DOCUMENT RESUME

ED 465 786 TM 034 171

AUTHOR	Bastick, Tony
TITLE	Gender Differences for 6-12th Grade Students over Bloom's Cognitive Domain.
PUB DATE	2002-04-00
NOTE	8p.; Paper presented at the Annual Meeting of the Western Psychological Association (Irvine, CA, April 14-17, 2002).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Cognitive Ability; *Elementary School Students; Intermediate Grades; Secondary Education; *Secondary School Students; *Sex Differences; Student Evaluation
IDENTIFIERS	Bloom (Benjamin S); *Blooms Taxonomy; *Cognitive Domain

ABSTRACT

This study considered the possibility that different formats of objective test questions might differentially favor males or females and that males and females might respond differently to objective questions aimed at assessing abilities at different levels of Bloom's cognitive domain. Class tests were constructed on recently taught topics, with each test containing questions in three parallel subtests, multiple-choice, true-false, and matching. Each subtest had six questions, and each of the questions was targeted to one level of Bloom's Cognitive Domain by the test writers. Questions at each level were matched to the same expected difficulty level by the writing team using a variant of the Angoff method. This design was replicated in 5 schools across 4 curriculum areas with 65 male and 123 female students in grades 6 through 12. Results show only one significant difference in gender performances across the levels of Bloom's Cognitive Domain. This is a female advantage at the level of Analysis. A comparison of mean male and female scores on the three subtest formats also shows only one statistically significant advantage--an advantage for females on the matching questions. This was found to be due to significant female advantages at the Analysis and Synthesis levels. The relationship and relevance of these findings is discussed in relation to gender differences in science and mathematics test performances. (SLD)

Gender Differences for 6-12th Grade Students Over Bloom's Cognitive Domain

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Paper presented at the Western Psychological Association
WPA 2002 Convention
Irvine, CA
USA

Publication Date: April, 2002

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Abstract

Differential item analysis (DIF) is routinely used to identify test items that may advantage male or female students. Male advantages have been found for spatial reasoning questions and female advantages have been found for verbal questions. Such DIF loaded test items can be discarded to produce gender equitable tests. However, little research seems to have compared male and female abilities at different levels of Bloom's Cognitive Domain. It is therefore possible that items testing these different cognitive levels may differentially favour males or females, resulting in the use of gender inequitable tests.

To test this possibility, class tests were constructed on recently taught topics. Each test contained 18 questions in three parallel subtests – a Multiple-choice subtest, a True/False subtest and a subtest of Matching questions. Each subtest had six questions and each of the six questions was targeted to one level of Bloom's Cognitive Domain by the test writers – the class teacher and two teacher trainees. Further, the questions at each level were matched to the same expected difficulty level by the writing team using a variant of the Angoff method. This design was replicated in five schools across 4 curriculum areas with 65 male and 123 female, 6-12th grade students. The mean scores for males and females were compared for each level of Bloom's Cognitive Domain and for each subtest format.

Results showed that there was only one statistically significant difference in gender performances across the levels of Bloom's Cognitive Domain. That was a female advantage at the level of Analysis. A comparison of mean male and female scores on the three subtest formats also showed only one statistically significant advantage. That was also an advantage for females, on the Matching subtest. When this female advantage on Matching questions was examined more closely, it was found to be due to significant female advantages at the Analysis and Synthesis levels of the Matching questions, and not at the other levels. Overall, girls showed superior analytical ability.

The relationship and relevance of these significant findings is discussed in relationship to gender differences in science and mathematics test performances.

Introduction

This study considered the possibility that different formats of objective test questions might differentially favour males or females and that males and females might respond differently to objective questions aimed at assessing abilities at different levels of Bloom's cognitive domain. There is extensive research on differential gender responses to questions in various content areas but little research considering differential gender responses to the formats of objective tests at the levels of Bloom's cognitive domain to which these questions are targeted.

Many researchers have studied gendered content of test items to test the belief that males perform better on items with masculine content and females perform better on items with feminine content. There is weak support for such simplistic content analysis of test items (Ross, 1988). Differential item functioning is routinely used to identify test items that are gender biased (Hamilton, 1999). These analyses are frequently performed on very large national samples and are able to detect very fine gender biases. For example Abigail Harris and Sydell Carlton (1993) used 181,228 male and 198,668 female students' Scholastic Aptitude Test results to examine gender

Bastick, T. (2002, April). *Gender differences for 6-12th Grade Students Over Bloom's Cognitive Domain. Paper* presented at the Western Psychological Association, WPA 2002 Convention, Irvine, CA. USA.

differences related to item format and content of mathematics items. The female disadvantage on spatial items has been found to be most marked. In a large study (n=116,017) Asa Makitalo (1996) found that female performance on spatial items can vary substantially according to the formatting of tables and maps. Anita Wester (1995) analysed similar data to find if changing item format, from multiple choice to open response, would reduce these gender differences. She found that this did not reduce the item bias. Although gender bias has been studied in most school subjects, there seems to be a preponderance in the literature of differential gender studies in mathematics (Bielinski, & Davison, 1998; Garner, & Engelhard, 1999). However, there are very few studies that compare gender differences in objective test formats at different levels of Bloom's cognitive domain that are not topic centred. This study contributes in this under-represented research area.

Method

The following design was replicated in five classes, each in a different school. A 20-minute class test was constructed on a recent topic taught by the class teacher. The test was comprised of 18 questions in three different objective item formats; being six multiple choice (MC), six True/False (T/F) and six Matching (M) questions. Within each item format each of the six questions was aimed at assessing a different level of Bloom's cognitive domain. Each test was written by three teachers, one of whom was the class teacher who had recently taught the subject to be tested and two teachers in training. The three teachers adjusted the questions at the same cognitive level to be of the same expected difficulty. The expected difficulties were not matched between levels. So, for example all Knowledge questions were of the same expected level of difficulty and all Analysis questions were the same level of difficulty, but the Knowledge questions were not necessarily set at the same expected difficulty as the Analysis questions. The test formats were then randomised and the six questions within each format were also randomised for the class test. Figure 1 is a schematic showing the six levels of each question in the three formats before and after the order was randomised. A different random sequence was used to randomise the test formats and questions for each of the five classes.

Figure 1: Structure of class tests. Three objective test formats, each of six questions with each assessing a different level of Bloom's cognitive domain, and all questions at the same Level having equal expected difficulty.

Structure of each test	18 Objective Questions - Questions at the same level have same expected difficulty																	
Format of questions	Six Multiple Choice Questions MC						Six True/False Questions TF						Six Matching Questions MQ					
Cognitive ability Level	L1	L2	L3	L4	L5	L6	L1	L2	L3	L4	L5	L6	L1	L2	L3	L4	L5	L6
Question Number	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18

Example of random	MQ						TF						MC					
presentation order	Q16	Q15	Q13	Q14	Q17	Q18	Q10	Q8	Q9	Q11	Q7	Q12	Q15	Q14	Q13	Q16	Q17	Q18
Queston order on test	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	R18

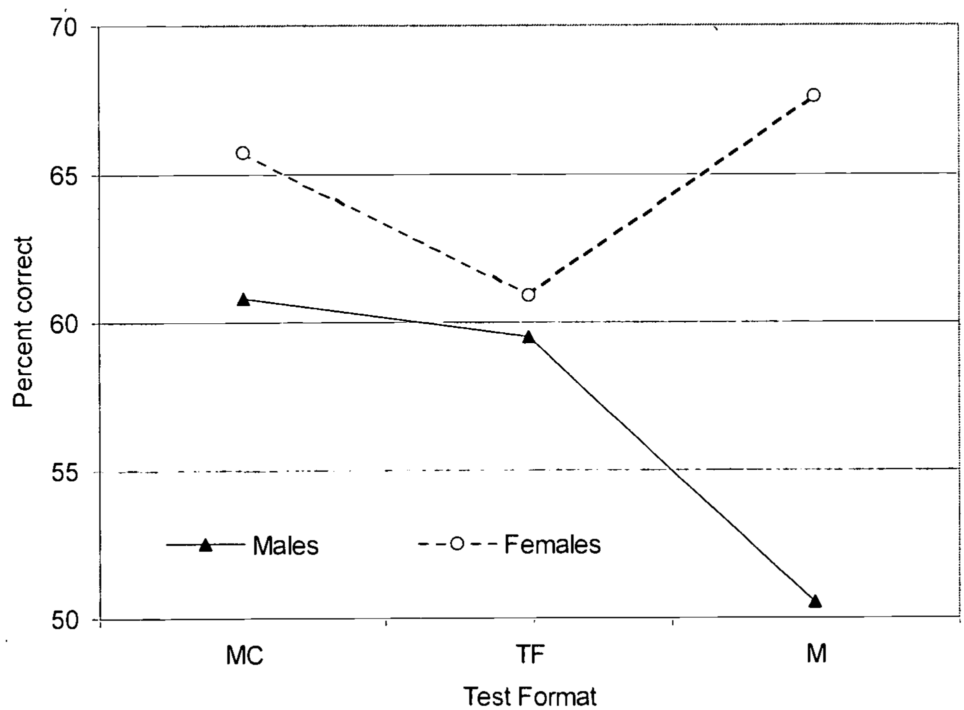
Subjects

The sample of five schools, whose principals agreed to their schools and teachers participating in this research, were drawn from high and low socio-economic-status populations and represents both urban and rural areas in and around Kingston, Jamaica, West Indies. 188 students, took part in this study from five classes, one in each secondary school. The students were 65 boys and 123 girls, aged from 10 to 16 years with a mean age of 12 years 8 months. Class tests were written in four topic areas. The numbers of males and females in each of the topics tested were Biology 1 - sexual reproduction in flowering plants (m=13, f=16, n=29), Biology 2 - Endocrine Systems (m=18, f=15, n=42), Physics - States of matter (m=18, f=15, n=33), English – Nouns (m=15, f=35, n=50) and Social Studies - The Family and The Peer Group (m=11, f=23, n=34).

Analysis and results

The responses for each test were scored by the three teachers and entered into SPSS for global analysis. The separate performances of boys and girls were then compared on the three matched subtests. These mean percentage scores are illustrated in Figure 2 and tabulated in Table 1 with the mean scores for each subtest and the significance of the gender differences.

Figure 2: Comparative gender performance on three different test formats matched for expected difficulty



Key: MC - Multiple Choice format. TF - True/False format. M - Matching format

Table 1: Mean Percent Scores for each of three item formats of equivalent expected difficulty by sex of respondents

Scores as % of each item format	Objective Test Formats: Multiple Choice	True False	Matching
Sex			
Males	61	59	51
Females	66	61	68
Significance	P=0.106	P=0.636	P=0.000

The most significant sex difference was the superior performance of the girls on the Matching Subtests. The Matching subtests, like the other subtests, were composed of one question at each level of Bloom's cognitive domain. The scores of boys and girls were then compared at each domain level for the Matching subtests, across all school topics tested, in order to isolate the levels of abilities contributing to female advantage on Matching subtests. Figure 3 illustrates these sex differences in performance at each level and Table 2 lists the mean scores and the significances of these gender differences.

Figure 3 : Sex differences at each Level of Bloom's cognitive domain for Matching format items

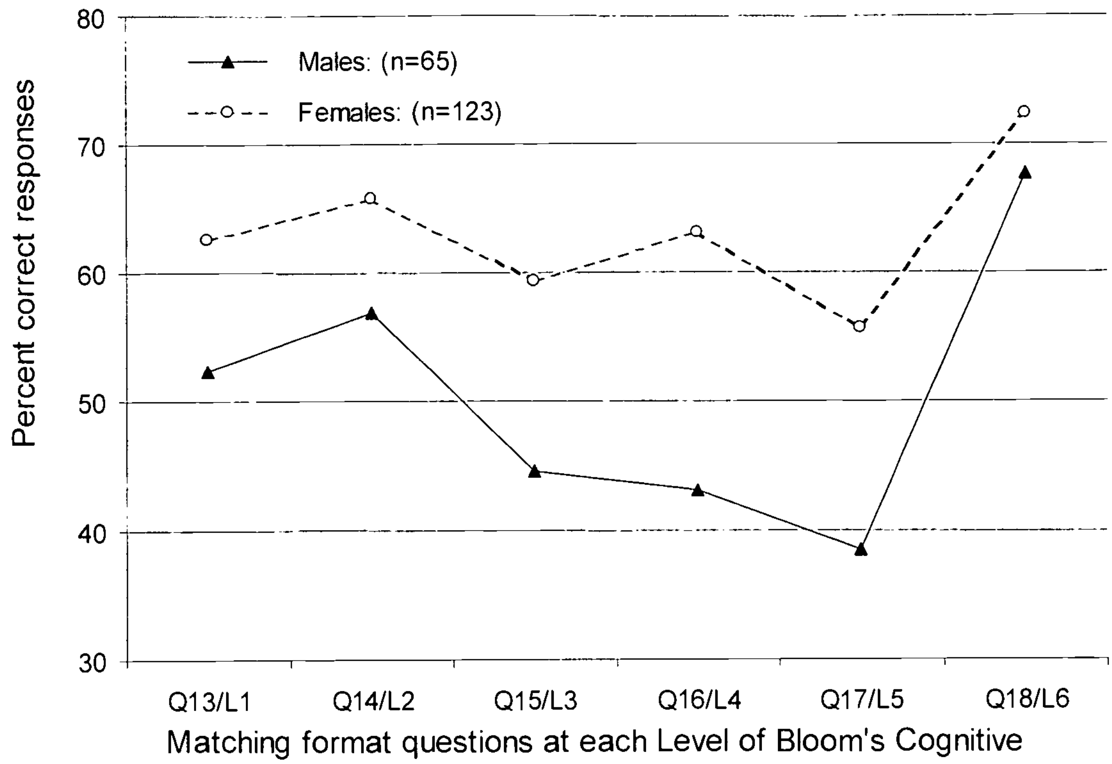


Table 2: Significant differences in scores of boys and girls at each Level of Bloom's cognitive domain for Matching format items

Cognitive Levels Matching Format only Question #	L1 Knowledge Q13	L2 Comprehension Q14	L3 Application Q15	L4 Analysis Q16	L5 Synthesis Q17	L6 Evaluation Q18
% Score at each Level						
Sex						
Males: (n=65)	52	57	45	43	38	68
Females: (n=123)	63	66	59	63	56	72
Significance	P=0.174	P=0.231	P=0.054	P=0.008	P=0.024	P=0.056
For all: (n=188)	59	63	54	56	50	71

We should not pay particular attention to the relative scores of different cognitive levels, i.e. that Q18 has a higher mean score than Q17 say, because different levels were not pre-matched for expected difficulty. However, we do note the significant gender differences ($p<0.05$) in Matching format items at the levels of Analysis (Q16) and Synthesis (Q17).

It is again noted that questions were not designed to be equivalent in expected difficulty across different Levels of the Cognitive Domain. For example, questions at Level 1 were not equated in expected difficulty with questions at Level 2, or any other level. Hence, the expected difficulties could not be compared across levels in this research. However, a question at any Level was of the same expected difficulty for boys and girls. Hence, the we can compare the resulting expected difficulties for boys and girls within each level to find if boys or girls are advantaged at each level of Bloom's Cognitive Domain.

Sex differences of scores at each Level, summed across all three objective item formats, are illustrated in Figure 4 with the total scores and significances of the sex differences tabulated in Table 3.

Figure 4: Sex differences in scores summed across all three objective item formats at each Level of Bloom's Cognitive Domain

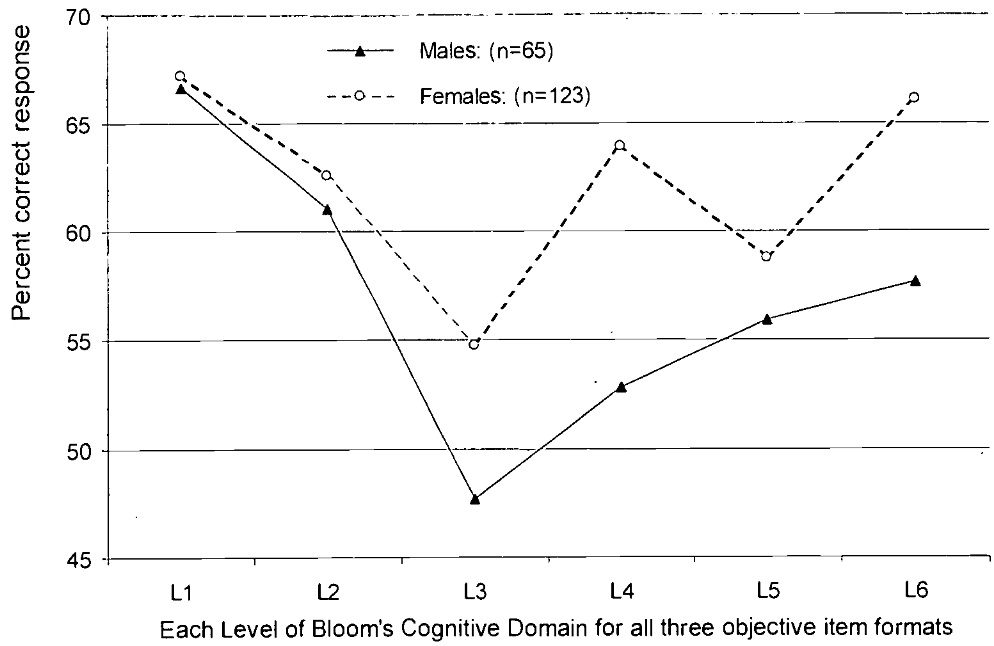


Table 3: Significances of sex differences in scores summed across all three objective item formats at each Level of Bloom's Cognitive Domain

Question #	Q1, Q7, Q13	Q2, Q8, Q14	Q3, Q9, Q15	Q4, Q10, Q16	Q5, Q11, Q17	Q6, Q12, Q18
All Recognition Formats	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
Levels	L1	L2	L3	L4	L5	L6
% Score at each Level						
Sex						
Males: (n=65)	67	61	48	53	56	58
Females: (n=123)	67	63	55	64	59	66
Significance	P=0.91	P=0.702	P=0.149	P=0.012	P=0.48	P=0.077
For all: (n=188)	67	62	52	60	58	63

It will be noticed from Figure 4 that boys and girls scored virtually the same only at the lowest Level of 'Knowledge'. At all other Levels of objective formats girls scored more than boys. Table 3 shows particularly that girls outperformed boys significantly ($p<0.05$) in Analysis (Level 4).

Discussion

This research has explored differences in the way 10 to 11 year old boys and girls respond to three objective test formats at the six levels of Bloom's cognitive domain. It is particularly, noteworthy that girls outperformed boys on all three test formats and at every cognitive level. They out-performed boys significantly in the matching format and within the matching format, they out-performed boys significantly at the cognitive levels of synthesis and Analysis. When we compared the mean responses of boys and girls for all three formats at each level, we noticed that girls out-performed boys significantly in analytical ability.

It is interesting to note that in subject areas that are assumed to require higher analytical ability, such as physics and mathematics, the literature has shown boys are usually in advance of girls, although the gap is narrowing. This study has shown that, at least in this sample of 188 Jamaican children, that it is not necessarily a lack of analytical ability that might be responsible for the gap. This implies that researchers have been correct in looking to social rather than cognitive areas for an explanation of female under performance in these more analytical subjects. Hence, these results support research into socio-cultural factors that might result in gender bias on test performance.

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Title: Gender differences for 6-12th Grade Students Over Bloom's Cognitive Domain	
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