Are High School Chemistry Textbooks Gender Fair?

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Abstract

This study compared two generations of seven high school chemistry texts (1970/1973) and current editions analyzed for gender fairness in illustrations and in concrete analogies. Results support these conclusions: (a) considering the texts as a group, there are significant differences between relative frequencies of named and unnamed illustrations of men and women and no significant differences between relative frequencies of illustrations of boys and girls in seven high school chemistry texts in the 1970 editions compared to current edition of the same texts; (b) a current best-seller is the only text that has achieved balance between male/female illustrations; (c) the other texts overwhelmingly favor pictures of males; (d) most current texts had more analogies than their 1970 editions; the former favored images reflecting girls’ interests.

Thirteen years have elapsed since the passage of the Sex Discrimination Act of 1975. Whether educational practices related to gender equity have since changed should be of high interest to all thoughtful citizens.

Labeling and socialization processes that relegate women to stereotypical roles may severely deter them from becoming functionally competent and autonomous human beings. At age 9, girls express more interest in science-related activities than boys do; however, by age 17, boys are the predominant gender in elective physical science courses (Cho, Hahle, & Matyas, in press).

Researchers have found that a mere handful of women choose to enter careers that have been traditionally viewed as men’s work. For example, women represent only 20.5% of the natural science and 5.8% of the engineering work force in the United States, according to a 1983 survey (Deboer, 1986).

The question is, could textbooks contribute to this disparity?

Textbooks are an integral part of instruction and can give messages about science and society as well as science careers. Textbooks, irrespective of subject area, are a primary source of information in secondary and elementary science classrooms (Easely...
If texts lack images of science-involved women and minorities, students may view science as an activity that excludes most people. Therefore, a balanced and comprehensive portrayal of women and minorities in printed materials is an important statement for students' consideration.

Taylor (1979) and Walford (1981) examined pronoun use and illustrations in selected British physics texts. Personal pronoun choices may have some limited importance, but in science texts the numerous pictures and analogies seem likely to have more impact on students' world views.

A literature search uncovered only one example of gender analyses of chemistry texts, the Heikkinen study (1973) and report (1978). Heikkinen (1973) examined 10 high school chemistry textbooks to analyze gender-specific representations and analogies. His research team members assessed illustrations as to number of adolescents and adults, role associations, frequency of female/male figures, and overall images of those figures. They also classified verbal analogies or concrete examples according to Walberg's (1967) method. Heikkinen concluded that 1970–1973 chemistry textbooks were pervasively gender unfair, favoring men.

Replicate Study

This replicate study's (1988) primary purpose was to compare the results of the analyses of textbooks from the Heikkinen study/report (1973, 1978) with the results of a similarly analyzed sample of current textbooks and, by controlled sampling, to generalize to the major population of current best-selling high school chemistry textbooks.

Six research questions were addressed:

1. Is there a measurable shift toward gender balance in illustrations from the 1970/1973 to current editions of high school chemistry textbooks?
2. Is there a significant difference between the relative frequencies of named male and female illustrations in high school chemistry textbooks when comparing 1970/1973 editions to current editions of these textbooks?
3. Is there a significant difference between the relative frequency of unnamed male and female adult illustrations in high school chemistry textbooks when comparing 1970/1973 editions to current editions of these textbooks?
4. Is there a significant difference between the relative frequency of unnamed male and female youth portrayals in high school chemistry textbooks when comparing 1970/1973 editions to current editions of these textbooks?
5. Is there a significant difference between relative frequencies of male and female verbal analogies found in two 1973 editions (Choppin, Jaffe, Summerlin, & Jackson, 1973; O'Connor, Davis, Haenisch, MacNab, & McClellan, 1973) compared to the current editions (Choppin & Summerlin, 1982; O'Connor, Davis, Haenisch, MacNab, & McClellan, 1982) of these same high school chemistry textbooks?
6. Is there a significant difference in gender representations when comparing those in current high school chemistry textbooks to the approximate 50/50 proportion of men/women that exists in our population?

The Sample

Heikkinen (1973) analyzed 10 1970/1973 textbooks which he believed to be representative of 60–70% of the total high school chemistry textbook market in 1973.
The replicate study (1988) analyzed seven current high school chemistry textbooks and compared them to seven 1970s editions in Heikkinen's study. One text researched by Heikkinen was randomly chosen for a reliability study. Two texts (Ledbetter & Young, 1973; Thompson, 1973) were not included in the comparative study because there were no current editions.


Chemistry: An Investigative Approach (Cotton, Darlington, & Lynch, 1973) was the randomly chosen text for a reliability study.

Methods

A conscientious effort was made to replicate Heikkinen's (1973) methods as accurately as possible. For simplification, the compared texts are referred to hereinafter by the first author's name only. In the tables they are noted as A (Atkinson), Ch (Choppin), Co (Cotton), G (Gordon), M (Metcalfe), O (O'Connor), P (Parry), and T (Toon).

A frequency of illustrations chart (Table 1) similar to Heikkinen's (1978) frequency chart (Table 2) was developed for the current editions of textbooks listed. A count for all seven current textbooks was kept for the following criteria:

1. Number of named (identified) male and female figures (photos or drawings) from the beginning of the books up to, but not including, the Appendix section. Named means that the picture was of some historic or contemporary figure named in the text.

<table>
<thead>
<tr>
<th>Texts</th>
<th>Total Named adults</th>
<th>Unnamed adults</th>
<th>Youths</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>% M</td>
<td>N</td>
</tr>
<tr>
<td>A</td>
<td>7</td>
<td>71</td>
<td>54</td>
</tr>
<tr>
<td>Ch</td>
<td>30</td>
<td>77</td>
<td>39</td>
</tr>
<tr>
<td>G</td>
<td>23</td>
<td>96</td>
<td>54</td>
</tr>
<tr>
<td>M</td>
<td>44</td>
<td>89</td>
<td>40</td>
</tr>
<tr>
<td>O</td>
<td>1</td>
<td>100</td>
<td>36</td>
</tr>
<tr>
<td>P</td>
<td>17</td>
<td>76</td>
<td>37</td>
</tr>
<tr>
<td>T</td>
<td>30</td>
<td>97</td>
<td>54</td>
</tr>
</tbody>
</table>
TABLE 2

Frequency of Illustrations by Gender in Eight 1970/1973 High School Chemistry Texts

<table>
<thead>
<tr>
<th>Texts</th>
<th>Named adults</th>
<th>Unnamed adults</th>
<th>Youths</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%M</td>
<td>N</td>
<td>%M</td>
</tr>
<tr>
<td>A</td>
<td>5</td>
<td>80</td>
<td>54</td>
<td>65</td>
</tr>
<tr>
<td>Ch</td>
<td>30</td>
<td>97</td>
<td>29</td>
<td>100</td>
</tr>
<tr>
<td>Co</td>
<td>46</td>
<td>91</td>
<td>48</td>
<td>94</td>
</tr>
<tr>
<td>G</td>
<td>24</td>
<td>96</td>
<td>62</td>
<td>82</td>
</tr>
<tr>
<td>M</td>
<td>3</td>
<td>100</td>
<td>21</td>
<td>86</td>
</tr>
<tr>
<td>O</td>
<td>0</td>
<td>—</td>
<td>14</td>
<td>100</td>
</tr>
<tr>
<td>P</td>
<td>14</td>
<td>100</td>
<td>13</td>
<td>92</td>
</tr>
<tr>
<td>T</td>
<td>31</td>
<td>97</td>
<td>48</td>
<td>92</td>
</tr>
</tbody>
</table>

2. Number of adult unidentified female and male figures (photos or drawings) from the beginning of the books up to, but not including, the Appendix section. A single photo of five women was counted as five (Table 1).

3. Number of unidentified male and female young people depicted in photos or drawings from the beginning of the books up to, but not including, the Appendix section. Figures which were genderless (stick figures) or gender-ambiguous were not tabulated. Also, group photos of more than 10 people, indistinguishable as men or women, were not counted (Table 1).

4. Textbooks by Choppin (1973, 1982) and O'Connor et al. (1973, 1982) were analyzed page-by-page for the first half of the text narrative for verbal analogies. (This task was time-consuming. Given constraints of time and money, Heikkinen previously decided that half-text sampling would be sufficient for the purposes of classifying the kinds of verbal images used.) To qualify for tabulation, the example/analogy referred to something physically or figuratively outside the confines of the classroom or laboratory. Items referred to by common name instead of by chemical name were included. For example, the use of the word sugar or gasoline instead of sucrose or hydrocarbon was included as an analogy. The examples were then classified by Heikkinen's (1973) criteria for male/female stereotypical interests. Care was used to replicate this part of the study as accurately as possible.

Heikkinen (1973), using Walberg's (1967) method, assigned female/male categories to each of the classifications as follows:

- Work/Mechanical: Boys' interests
- Kitchen/Food/Household: Girls' interests
- Nature/Geography: Girls' interests
- Sports/Recreation/Leisure: Neutral
- Self: Neutral
- Technology/Engineering: Boys' interests
- Everyday miscellaneous: Neutral

The frequencies of all the categories, and frequencies grouping boys' interests, girls' interests, and neutral categories, are listed in Table 3.
Data Collection

The Coders

Five high school students who volunteered to do the frequency counts during their study halls were used to record data on the text illustrations. Each coder worked independently. Then 5 other coders recorded verbal analogy data. All 10 coders were instructed beforehand on the method of data collection.

The training sessions consisted of verbal instructions and practice using worksheets provided for the coding. Five coders of illustrations made tallies of all seven current texts plus Cotton's (1973) text. Five additional coders worked on analogies, following verbal instructions and using prepared forms and written lists of Walberg’s (1967) examples for each category. They also analyzed O'Connor’s (1973) text. All sessions were formal group sessions and quiet, independent work was required of each coder during a 2-week sequence of study halls.

Illustration Analysis

Cross-study reliability of the coding on illustrations was established by having the five graphics-oriented students use the Cotton (1973) textbook which had been randomly chosen from the sample. Data were compared with results obtained by Heikkinen's (1973) coders, using the intrarater reliability coefficient formula that follows:

\[
R = \frac{MSs - MSw}{MSs + (K - 1) MSw}
\]

where

- \( R \) = reliability,
- \( MSs \) = mean squares between subjects,
- \( MSw \) = mean squares within subjects, and
- \( K \) = number of trials (Safrit, 1976).

A 0.98 reliability coefficient was achieved. The average intrarater reliability for the analyses of illustrations of the seven current texts was 0.85. Atkinson's (1978) book had a significantly lower coefficient (0.62) than the others due to difficulty the young
coders (ages 14–18) had in determining the gender of long-haired persons in unisex clothing which characterized illustrations in this particular text. The average reliability without this book would be .89.

**Verbal Analysis**

Cross-study reliability of the verbal analysis process was established by having the second group of five students record examples of analogies in the O'Connor (1973) textbook. Results were compared to those of Heikkinen's team (1973). Two coders were eliminated because of their low reliability with the other three coders and each other. A 0.90 reliability coefficient was computed for the remaining three coders.

The verbal analyses had an average of 0.95 interrater reliability. Both the illustrations and verbal analyses' coefficients were sufficiently high to suggest that the coders were able to accurately replicate Heikkinen's (1973) method.

**Data Processing and Analysis**

Descriptive statistics were used to summarize the data collected for all three evaluations of text illustrations and for the verbal analogies. Inferential statistics were used to determine differences between the 1970/1973 and current editions.

**Results**

Interrater reliability values of the 1973 and 1988 analyses of illustrations and verbal analogies (0.85 and 0.95, respectively) of the Cotton (1973) text suggest that Heikkinen's (1973) method for gender analysis of texts can be replicated and provides reliable results for high school chemistry textbooks.

Data from Tables 1 and 2 were analyzed using a chi-square test for independence, chi-square goodness-of-fit tests, and Kruskal’s $T_Y$ (Table 4). Preliminary analyses of data were completed to determine if there were gender differences among illustrations in all texts, both editions, and for each text, both editions.

There were significant changes (Table 5) in the direction of gender fairness in illustrations from the 1970/1973 to current editions of high school chemistry texts in texts by Choppin (1982) and by Parry (1987).

There were significant changes (Table 5) in the direction of gender fairness in named and unnamed adult illustrations in high school chemistry textbooks in the 1970/1973 and current editions in texts by Choppin and by Parry. There were also changes in the direction of gender fairness in youth illustrations only between the 1970 chemistry text and the current edition by Parry.

There were significant changes in gender balance of illustrations when comparing current high school chemistry textbooks to the proportion of 50/50 male/female that exists in the human population (Table 6). Parry had become more gender balanced in total illustrations and Toon had shown the least change in balance of illustrations by gender.

Concerning the relative frequencies of verbal analogies found in two 1973 and current editions tested ($p = 0.0470$) (see Table 3), the text by Choppin had significant changes in the direction of gender fairness.
### TABLE 4

<table>
<thead>
<tr>
<th>Texts</th>
<th>$\chi^2$</th>
<th>$df$</th>
<th>$p$</th>
<th>Kruskal's $T_Y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3.55</td>
<td>5</td>
<td>0.6166</td>
<td>0.02</td>
</tr>
<tr>
<td>Ch</td>
<td>14.35</td>
<td>5</td>
<td>0.0110</td>
<td>0.11</td>
</tr>
<tr>
<td>G</td>
<td>27.89</td>
<td>5</td>
<td>0.0001</td>
<td>0.15</td>
</tr>
<tr>
<td>M</td>
<td>21.54</td>
<td>5</td>
<td>0.0006</td>
<td>0.19</td>
</tr>
<tr>
<td>O</td>
<td>6.66</td>
<td>4$^b$</td>
<td>0.1549</td>
<td>0.10</td>
</tr>
<tr>
<td>P</td>
<td>29.54</td>
<td>5</td>
<td>0.0001</td>
<td>0.24</td>
</tr>
<tr>
<td>T</td>
<td>21.94</td>
<td>5</td>
<td>0.0005</td>
<td>0.11</td>
</tr>
</tbody>
</table>

*a 2 × 6 design.  
*b O'Connor has but 4 $df$ because one set of values was 0/0 and, therefore, impossible to calculate.  
* $p < 0.05.$

### TABLE 5

**Comparisons of Significance for each of Five Texts for Named Adults, Unnamed Adults, and Youth Compared in the 1970–1973 and Current Editions by Gender**

<table>
<thead>
<tr>
<th>Category</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ch</td>
</tr>
<tr>
<td>Named adults</td>
<td>0.0227$^*$</td>
</tr>
<tr>
<td>Unnamed adults</td>
<td>0.0032$^*$</td>
</tr>
<tr>
<td>Youth</td>
<td>0.5050</td>
</tr>
</tbody>
</table>

* $p < 0.05.$

### TABLE 6

**Goodness-of-Fit of Illustrations for Named Adults/Unnamed Adults/Youths Compared in the 1970/1973 and Current Editions by Gender**

<table>
<thead>
<tr>
<th>Texts</th>
<th>1970/1973 editions</th>
<th>Current editions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\chi^2$</td>
<td>$p$</td>
</tr>
<tr>
<td>A</td>
<td>4.26</td>
<td>0.0389</td>
</tr>
<tr>
<td>Ch</td>
<td>56.07</td>
<td>0.0001</td>
</tr>
<tr>
<td>G</td>
<td>32.82</td>
<td>0.0001</td>
</tr>
<tr>
<td>M</td>
<td>15.70</td>
<td>0.0001</td>
</tr>
<tr>
<td>O</td>
<td>16.00</td>
<td>0.0001</td>
</tr>
<tr>
<td>P</td>
<td>31.34</td>
<td>0.0001</td>
</tr>
<tr>
<td>T</td>
<td>52.76</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

*a 2 × 1 design.  
* $p < 0.05.$ Significance indicates deviation from ideal 50/50 gender balance.
Conclusions

The purpose of this study was to provide information on gender fairness in high school chemistry textbooks and to test a method for doing so. The findings have demonstrated that the assessment method developed by Heikkinen (1973) is valid, easy to use, and reliable. There is, however, a limitation in the method; the assumption that Walberg's (1967) male/female interest categories reflect orientation of today's young people is questionable. Girls' and boys' interests may have shifted somewhat or may overlap more than was characteristic of students in the 1970s. It would be valuable to replicate Walberg's (1967) study to determine whether these changes exist.

Assumptions that cars, planes, water purification, space exploration, and flashlights are things primarily of interest to boys and that nature reflected in plants, animals, minerals, and the solar system are primarily of interest to girls, for example, may not be valid today. Familiar tools and household objects are not the same in the age of microwave ovens, microcomputers, water pollution, and AIDS as they were more than two decades ago. If there is a gender-specific difference of interest in them, evidence has not yet been published.

Answers to the research questions on gender fairness are mixed.

1. Only one text (Parry, 1987) changed dramatically in overall proportion of male/female images to become gender fair in its current edition. Four texts maintained the gender imbalance of their graphics, and two others increased the disproportion of illustrations favoring men.


4. Only Parry (1987) showed a significant increase in representations of female youth. Gordon (1978) and Toon (1978) showed an opposite movement toward increased disproportion of male youth images.

5. There was no significant change in relative frequencies of male and female verbal analogies in Choppin (1973, 1982) and O'Connor (1973, 1982) although the proportion of female images in Choppin, in particular, did increase.

6. There were proportional differences in gender of youths and of named adults in both editions of the texts, and changes of unnamed adult representations in current editions only. Overall, gender ratios improved from five male images to every female image in the 1970/1973 editions to three male images to every female image in current editions. Only Parry (1987) equalized the total number of male/female illustrations.

The knowledge gained by this study can be used by high school chemistry teachers in their evaluations and selections of curricular materials. Also, the method of assessing the gender of illustrations has demonstrated usefulness and could be applied to all science textbooks from elementary through college levels. High school science teachers rely primarily on textbooks for their course content. Now, it is hoped they will consider the subliminal as well as theoretical messages that books convey, and use the criterion of gender fairness when making their selections.
References


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