttest were from the non-participants yielded non-significant results ($t = 0.5048$, $p = 0.61$). This test suggests that participant self-selection did not create two significantly different groups from within our population of interest.

Long-term Learning

Several t-tests were performed to determine the amount of information retained from DLOC as it compared to the amount that was present at the termination of the course. The pretest mean for 2004 was 20.48 (out of 25), and for 2005, was 20.59; while the posttest means for 2004 and 2005 were 17.93 and 18.23 respectively. These differences are statistically significant ($t_{2004} = 4.277$, $p = 0.003$; $t_{2005} = 5.517$, $p < 0.001$).

Specifically, Chi-Square test determined that items 4, 13, 19, and 24 were answered significantly worst in the posttest compared to the pre-test for the 2004 group, and that items 1, 4, 12, 13, 14, 17, 19, and 24 were answered significantly worst in the posttest compared to the pre-test for the 2005 group. An examination of the items revealed that some were not as efficient in discriminating between high achievers and low achievers on the test. For others, no specific reason for the difference was found. A possible reason for the disproportionate amount of significantly different responses in 2005 is because the sample size was larger, making it easier to become statistically different.

Level of Applicability

On a scale from 1 to 9, the average application for the 2004 class was 7.60, with a range of 1.5 to 9. Similarly, the 2005 class had an average application of 7.18 and a range of 2 to 9. Reported applications were grouped into one of two categories, low application (1-6), and high application (7-9) and put into categories by NWS regions (figure 4). Although an inspection of the table reveals that the mean rank for the region titled “Other” looks different from the other mean ranks, a Krustal-Wallis test found no statistically significant difference between the applicability level and the participant’s region of residence ($p = 0.15$). It is important to note that the Krustal-Wallis test is best used when there are at least 5 items per cell, which is not the case in this scenario. Therefore the results of the test must be interpreted cautiously. If the Krustal-Wallis test is performed again without the “Other” group, the p value becomes 0.96, suggesting that there is no difference between regions and their reported applicability.

Correlations between Applicability and Long-term Learning

Correlations between the posttest scores and the reported application for each student are contained in figure 3. Figure 3a shows a slight positive correlation between reported application and the resulting posttest score for both years, with a statistically significant Pearson correlation coefficient ($r = 0.233$, $p = 0.06$). For 2004 (figure 3b) a stronger and significant positive correlation was found ($r_{2004} = 0.503$, $p = 0.007$). Interestingly, an apparent outlier was noticed among the data. To avoid reporting a false positive results due to the outlier, the correlation analysis was performed again without that person, and a statistically significant correlation was still found ($p = 0.016$) (figure 3d). In figure 3c, however, the correlation between the 2005 posttest scores and the reported application is not significantly different from zero ($r_{2005} = 0.044$, $p = 0.79$).

Discussion

The goal of the first test run on the data was to conclude if the students who responded to the survey and took the test were different from those who did not participate. The fact that there is no statistical difference shows that the two groups are the same and our results will not be tainted by a biased sample (such as only the "overachievers" participated in the study). In fact, the mean score on the initial test for those participating in the study was actually slightly lower than that for the non-participators (20.48 versus 20.66). Now that we can assume a representative sample, we can begin to make some conclusions based on the results.

The first goal of the study was to determine the amount of information retained from the course. The second round of t-test performed on the posttest scores of both years compared to the initial tests scores shows a statistical difference. This means that something has changed over the amount of time since DLOC. Some of the information learned during DLOC has been forgotten, which was hypothesized. The means for the two posttests, however, are 17.93 and 18.23 for 2004 and 2005 respectively (out of 25). Therefore, both years averaged above a passing grade of 70% some time after the training, which would indicate successful training. There exists enough retention of the information learned in DLOC to successfully change workplace behaviors to fit the desired standard.

Was the information retained due to effective training, workplace application, or a combination of both? The correlations in figure 3 show that there is indeed a statistically significant relationship between application and the score on the posttest. Breaking the figure up into years, however, shows different results for each year. The students who took DLOC in 2004 depend more heavily on application to recall DLOC techniques than do their 2005 counterparts. Some reasons for this include the fact that the 2005 class only recently completed the training and can possibly still recall the information clearly, while the 2004 group only recalls what they have been able to apply on a regular basis. Also, the 2004 group has had more of an opportunity to apply the DLOC objectives in the workplace than have the 2005 group, leading to a stronger relationship between application and retention.

From these figures it seems as though the retention of the material comes from both effective training and regular application. In the short term, before the material has had sufficient time to be applied, it can still be recalled thanks to effective training techniques. In the long term, however, a stronger relationship occurs between retained knowledge and application since the material not applied begins to fade from memory.

There is not, however, a difference in reported application by region as was hypothesized. There is, on the other hand, a difference between the application for those in a region and those who have moved to a national office or some other NWS branch (Group 5 *Other* in figure 4). With the low application for this group, it would make sense for the NWS to limit the participants in DLOC to forecasters from NWS forecast offices, excluding those in national offices and not forecasting branches.

In order to solidify these claims, more research needs to be done. A study which has future implications would be to show whether or not time influences the dependence on application to retain course knowledge. Also, a larger sample size would give clearer, more statistically significant results. Perhaps this research can be repeated when a level 3 performance study begins and the two together can provide a better understanding of the relationship between prolonged learning and application.

Conclusions

In this study, 66 former students of the Distance Learning Operations Course, given by the NWS's WDTB, were given a post-course test in order to do a level 2 evaluation of the course. It was concluded that the information was retained sufficiently to be applied to change behaviors and possibly improve performance. There was a slightly significant correlation between the application of DLOC objectives and the recollection of these objectives at some time later. The correlation was much stronger for the 2004 participants than it was for those participating in 2005, possibly for the reasons listed above, but the dependence on time needs to be further investigated.

It was also concluded that there is no relationship between application and region within the NWS. DLOC students from all of the regions reported a majority of high application of the course, with the notable exception of those currently in national or non-forecasting branches. With this in mind, the National Weather Service could save time and money by not encouraging those students to participate in DLOC. They should, however, encourage those in regions where significant severe weather is not prominent to still take DLOC since a high degree of applicability is reported.

Finally, the scores found in the posttest support that prolonged learning has occurred, especially when combined with high levels of application, and can transfer to behavior changes in the workplace. In the future, a level 3 evaluation should be performed and compared to the prediction given as a result of this study. Eventually, level 4 data should be gathered and a Return on Investment could be calculated.

Some limitations of this study come from the fact that a test covering only one section was used to measure supposed learning from an entire course. Due to time constraints, this was the only option for this study, but if repeated, a new test could be constructed which tests material from all parts of the course. Other limitations originate from our small dataset. Since only two weeks were given to the former students to respond to the survey and take the test, only 40% responded. If repeated, giving the students longer to respond may allow a higher response rate, and thus yield better results.

Acknowledgement

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APPENDIX A

DLOC Post-Training Evaluation Survey / Quiz
(to be entered into online OCWWS survey for administration)

Part I. Logistical questions

1. Last Name, First Name:
2. Current Office:
3. Year enrolled in DLOC: 2004/2005

Part II. Opportunities to apply DLOC objectives

Specific Instructions:
Please indicate the degree to which you have applied the following instructional components of the Distance Learning Operations Course (DLOC) in your current position. In this scale, "1" implies that you have not applied any of the DLOC training. On the other hand, "9" implies full application of the DLOC training in your current position. Numbers in between the scale refers to linear gradations between the two extremes.

DLOC Instructional Component				Rating Scale					
Radar Applications using AWIPS	1	2	3	4	5	6	7	8	9
Introduction to WSR-88D	1	2	3	4	5	6	7	8	9
Principles of Met. Doppler Radar	1	2	3	4	5	6	7	8	9
Velocity Interpretation	1	2	3	4	5	6	7	8	9
Base and Derived Products	1	2	3	4	5	6	7	8	9
System Operations and Control	1	2	3	4	5	6	7	8	9
Convective Storm Structure and Evolution	1	2	3	4	5	6	7	8	9
DLOC In-Residence Workshop	1	2	3	4	5	6	7	8	9

Specific Instructions:
Answer each of the following questions as completely and detailed as possible.

1. What specific topic from the DLOC training have you applied the most in your current position? Provide an example to illustrate your point.

2. What specific topic from the DLOC training have you never applied in your current position? Describe the reason why.

Figure 1

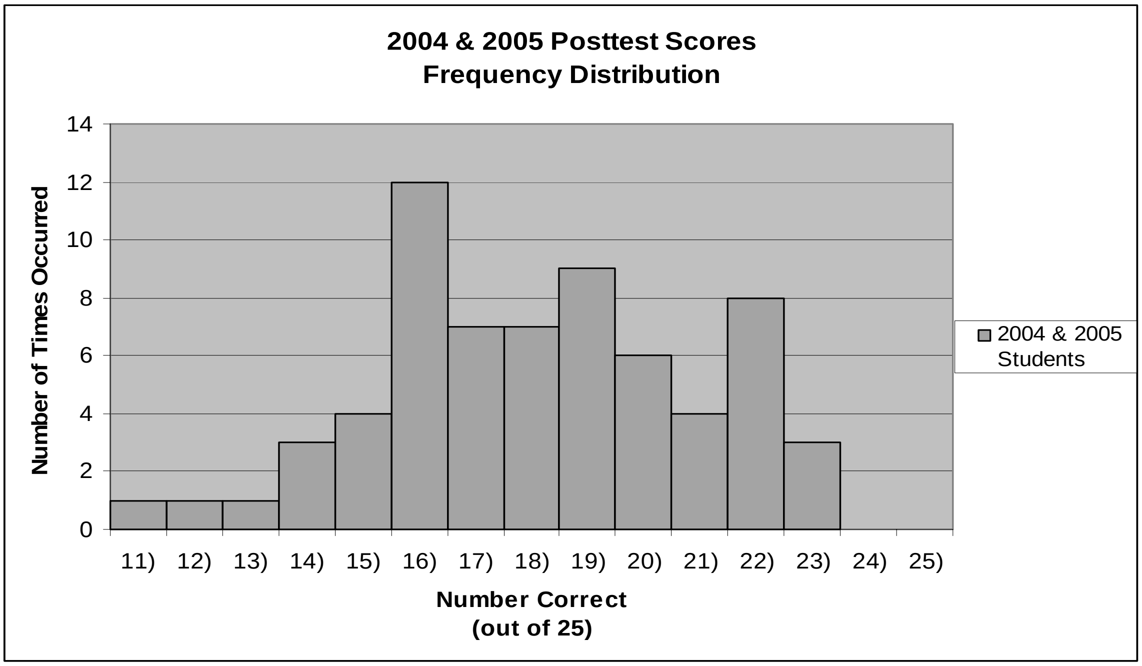

Figure 1a: Frequency distribution of combined 2004 and 2005 student's posttest scores. Notice the near normal distribution (bell-shaped curve) centered on the mean, which is 18.1.

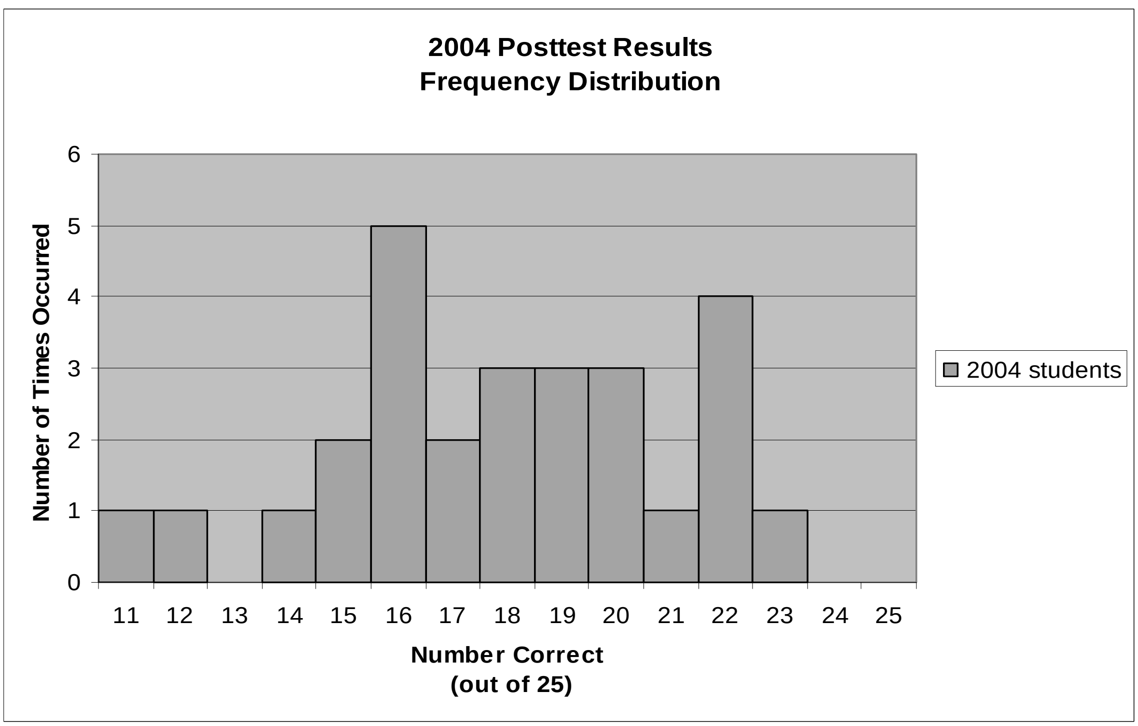

Figure 1b: Frequency distribution of combined 2004 student's posttest scores. Notice the near normal distribution (bell-shaped curve) centered on the mean, which is 17.93.

Figure 1 Continued

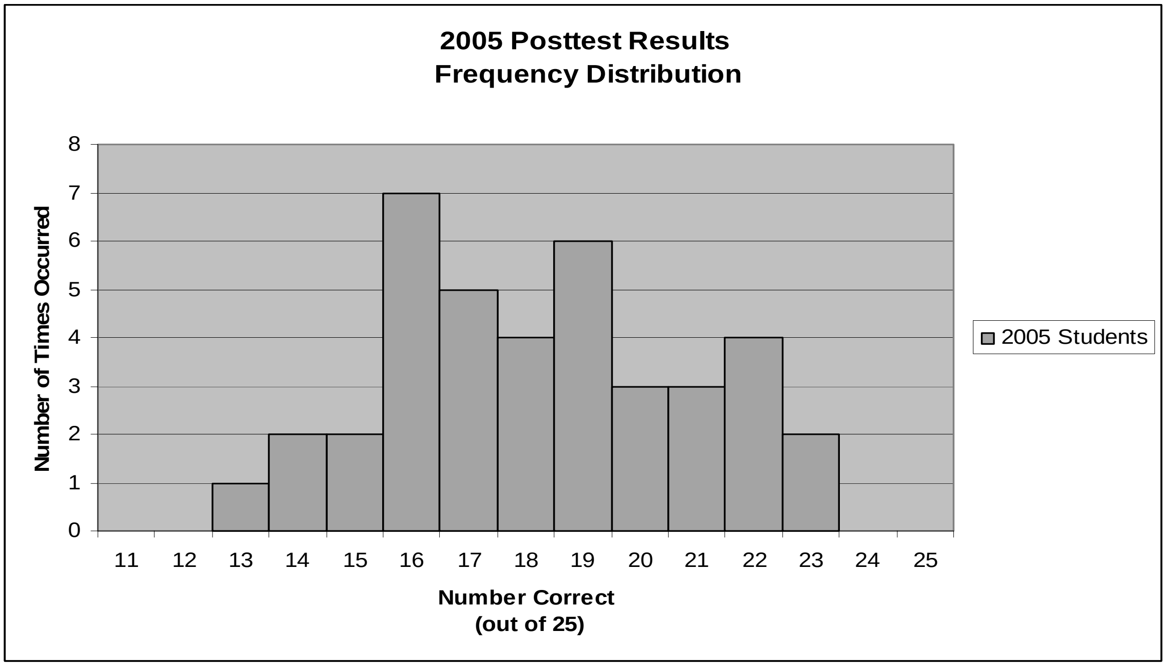

Figure 1c: Frequency distribution of combined 2005 student's posttest scores. Notice the near normal distribution (bell-shaped curve) centered on the mean, which is 18.23.

Figure 2

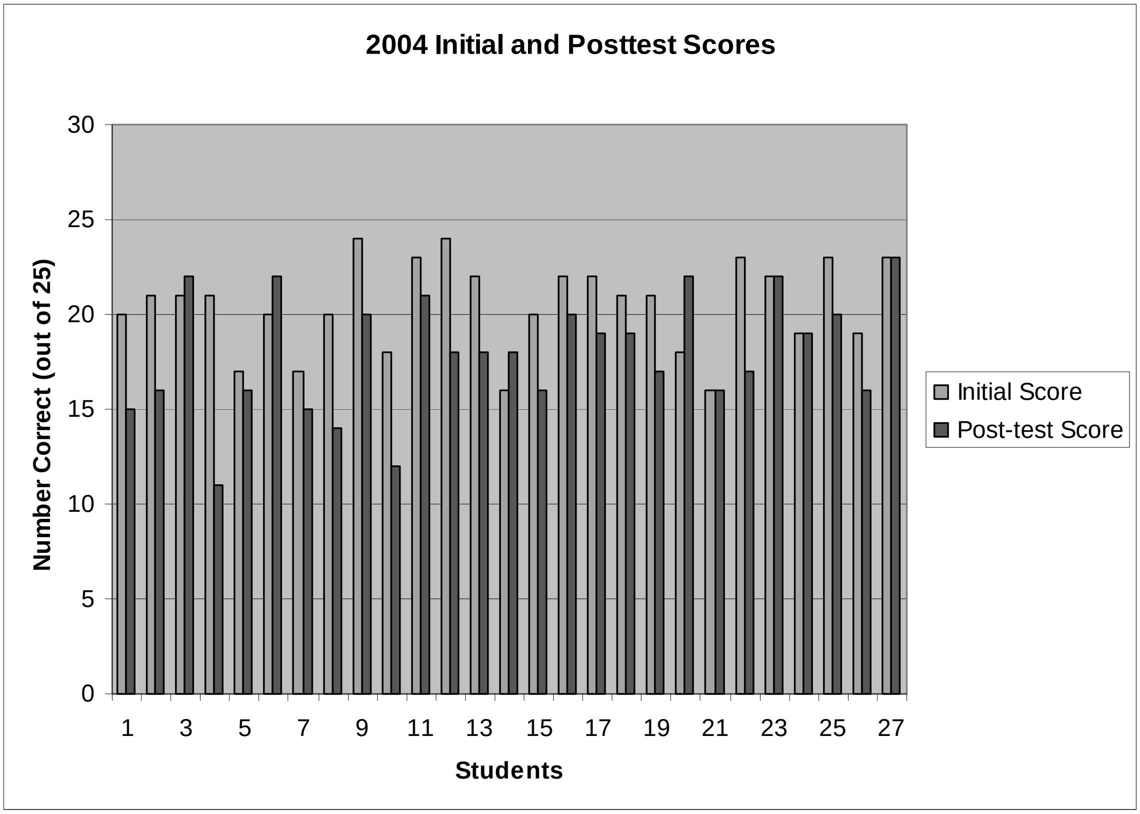

Figure 2a: Each students initial score and posttest score. Initial mean 20.48, Posttest mean-17.93

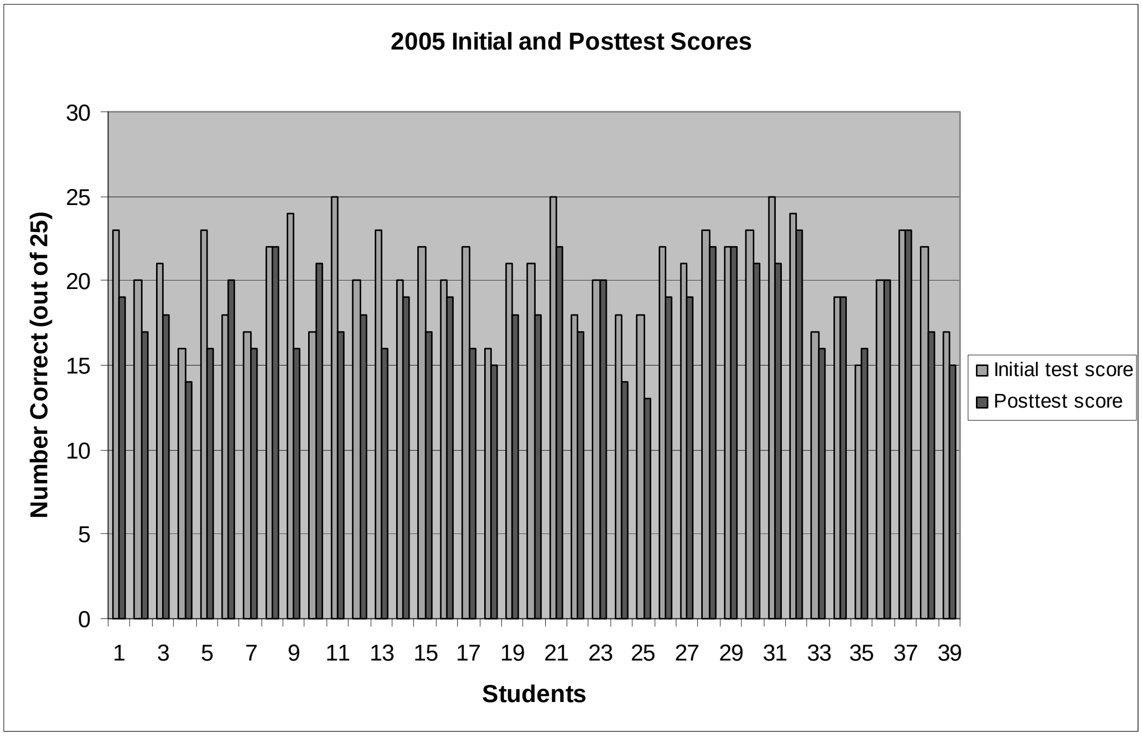

Figure 2b: Each students initial score and posttest score. Initial mean 20.59, Posttest mean-18.23

Figure 3

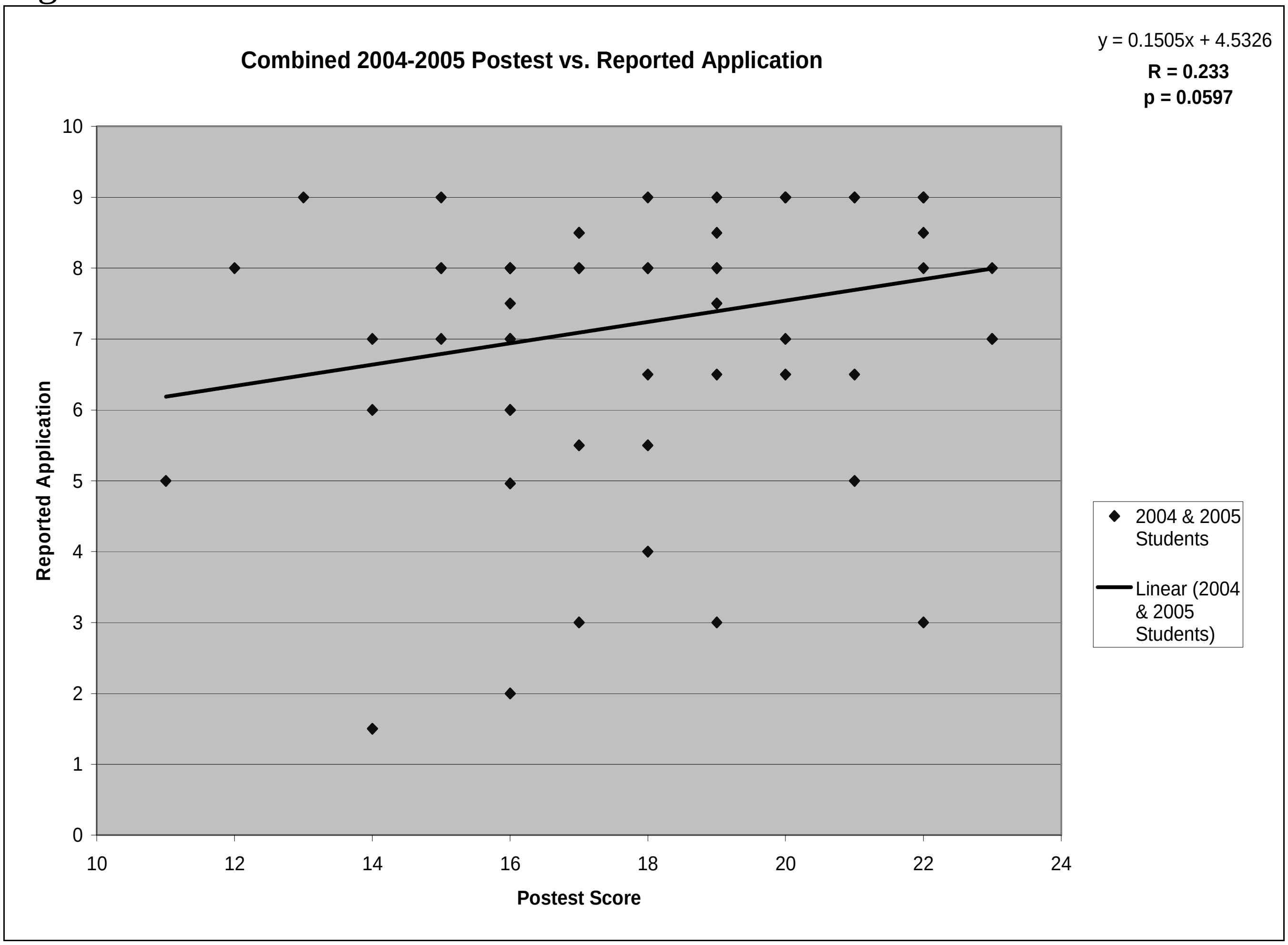

Figure 3a: Slight positive correlation between posttest score and the reported application. P value of 0.0597 means the relationship is significant.

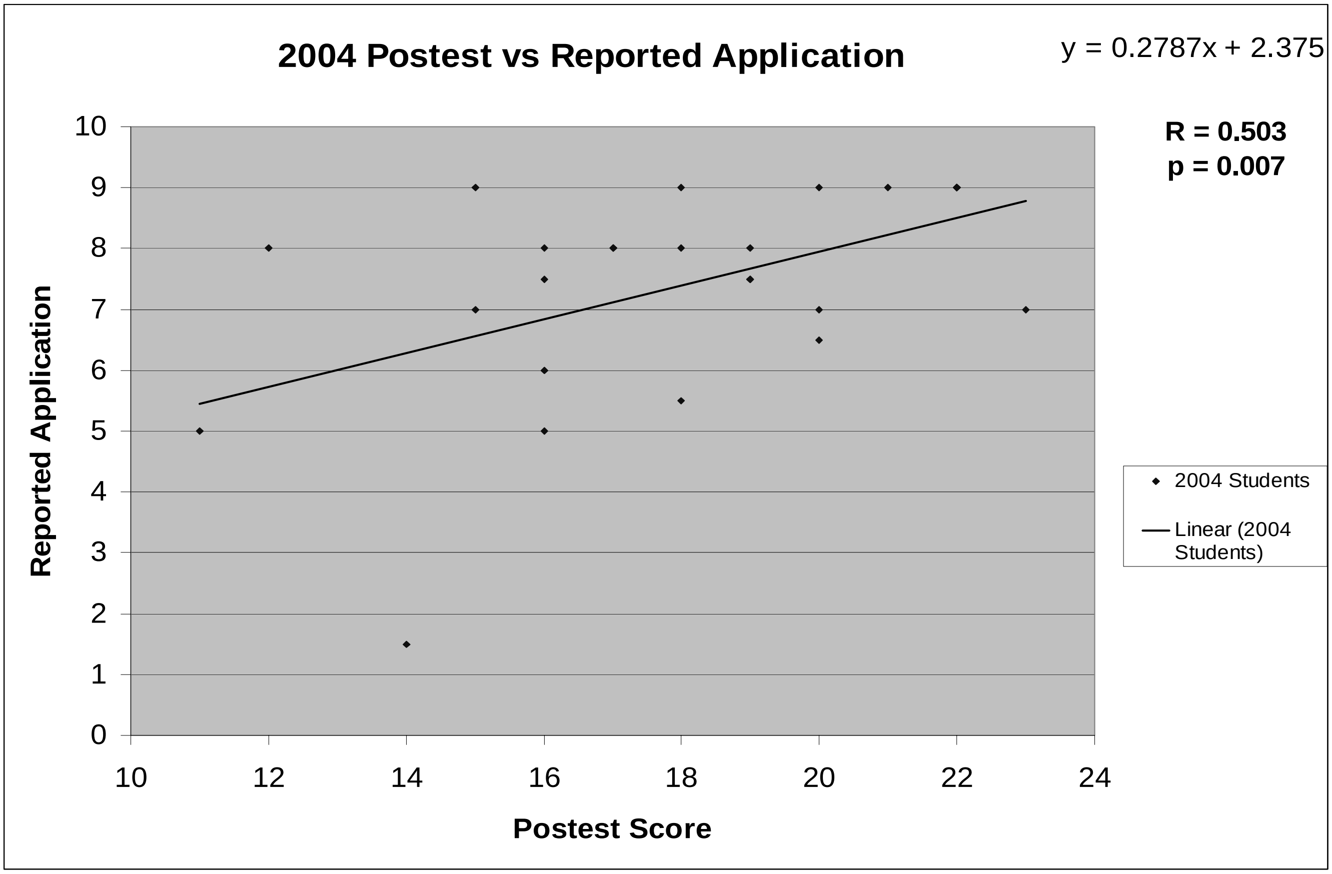

Figure 3b: Slightly stronger (than figure 3a) positive correlation between posttest score and the reported application. P value of 0.007 means the relationship is very significant.

Figure 3 continued

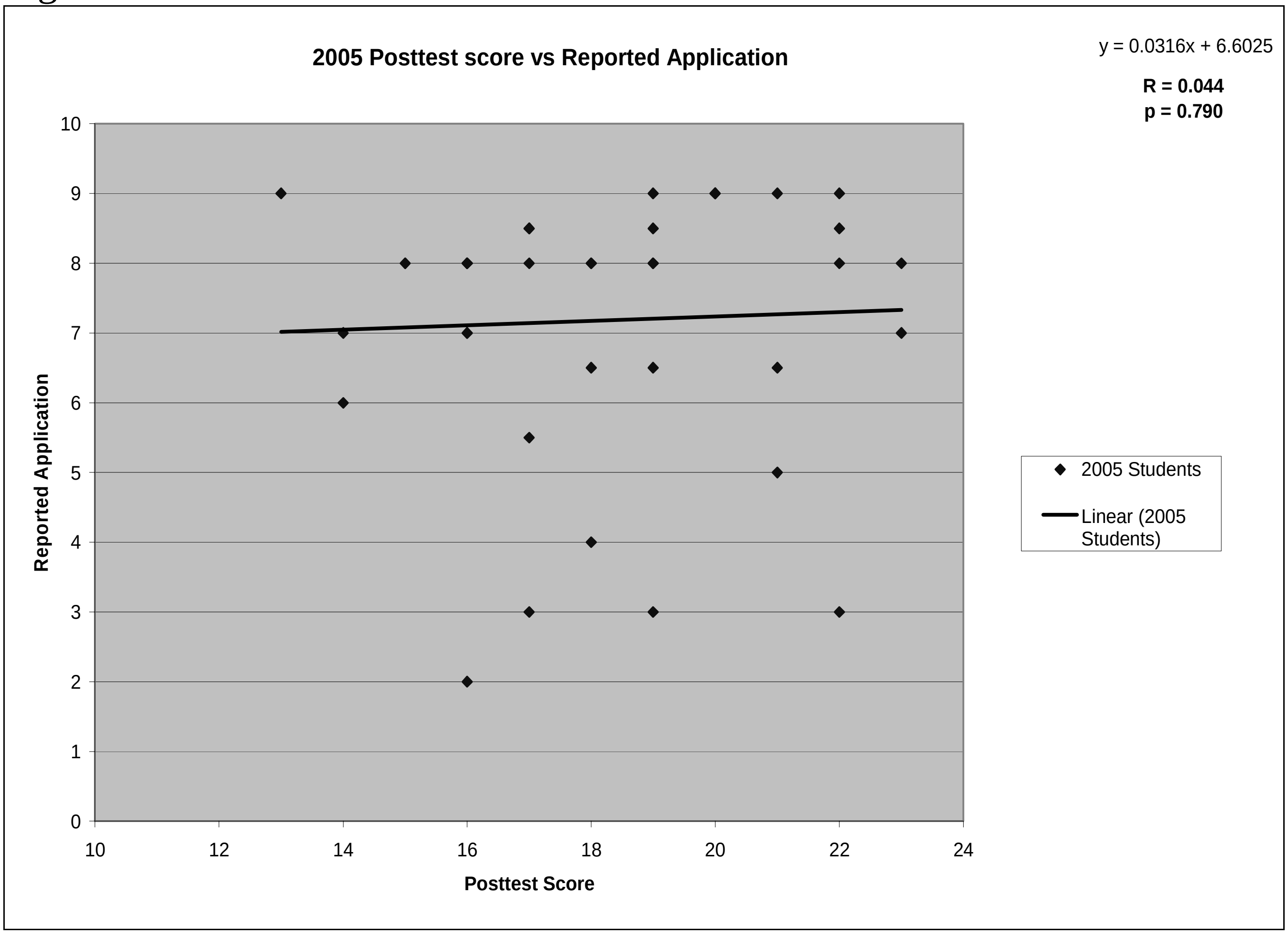

Figure 3c: Near zero correlation between posttest score and the reported application. P value of 0.790 means the relationship is not significant.

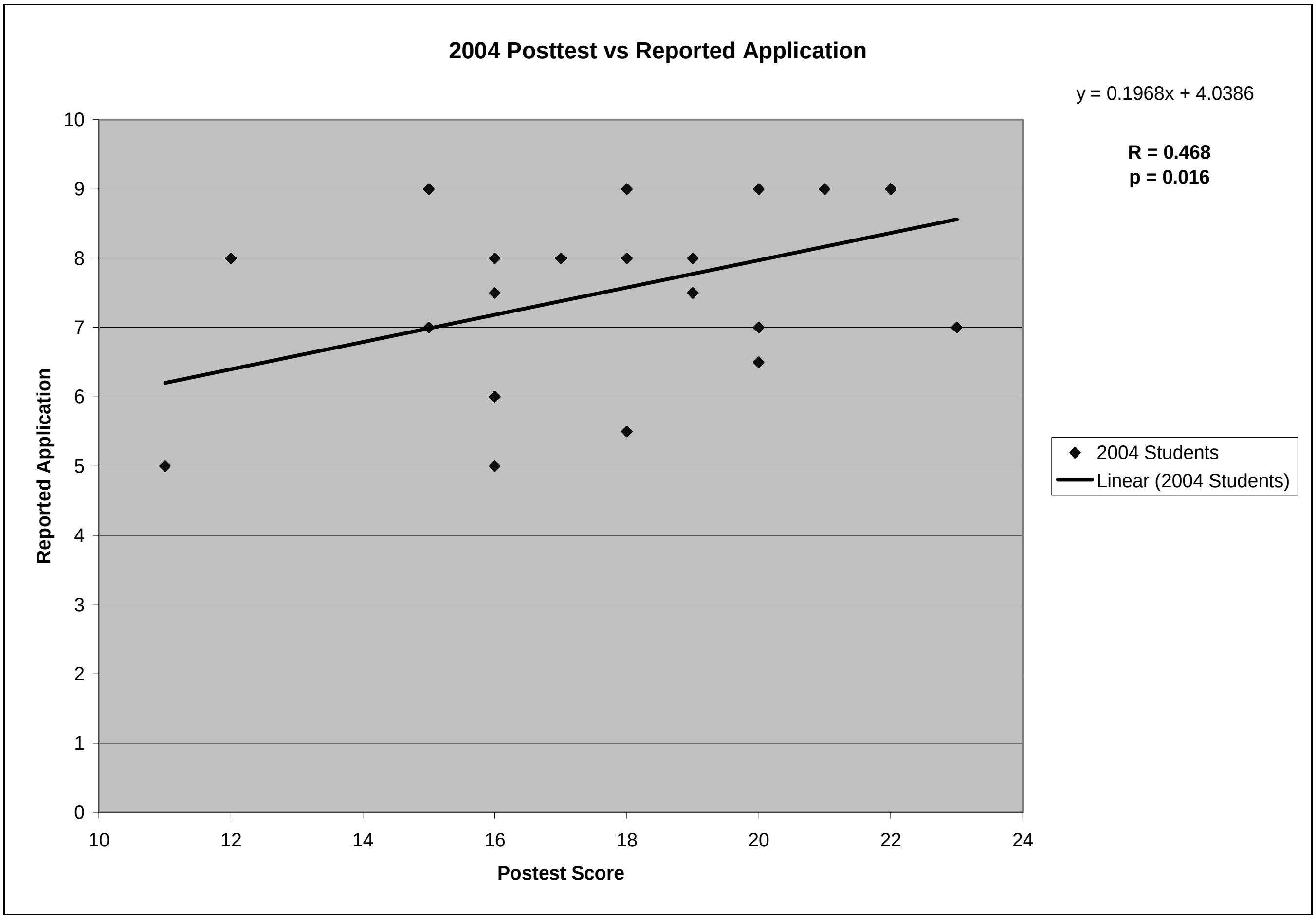

Figure 3d: Same as figure 3b with outlier removed at (14, 1.5). Notice correlation not as strong but still significant.

Figure 4

Region	Low Applicability (1-6)	High Applicability (7-9)
Eastern (1)	1	7
Central (2)	4	13
Southern (3)	3	11
Western (4)	4	11
Other (NHC, WDTB, etc.) (5)	4	1
Pac/AK (6)	1	3

(group number)

Krustal-Wallis: **p value = 0.146**

Group 1 n=8 Mean Rank=36.5625
Group 2 n=17 Mean Rank=33.0882
Group 3 n=14 Mean Rank=33.7500
Group 4 n=15 Mean Rank=32.1000
Group 5 n=5 Mean Rank=15.3000
Group 6 n=4 Mean Rank=32.6250