A Study on Comparability of Paper-based and Computer-based Reading Test Scores*

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One of the most important concerns regarding computerized testing is the possibility of test mode effects when administering test items on a computer. This study examined the equivalence of computer-based and paper-based reading tests. The subjects of 36 college students enrolled in a college English course at a university participated in the study, taking both modes of a reading test in a counterbalanced order. Data were collected from the scores of the two test modes and analyzed by employing repeated measures ANOVA. A posttest questionnaire was administered in order to see whether there is any relationship between the test scores and the subjects' examinee characteristics such as attitude and ability, use of and experience with computers, and attitude toward computers. The statistical analysis shows that there is a significant test mode effect; the paper-based test scores are higher than the computer-based test scores. The findings from the questionnaire also support the test mode effect.

I. INTRODUCTION

With the development of the Internet and the World Wide Web, more and more information is now available on computer. Consequently, more and more tests are being administered by computer in the field of language assessment. Examples include the CBT TOEFL by Educational Testing Service and CommuniCAT by the University of Cambridge Local Examinations Syndicate. With the transition from a paper-based to a computer-based language testing system comes a serious concern that identical paper-based and computer-based tests will not obtain the same results (Clariana & Wallace, 2002; Shermis & Lombard, 1998).

* This work was supported by Inha University Research Grant(INHA-22733).
However, empirical evidence to show whether the two tests are equivalent is not sufficient. Only a little research has been conducted that focuses on the development of computer adaptive tests, which are a special case of computer-based testing, where items administered to examinees are tailored to the individual examinee's ability on the construct being measured (Chalhoub-Deville, 1999; Dunkel, 1991). Comparability research in second language tests is scarce, despite the importance of conducting comparability studies in local settings to detect any potential test mode effect when a traditional language test is converted to a computerized language test (Chalhoub-Deville & Deville, 1999). As a preliminary attempt to find out new test mode effect, the present study compares paper-based and computer-based scores on a reading test for college students. The study also examines the effects of computer ability and experience, and preference for test mode on the test scores.

II. LITERATURE REVIEW

In order to investigate the effect of test mode on reading test performance, the present study first reviews the studies that address validity issues of computerized testing in cognitive ability tests; there has been mounting empirical evidence in the field of cognitive ability assessment and thus it is expected to shed some light on computerized language assessment. Then, studies are to be reviewed that focus on the effects of test mode on language test performance, particularly reading performance.


Most of the research in the field of cognitive ability assessment has presented conflicting findings (Jaeyool Boo, 1997; Bunderson, Inouye & Olsen, 1989; Clariana & Wallace, 2002; Mazzaro & Harvey, 1988; Mead & Drasgow, 1993; Parshall & Kromrey, 1993). After reviewing the findings from several studies on the equivalence of scores acquired through computer or paper-and-pencil test forms, Bunderson, Inouye and Olsen (1989) reported three studies that showed a superiority for computer-based tests, while nine studies that showed a superiority for paper-based tests. Based on their findings, it can be said that the scores on paper-and-pencil tests were higher than on computer-administered tests. More recently, Mead and Drasgow (1993) performed a meta-analysis of 159 correlations obtained from the previous studies of the equivalence of computerized and paper-and-pencil cognitive ability tests. They found that paper-based test scores were slightly greater than computer-based test scores and such test mode
effect is significantly shown for speeded tests. By contrast, Jaeyool Boo (1997) supported the comparability of scores across administration modes in his study of evaluating the comparability between computerized and paper-and-pencil scores from three subtests of the Iowa Tests of Educational Development. Parshall and Kromrey (1993) reported that computer-based test scores on all three sections of the Graduate Record Examination were greater than complementary paper-based test scores.

While the above studies are mainly concerned about test score differences between the two test formats, other studies (Parshall & Kromrey, 1993; Shermis & Lombard, 1998) explore the influence of individual examinee characteristics on the test performance. Parshall and Kromrey (1993) found that examinees' gender, race, and age were associated with test mode. Shermis and Lombard (1998), who examined the degree to which computer and test anxiety had a predictive role in performance across three computerized tests, show that test anxiety was a significant predictor for math and reading achievement tests.

Since factors such as individual examinee characteristics significantly affect test performance and the growing interest in converting traditional paper-based tests to computerized tests has been shown in the field of cognitive ability assessment, the American Psychological Association (1986) published 'Guidelines for Computer-based Tests and Interpretations.' As a criterion for achieving psychometric equivalence of paper-based and computer-based tests, it specifies the technical considerations regarding comparability as follows. First, the rank orders of individual scores in alternative modes closely approximate each other. Second, the means, dispersions, and shapes of the score distributions are approximately the same, or have been made approximately the same. Later, this issue of the criteria was readdressed by Bugbee (1996), who claimed that the criteria should be used differently depending on whether a computer-based test is used as an alternative or an exchangeable form for a paper-based test. More recently, in addition to the standard psychometric procedures provided by the American Psychological Association, more sophisticated research methods such as structural equation modeling or factor analysis are suggested and employed by some researchers (Neuman & Baydoun, 1998; Staples & Luzzo, 1999).

In summary, it can be said that despite abundant empirical evidence in the field of cognitive ability assessment, the findings as to comparability of paper-based and computer-based tests are inconsistent. Such inconsistencies might be due to the interaction of examinee characteristics and test modes, or lack of more sophisticated testing procedures in the experimental designs. Further studies are expected to provide direction for research and practice on the comparability of language assessment.
2. Comparability of Computer-based and Paper-based Reading Assessment

As shown well in Dillon's (1992) literature review on the effect of mode of presentation on reading, research that compares paper-based and computer-based text reading in a first language is quite extensive. However, little empirical research on the effects of test mode on reading comprehension has been conducted in second language reading area (Sawaki, 2001). The most recent research on the issue of comparability of paper-based and computer-based reading comprehension tests is as follows. Kobrin (2000) used verbal protocols rather than traditional psychometric methods to find out test mode effects, in order to see whether there is any difference of examinees' cognitive processes and strategies between paper-based and computer-based test modes. Results indicated no significant statistical differences on both test modes, suggesting that computer-based reading comprehension tests are cognitively similar to paper-based tests. Yessis (2000) also reported that with special care taken to counterbalance the order of reading presentation modes and reading passages, the mode differences in second language reading performance were not significant. He found that students' focus on reading content was more in the computer-based presentation mode than in the paper-based presentation mode.

Another concern related to the validity of computerized reading test is the effect of examinee backgrounds on test performance and attitudes toward new forms of reading tests. Two large-scale studies focused on computer familiarity and its potential effects on language performance. Taylor, Jamieson, Eignor, and Kirsch (1998) and Kirsch, Jamieson, Taylor, and Eignor (1998) investigated the effects of computer literacy on examinees' scores on CBT TOEFL, and concluded that computer familiarity does not play a major role in CBT TOEFL. Along with the finding is more recent research undertaken by Sawaki (2001). Based on her extensive overview on comparability research on reading, Sawaki (2001) concluded that the issue of familiarity is not a serious concern due to rapid growing use of computers and advancements in technology.

However, such findings from the previous studies are hard to generalize to other contexts because of some limitations. For example, Kirsch et al.'s (1998) study measured computer familiarity in relation to examinees' paper-based TOEFL score. No real data were employed in Sawaki's (2001) study, although her overview of comparability reading research is quite extensive. Therefore, the present study is designed to explore score comparability of a paper-based and a computer-based test in a counterbalanced order with real data. The study also attempts to investigate the relationship between computer attitude and ability, use of and experience with computers, examinee preference for a test mode, and test performance by administering a posttest questionnaire.
III. METHOD

1. Participants

The subjects of the study were 36 sophomores at a large university in Korea. Participants were 14 females and 22 males, ranging in age from 21 to 24 years. They were in two sections of College English, a required course at the university. The two sections were among the 13 highest-level sections of the College English program that was implementing differentiated curriculum on the basis of students' English proficiency.

One section named Group 1 consisting of 16 students whose major was English Education took the paper-based test first, and the computer-based test two weeks later. The other section called Group 2 consisting of 20 students whose major was Engineering took the computer-based test first, and the computer-based test two weeks later in order to offset any effect of test order.

2. Instruments

To investigate the score comparability between paper-based and computer-based tests, the present study used two equivalent forms of a reading test. The two forms with 20 multiple-choice questions each were made on the basis of two final reading achievement tests, whose 100 items were previously developed and employed for a different group of students at the university. 40 items were carefully selected from the previous reading tests and adjusted to balance item difficulty, content topics, length of reading passages, etc. Then, they were randomly divided into two sets to make two parallel forms. The paper-based form was prepared in the same as other conventional reading tests. With the computer-based form created by Visual Basic 6.0, a computer program, participants received one question per screen. They clicked on the circle of the correct answer choice and then proceeded to the next question. They are allowed to review and change previously answered questions. The subjects were required to finish the tests within 20 minutes respectively.

In order to investigate examinee characteristics such as attitude and ability, use of and experience with computers, and preference for test mode, the Computer Familiarity Questionnaire developed by Eignor, Taylor, Kirsch, and Jamieson (1998) was used with some adjustments made for the purpose of the study. The Questionnaire, which appears in Appendix, consists of 13 questions that are relevant to university students. The questions fall into three categories: self-assessment of attitude and ability, use of and experience with computers, and preference for test mode.
3. Procedures

Prior to the administration of the reading tests, the participants were informed about the purpose of the study and were given detailed procedures for taking and returning the tests and questionnaire to their test supervisor. In particular, considering that there might be some participants without any experience of computerized tests, the researcher provided an approximately 3-minute-long practice session prior to the administration of the computer-based test. The test for the practice session consisting of 3 multiple-choice questions based on a middle school English textbook was to acquaint participants with computerized testing. After all the two tests were completed in 20 minutes respectively, the 13-item questionnaire was administered and collected.

IV. RESULT AND DISCUSSION

1. Student Performance Comparison

Table 1 presents descriptive statistics on the paper-based and computer-based reading tests. The table shows that all skewness and kurtosis indices were from -1 to 1, which indicate the data reflect a normal distribution. The table also shows that the score of the paper-based test was higher than that of the computer-based test.

<table>
<thead>
<tr>
<th></th>
<th>Paper-based</th>
<th>Computer-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of items</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Number of examinees</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>Mean</td>
<td>14.611</td>
<td>13</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>3.092</td>
<td>3.586</td>
</tr>
<tr>
<td>Skew</td>
<td>-1.72</td>
<td>-3.54</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-8.24</td>
<td>-6.72</td>
</tr>
<tr>
<td>SEM</td>
<td>.515</td>
<td>.598</td>
</tr>
<tr>
<td>Median</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>Mode</td>
<td>17</td>
<td>16</td>
</tr>
<tr>
<td>Minimum score</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Maximum score</td>
<td>20</td>
<td>19</td>
</tr>
</tbody>
</table>

In order to see whether the result is statistically significant and a possible test mode X test mode order interaction exists, the data was analyzed using repeated measures analysis of
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variance (ANOVA) design. The results are presented in Table 2 and Figure 1. As can be seen in Table 2, the test mode's main effect is statistically significant (F(1, 34)=15.08, p < .01). However, the interaction effect between test mode and test mode order is not significant (F(1, 34)=.15, p > .05). The results suggest that regardless of test administration mode order in each group, it is likely that the paper-based test scores are higher than the computer-based test scores. It is different from the findings from previous studies (Kobrin, 2001; Yessis, 2000) which reported no test mode effect. However, the observed significant difference for test mode in the present study was anticipated by the findings in Innchull Choi (2000); in his study on the correlation between paper-based and computer-based TOEFL scores with Korean college subjects, Innchull Choi reported that the correlation of the TOEFL reading scores were lower than those of the TOEFL listening and grammar scores and that the subjects had difficulties in concentrating on reading passages due to eye fatigue. The significant test mode effect can be interpreted along with the findings from the questionnaire, which will be discussed in detail in the following section.

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test order</td>
<td>335.434</td>
<td>1</td>
<td>335.434</td>
<td>32.882</td>
<td>.000*</td>
</tr>
<tr>
<td>Test mode</td>
<td>45.156</td>
<td>1</td>
<td>45.156</td>
<td>15.075</td>
<td>.000*</td>
</tr>
<tr>
<td>Test mode* Test order</td>
<td>.434</td>
<td>1</td>
<td>.434</td>
<td>.145</td>
<td>.706</td>
</tr>
</tbody>
</table>

p < .01

FIGURE 1

Paper-based and Computer-based Test Scores By Groups
In Table 2 is shown a statistically significant test mode order effect ($F(1, 34)=32.88, p < .000$). The result indicates that there is test mode order effect between Groups 1 and 2. However, the result seems to relate to the subjects’ major rather than test mode order itself; while Group 1 consisted of 16 students majoring in English Education, Group 2 was composed of 20 students majoring in Engineering. The unexpected between-subject effect, which might not have occurred if random assignment of the subjects to the two groups had been made, needs to be examined in a more controlled way in future research.

2. Analysis of the Questionnaire

In this section, the statistical results presented above are discussed along with the findings from the questionnaire. As mentioned above, the questions on the Questionnaire fall into three categories: self-assessment of attitude and ability, use of and experience with computers, and preference for test mode. Questions 1 through 4 are as to examinees’ attitude and ability. The subjects’ responses on the questions are presented in Table 3.

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>very comfortable</th>
<th>comfortable</th>
<th>somewhat comfortable</th>
<th>not at all comfortable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How comfortable are you with using a computer?</td>
<td>6</td>
<td>11</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.78%)</td>
<td>(30.56%)</td>
<td>(38.89%)</td>
<td>(13.89%)</td>
</tr>
<tr>
<td>2</td>
<td>How comfortable are you with using a mouse?</td>
<td>8</td>
<td>13</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(22.22%)</td>
<td>(36.11%)</td>
<td>(25%)</td>
<td>(2.78%)</td>
</tr>
<tr>
<td>3</td>
<td>How comfortable are you with using a computer to write a paper?</td>
<td>10</td>
<td>16</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(27.78%)</td>
<td>(44.44%)</td>
<td>(19.44%)</td>
<td>(8.33%)</td>
</tr>
<tr>
<td>4</td>
<td>How comfortable are you with taking an English test on a computer?</td>
<td>0</td>
<td>6</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0%)</td>
<td>(2.78%)</td>
<td>(52.78%)</td>
<td>(30.56%)</td>
</tr>
</tbody>
</table>

As shown in Table 3, the majority of the subjects (about 86%) are more than somewhat comfortable with using computers. It, however, should be noted that about 31 percent of the subjects responded that they were not comfortable at all with taking an English test on a computer. The result might be due to the subjects’ lack of experiences in taking computerized tests, which was shown in Table 4; while about 14 percent of the subjects took a computer-based test at least three times, more than half of the subjects had never taken a computer-based test before. However, considering their greater familiarity with using a computer in everyday life including school life indicated in the responses to questions 1 through 3, the lack of experiences in taking a computer-based test does not seem to solely explain the subjects’ being uncomfortable with computerized testing. Rather, it seems to be more appropriate to interpret
the result along with the reasons why the subjects preferred paper-based reading tests, which were provided as answers to the open-ended question 13: being unable to underline main points or taking notes with their pens, difficulties in concentrating reading passages, eye fatigue, unfamiliarity with computerized testing, etc. From these responses, it can be inferred that a computer-based reading test might require examinees to employ different test-taking or cognitive strategies, which needs for further studies.

The negative aspects on the computer-based reading test were also pointed out in the aforementioned Inchull Choi's (2000) study. Mazzeo and Harvey (1988) cautioned that examinees’ being unable to concentrate on a reading test might cause serious harm to the test validity and reliability. In summary, it can be said that despite that the examinees’ ability to use computers is generally great and their attitude toward using computers is positive, the ability and attitude may not applicable to computerized testing contexts. Precise description of how people interact with computers under computer-based testing conditions is necessary in order to establish the validity of the computer-based tests of reading.

**TABLE 4**

|  | Examinees' Experience with Computerized Testing |
|---|---|---|---|---|
| No. Item | more than 5 times | 3-4 times | once or twice | never |
| 5 How many examinations have you taken on a computer? | 3 | 2 | 10 | 21 |
| | (8.33%) | (5.56%) | (27.78%) | (58.33%) |

Table 5 provides the subjects' responses on the questions related to their use of and experience with computers. As can be seen in the Table, the majority of the subjects (about 92%) responded that they used the Internet once a day or more often. Fairly frequent use of email was also reported by 75 percent of the subjects. By contrast, it is shown that the subjects did not use computer programs including spreadsheets or graphics as much as the Internet and email. The result shows radical change in people's use of computer; Kirsch et al.'s (1998) study reported that 53% of the subjects surveyed in 1996 never used the Internet on a computer. One notable thing is the relatively low frequency of the subjects' use of word processing in English, which is shown in question 10. It does not seem to have any direct impact on the multiple-choice test method employed in the present study, on which just mouse-clicking and scrolling reading passages up and down were needed. If other test methods such as open-ended questions or essay tests were employed on a computer-based test, however, examinees' typing skills would be a factor to influence on their scores. In fact, according to a recent study on composition medium comparability in a direct writing assessment (Wolfe & Manalo, 2004), a weak but significant interaction was found between composition medium and English language proficiency with
examinees with weaker English language scores performing better on handwritten essays.

**TABLE 5**

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>once a day or more often</th>
<th>once a week</th>
<th>once a month</th>
<th>never</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>How often do you use the Internet?</td>
<td>33 (91.67%)</td>
<td>2 (5.56%)</td>
<td>1 (2.78%)</td>
<td>0 (%)</td>
</tr>
<tr>
<td>7</td>
<td>How often do you use a computer to send or receive email?</td>
<td>27 (75%)</td>
<td>7 (19.44%)</td>
<td>2 (5.56%)</td>
<td>0 (%)</td>
</tr>
<tr>
<td>8</td>
<td>How often do you use a computer to play games?</td>
<td>12 (33.33%)</td>
<td>5 (41.67%)</td>
<td>4 (11.11%)</td>
<td>5 (13.89%)</td>
</tr>
<tr>
<td>9</td>
<td>How often do you use a computer for word processing in Korean?</td>
<td>6 (16.67%)</td>
<td>22 (61.11%)</td>
<td>6 (22.22%)</td>
<td>0 (%)</td>
</tr>
<tr>
<td>10</td>
<td>How often do you use a computer for word processing in English?</td>
<td>0 (0%)</td>
<td>11 (30.56%)</td>
<td>19 (52.78%)</td>
<td>6 (16.67%)</td>
</tr>
<tr>
<td>11</td>
<td>How often do you use a computer to do spreadsheets?</td>
<td>0 (0%)</td>
<td>4 (11.11%)</td>
<td>11 (30.56%)</td>
<td>21 (58.33%)</td>
</tr>
<tr>
<td>12</td>
<td>How often do you use a computer to do graphics?</td>
<td>1 (2.78%)</td>
<td>1 (2.78%)</td>
<td>2 (5.56%)</td>
<td>32 (88.89%)</td>
</tr>
</tbody>
</table>

**TABLE 6**

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>paper-based</th>
<th>computer-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Which do you like better — paper-based or computer-based test modes?</td>
<td>26 (72.22%)</td>
<td>10 (27.78%)</td>
</tr>
</tbody>
</table>

Finally, Table 6 shows that about 72 percent of the subjects had preference for the paper-based test, while only about 28 percent of the subjects preferred the computer-based test. As mentioned above, the subjects addressed eye fatigue, lack of concentration, being unable to underline or take notes, etc. as the disadvantages of the computer-based test. However, they viewed receiving their scores right after the test is finished, being unable to cheat, etc. as the advantages of the computer-based test. The strong preference for a paper-based test in the present study is different from the findings in Inchull Choi’s (2000) study that examinees possess great typing skills and prefer typing to handwriting in taking a writing test. The different result may due to gender or age difference; while the subjects in Inchull Choi’s study were all female juniors, those of the present study consisted of 14 female and 22 male sophomores. Thus, future research is needed to account for the disparity of results with careful consideration and control of relevant variables in research design.
V. CONCLUSION

The purpose of the current study was to investigate the score comparability between a paper-based test and a computer-based test on the basis of repeated measures ANOVA and a posttest questionnaire. The statistical analyses revealed that there was a significant difference between the two test modes, indicating the two tests might not be comparable. The findings from the posttest questionnaire on examinees' characteristics also revealed the impact of examinees' computer familiarity on their scores on the computer-based test.

As shown in the statistical analysis on tests of between-subjects effects, however, a confounding test mode order effect was found, which is interpreted as the effect of the subjects' different majors rather than test mode order effect. It resulted from not being able to assign the subjects to each group or taking the subjects' majors into serious consideration, which is a limitation of the current study. The small number of subjects in the study also imposes some limitations in generalizing the findings. Nevertheless, the findings of this investigation indicate it is critical to realize that paper-based and computer-based tests will not necessarily produce equivalent measures of students' reading performance. Time, cost, and effort to mitigate test mode effects should be spent with the serious considerations of the recommendations made by Bugbee (1996) that test developers must show that paper-based and computer-based test versions are equivalent and provide scaling information to allow the two to be equated.

Based on the findings of the current study, a more sophisticated study is required for validation research on comparability issues. Since the issues are related not only to the potential impact of computer mode administration on reading tests but also to the washback effect on teaching reading, they should be tackled with a variety of research methods including ethnographic approaches, rigorous psychometric procedures, etc.

REFERENCES


**APPENDIX**

**Questionnaire**

Identification number:

Name:

After reading the questions below, tick the correct box for each question, and write your answer if necessary.

1. How comfortable are you with using a computer?
   - very comfortable □
   - somewhat comfortable □
   - not at all comfortable □

2. How comfortable are you with using a mouse?
   - very comfortable □
   - somewhat comfortable □
   - not at all comfortable □

3. How comfortable are you with using a computer to write a paper?
   - very comfortable □
   - somewhat comfortable □
   - not at all comfortable □

4. How comfortable are you with taking an English test on a computer?
   - very comfortable □
   - somewhat comfortable □
   - not at all comfortable □

5. How many examinations have you taken on a computer?
   - more than 5 times □
   - 3-4 times □
   - once or twice □
   - never □
6. How often do you use the Internet?
   - once a day or more often □
   - once a week □
   - once a month □
   - never □

7. How often do you use a computer to send or receive email?
   - once a day or more often □
   - once a week □
   - once a month □
   - never □

8. How often do you use a computer to play games?
   - once a day or more often □
   - once a week □
   - once a month □
   - never □

9. How often do you use a computer for word processing in Korean?
   - once a day or more often □
   - once a week □
   - once a month □
   - never □

10. How often do you use a computer for word processing in English?
    - once a day or more often □
    - once a week □
    - once a month □
    - never □

11. How often do you use a computer to do spreadsheets?
    - once a day or more often □
    - once a week □
    - once a month □
    - never □

12. How often do you use a computer to do graphics?
    - once a day or more often □
    - once a week □
    - once a month □
    - never □

13. Which do you like better—paper-based or computer-based test modes?
    - paper-based □
    - computer-based □

What makes you choose the test mode?

Applicable levels: higher education
Key words: reading testing, computer-based tests, paper-based tests

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Received in March 2004
Reviewed in March 2004
Revised version received in April 2004