Available online at www.sciencedirect.com
ScienceDirect
Procedia - Social and Behavioral Sciences 174 (2015) 1321 – 1329
Procedia
Social and Behavioral Sciences

INTE 2014

Images of chemical scientists through Turkish primary students' eyes: implications for curriculum and instruction

Hünkar Korkmaz[a*], Nilgun Secken[b]

[a]Hacettepe University, Faculty of Education, Department of Educational Sciences, Division of Curriculum and Instruction, Ankara06800, Turkey
[b]Hacettepe University, Faculty of Education, Department of Secondary Science and Mathematics Education, Division f Chemistry Education, Ankara 06800, Turkey

Abstract

This study investigated the images of chemical scientists held by Turkish primary students by gender. The Draw a Chemical Scientist Test was administered to 542 students from an urban area. A Chi-Square Test of Independence was used to test for statistically significant differences between gender groups. Significant differences were found between girls' and boys' images of chemical scientists in terms of some aspects. It is thought that the findings of this research will contribute to the development of chemistry education, to the researchers studying on gender issues, cultural diversity, and also to the international literature on chemistry education. While DACST is a feasible and simple method, future studies should supplement it with interviews for deeper understanding of students' constructs

Peer-review under responsibility of the Sakarya University

*Keywords:*images of chemical scientist, science education, chemistry curiiculum, instruction, primary students

1. Introduction

Chemistry was developed greatly throughout the 20th century. An outcome of this development was the introduction of chemistry in the curriculum of elementary and secondary education, either as part of science course or as separate disciplines (Salta & Tzougraki, 2004). Chemistry education, or often chemical education, has two principal purposes: to teach the basic concepts students need to undertake further education in chemistry (and other science-related disciplines) and to develop scientific literacy. Science educators have agreed that the development of scientific literacy should be an important goal of the school curriculum. In this context, current science education

* Corresponding author. Tel.: 00-000-000-0000
E-mail address: nsecken@hacettepe.edu.tr

Peer-review under responsibility of the Sakarya University
doi:10.1016/j.sbspro.2015.01.754

reform urges that every student be frequently and actively involved in exploring the natural world in ways that resemble how scientists work (Luehman & Markowitz, 2007). Understanding how scientists build, evaluate, and apply scientific knowledge in a scientific inquiry context is a core part of scientific literacy as a science curriculum goal (American Association for the Advancement of the Science [AAAS], 1993; Fensham & Harlen, 1999; OECD, 2000). Students' images of science (Driver, Leach, Millar & Scott, 1996) and their images of scientists are widely accepted as important aspects of their scientific literacy (National Research Council, 1996) and have important implications for how they learn and engage with science in a classroom context (Hofer, 2001).

Many studies have examined gender differences in images of scientists. Manzoli et al (2006), working with 48 Grade 3 students from Italy, found that girls were more likely to draw female scientists, but that they often asked permission to do so. In addition, the girls' drawings typically depicted biological or medical sciences; the boys' drawings typically included more technology. In a study, Losh, Wilke, and Pop (2008) investigated elementary school students' conceptualization of scientists. The researchers also found that girls were more likely than boys to draw female scientists and that girls were more likely to draw figures in which gender could be determined.

Song and Kim (1999) investigated Korean students' images of the scientists. In their study, the data, quantitative and qualitative, from the responses of a total of 1137 from the different groups (ages 11, 13, and 15) were analyzed to calculate the relative frequencies of some identified patterns of responses and to make comparisons between different genders and different age groups. They found that there were some differences between the gender groups: girls more frequently mentioned ''experiment'' while boys did ''research.'' In addition, nearly three quarters of the students (74.4%) identified the scientists as male while only 16.1% did as female. There was a clear difference according to the respondents' gender: in trend girls drew a much higher proportion of female scientists. In 2001, Gounselin (2001) conducted a study on images of scientists held by 373 middle school students and found that male students depicted scientists as males, but females depicted scientists as both male and female.

In this study, it was examined the images of students at middle school level and explore the contexts and implications. In many countries, middle school is the last opportunity for students to relate to science and technology in any organized framework. It is also the period when students decide whether to take science as a major subject at high school level or stop learning science subjects (Scherz & Oren; 2006). Therefore, it is necessary to promote the development of positive images and attitudes toward scientific topics including chemistry at this critical time. The responsibility of science education to shape scientific attitudes is highlighted by DeBoer's (2000) review of the history of science education. The eight goal is summarized as "Preparing citizens who are sympathetic to science" which is understood to refer to promotion of positive scientific attitudes, including a willingness to make use of scientific expertise (Citied in Scherz & Oren; 2006).

Over the past 50 years, a growing body of research has been conducted on people's images of science and scientists. Much of this research has focused on children's images in general science context rather than a specific science context such as biological science and scientists, astronomical science and scientists, physical science and scientists, and chemical science and scientists. There is a lack of information in how students view chemical science and scientists. This study is aimed to provide descriptive information about students' images of chemical science and scientists in terms of various aspects including stereotype images, alternative images, and additional images by gender.

2. Method

This study employs a survey design (Creswell, 1994) using a projective instrument adapted from Draw a Scientist Test (Chambers, 1983) to collect the perceptions of primary school students.

2.1. Sample

The study group consisted of five hundred forty-two primary students (269(49.6%) boy and 273(50.4%) girl) taken from the seventh or eighth grade of three urban schools located in the same city in Turkey. All these schools have a heterogeneous population from middle and lower middle socioeconomic backgrounds. For this study, researchers assumed that the 7th and 8th grades students at the primary school level were appropriate to exploring students' images of chemical scientists. At the primary school level in Turkey, Integrated science curriculum is given including biology, physic, chemistry, astronomy, and geology. Chemistry topics are taught intensively in these grade levels than other grade levels. The students at this level are more aware of chemistry as a separate science discipline.

2.2. Instrument

The instrument used in this study is based on Chambers' (1983) Draw a Scientist Test (DAST), a projective instrument designed to reveal students' images of a chemical scientist as to gender groups. The test requires students to draw a scientist using stick figures and other graphical rendition of their impression. The DAST was adapted for this study and the researchers refer to the adapted instrument as Draw a Chemical Scientist Test (DACST). DACST was revised through a pilot study carried out with about 150 students of different grade levels at primary school level.

The Draw a Scientist Test Checklist (DAST-C) developed by Finson et al. (1995) was adapted to design a scoring rubric including two sections. The seven *standard images* of a scientist identified by Chambers (1983) were adapted as the first section of DACST checklist shown Table 1. The second section of the DACST checklist represents the *alternative images* of a chemical scientist including gender, age, and ethnic origin. Ethnic minority representation was practically *nonexistent*. In other study on Turkish primary students (Turkmen, 2008) was explained the reason of this situation as following two sentences. One possible explanation is all Turks are Caucasian and students probably have never seen any black or Hispanic or Asian people. Undoubtedly, students did not depict any minority people as a scientist. Thus, the researchers considered these three indicators and eliminated the ethnic origin indicator for Turkish sample. These indicators and specific descriptors were added in the DACST checklist because they showed up frequently in the drawings of students during a pilot test. A third category, *additional images of chemical scientist* including emotions, natural setting of work, and nature of scientific work.

2.3. Administration of the DACST

The students in this study were instructed to draw their perceptions of a chemical scientist on a blank sheet of paper. On the back of paper, they were asked to clarify ambiguities their drawings. These questions were included (1) Briefly, describe the images of the chemical scientist you drew; and (2) What is the chemical scientist doing? Students were also instructed to write their gender, school, and grade level on the upper right hand corner of the drawing. Teachers were selected based on their willingness to volunteer. Students who participated in the study were randomly assigned to their classes by school administration prior to the opening of school and the initiation of the study. Teachers and the researcher gave the instrument during their science classes and provided students with unlimited time to complete all items.

2.4. Analysis of the DASCT

During the pilot study, inter-coder reliability for the drawings was 0.95, using Miles and Huberman's (1994) formula (total agreements/total codes). Each coder used the DACST checklist to analyze the drawings from all of the subjects. The students' drawings were coded into a set of categories as shown Tables 1–3. For the analysis of the data from the DASCT, quantitative and qualitative data obtained were frequently grouped into patterns the responses in order to give relative frequencies and percentages of the patterns. Also, chi-square analyses were conducted to determine if gender differences in student images were present.

3. Results and Discussions

The analyses of the drawings reveal that a chemical scientist is perceived by the Turkish primary school students in this study as a mosaic of the standard image of scientists, alternative images and have additional characteristics specific to scientists who study chemistry.

3.1. The standard image of a chemical scientist

All seven indicators of the standard images of a scientist (Chambers, 1983) were present in the subjects' drawings of a chemical scientist. Table 1 shows the frequencies, percentages, and chi-square results of indicators of a standard image of a chemical scientist drawn by the gender of subjects.

Table 1. Frequencies, percentages, and chi-square for DAAST

Rank order of the Standard image of a Scientist (Chambers, 1983)	Girl (n=273) f(%)	Boy (n=269) f(%)	X^2	P	Significance Level
1-Lab coat(3)	130(47.6)	126(46.8)	.0333	.864	NS
2-Eyeglasses(5)	109(39.9)	92(34.2)	1.904	.183	NS
3-Facial growth of hair(6)	95(34.8)	107(39.8)	1.436	.249	NS
4-Symbols of research (1)	249(92.2)	220(81.8)	10.326	.002	*
5-Symbols of knowledge(4)	115(42.1)	101(37.5)	1.185	.293	NS
6-Technology(2)	197(72.2)	177(65.8)	2.564	.115	NS
7-Relevant captions(7)	64(23.4)	38(14.7)	7.698	.006	*

The rank order of Chamber's list was used for comparison (See, Column 1 in Table 1). The rank order of the indicators were different to Chamber's list except the indicator "relevant captions". In this study, symbols of research, technology, and lab coat were ranked as the first three indicators by the students. These findings can be explained the effects of historical time. Chambers did his study before thirty-one years. This century, 21st century, is defined as science and technology age. The students' drawings are seen association of symbols of research and technology with computers. Two samples for students' drawings were given Appendix 1.

Also, as indicated in Table 1, there were statistically significant differences by gender for two indicators including symbols of research and relevant captions of standard images. More girls in this study depicted a chemical scientist sing research symbols ($X^2(1, N=542) = 10.326$, $p<0.05$) relevant captions($X^2(1, N=542) = 7.68$, $p<0.01$). Another account from Narayan (2009) is typical of the gender analysis found in the interpretation of DAST drawings: "Females more than males drew their scientist in a laboratory setting with symbols of knowledge such as books, charts, etc., and symbols of research.

3.1. Alternative images of a chemical scientist

When the drawings were analyzed for alternative images, it was interesting to observe the candor with which the subjects drew many alternative images of a scientist that helped define their perceptions of a chemical scientist. Six indicators assessed in this category are (8) gender, (9) age, (10) indications of danger, (11) presence of light bulbs, (12) mythic images, and (13) indicators of secrecy. Indicator 8, ''gender,'' was expanded to ''male,'' ''female,'' and ''gender-neutral.'' Indicator 9, ''age of scientist,'' had three choices that included ''young aged,'' ''middle aged'' and ''elderly scientist'' to accommodate the subjects' perceptions. Table 2 summarizes the responses to the indicators on the alternative images on a chemical scientist.

Table 2. Frequencies, percentages, and chi-square for DAAST

Alternative images (Finson et al., 1995)		Girl (n=273) f(%)	Boy (n=269) f(%)	X^2	P	Significance Level
8-Gender						
	Male	122(44.7)	134(49.8)	1.428	.263	NS
	Female	124(45.4)	93(34.6)	6.642	.011	*
	Male &female	13(4.8)	46(17.1)	21.264	.000	*
9-Age						
	Young aged	58(21.2)	81(30.1)	5.585	.019	*
	Middle aged	207(75.8)	181(67.3)	4.856	.029	*
	Elderly scientist	7(2.6)	7(2.6)	.001	1.00	NS
10-Indications of danger		74(27.1)	64(28.8)	.784	.430	NS
11- Presence of light bulbs		26(9.5)	34(12.6)	1.336	.275	NS
12- Mythic images		1(0.4)	3(1.1)	1.037	.370	NS
13- Indicators of secrecy		9(3.3)	8(3)	.046	1.00	NS

As indicated in Table 2, the girls drew female($X^2(1, N=542) = 6.642$, $p<0.05$) and middle aged($X^2(1, N=542) = 4.586$, $p<0.05$) scientists more than boys. Also, the boys drew young($X^2(1, N=542) = 5.585$, $p<0.05$) and both male and female ($X^2(1, N=542) = 21.264$, $p<0.05$) scientist. Although there was no a significant difference, more boys (n=134, 49.8%) drew male scientist than girls (n=122, 44.7%).

The single most widely studied variable in DAST research has been that of gender. Mead and Metraux (1957) noted that when asked to write essays about scientists, both male and female high school students mostly described male scientists. In the original DAST study, out of nearly 5,000 students tested, 28 girls, and no boys, drew female scientists (Schibeci and Sorenson, 1984; Kelly 1985). To a greater or lesser degree, almost all the hundreds of DAST studies observed this gender divide, as indicated in a recent review of the DAST literature. "A survey of students from across the United States found that only 14 percent of the drawings by girls and 8 percent of the drawings by boys depicted female scientists, and only 20 of the 1,600 drawings by both girls and boys depicted scientists of color (Fort and Varney 1989). A study of undergraduate biology and liberal studies majors showed that students in both groups drew more male scientists than female scientists, and only female students from both groups drew female scientists (Rosenthal 1993). Another study found that children in kindergarten through twelfth grade primarily drew pictures of male scientists (Barman 1999), and older students were less likely to draw female scientists than were younger students." It is also not surprising that males tended to draw their scientist as a male while females drew both male and female scientists.

Additional images of a chemical scientist

The additional images specific to a chemical scientist were depicted in three indicators of the DACST checklist. These indicators are (14) emotions depicted, (15) natural setting(s) of work, and (16) nature of scientific work. Indicator 14, the emotions of a chemical scientist, was expanded to include joy, hope, and sadness. Indicator 15, the settings of work, was expanded to include common environments in which chemical scientists perform their work. Finally, indicator 16 serves to record the nature of scientific work including science process skills drawn and described by subjects. The indicator named ‘‘type of scientist,’’ which existed on the original checklist developed by the Thomas and Hairston (2003), was not used in this study. Generally, the type of scientist was generic; a small percentage of the pictures drawn depicted a chemical scientist. Table 3 summarizes the additional images of a chemical scientist analyzed from the drawings of the subjects.

Table 3. Frequencies, percentages, and chi-square for DAAST

Additional images (Adapted from Thomas & Hairston, 2003; Korkmaz, 2009, 2011)		Girl (n=273) f(%)	Boy (n=269) f(%)	X^2	p	Significance Level
14-Emotions						
	Joy and hope	155(65.8)	154(57.1)	.012	.931	NS
	Sadness	53(19.4)	72(26.8)	4.127	.052	NS
	Neutral	65(23.8)	43(16)	5.199	.024	NS
15-Settings of work	Indoor	236(86.4)	224(83.3)	1.064	.338	NS
	Outdoor	12(4.4)	10(3.7)	.160	.828	NS
	Combination of indoor and outdoor	7(2.6)	6(2.2)	.064	1.00	NS
16-Nature of scientific work	Observing	33(12.1)	5(1.9)	.495	.525	NS
	Testing samples with scientific instruments	17(6.2)	11(4.1)	1.264	.261	NS
	Collecting data	17(6.2)	11(4.1)	.153	.733	NS
	Experimenting	202(74)	179(66.5)	3.601	.061	NS
	Reporting	10(3.7)	5(1.9)	1.639	.295	NS
	Working cooperatively	13(4.8)	10(3.7)	.364	.671	NS
	Teaching	1(0.4)	3(1.1)	1.037	.370	NS
	Presenting a study/research	4(1.5)	1(0.4)	1.772	.373	NS
	Reading a book	21(7.7)	21(7.8)	.438	.542	NS
	Thinking about a research idea	10(3.7)	11(4.1)	.066	.827	NS
	Finding a chemistry formula	14(5.1)	9(3.3)	1.059	.395	NS
	Planning a research/project	11(4)	7(2.6)	.895	.473	NS

The indicator for “emotions” helps to assess the expressions depicted in the drawings. The most of the drawings by the students in both gender groups express joy and hope that chemical scientists will rescue the earth from war and diseases. The most popular setting of work drawn by the students was the indoor. The most common perception in both gender groups about the nature of scientific work by a chemical scientist drawn and expressed by the students were experimenting. These findings were supported each other. Generally, in chemistry, an experiment was done a laboratory, indoor, setting.

The researchers examined the chemistry subjects in Turkish primary science curriculum content, regional matters, and concluded that the lesson and activities in chemistry unit in science curriculum context influenced primary school students. There were lessons on chemical weapons, life story of Madam Curie and her studies related to radiology, medicine, and others. The most of the visuals in students' books, a chemical scientist was presented doing an experiment in laboratory, indoor, setting.

4. Implications to Curriculum and Instruction in Science Education

The results of this study are important for curriculum developers, teachers, policy makers, and institutions with science/chemistry education, science/chemistry teacher preparation and enhancement programs. Information about students' images of scientists can guide in formulating educational aims and objectives, designing curriculum content and instructional practice to accommodate students' prior knowledge and personal experiences.

This study also has implications for the schools and the community. It has been shown that not all students have the same educational experiences. Schools and communities must provide equal opportunities for all students without regard to gender such as the effective schooling, extra educational help, and support systems they need to meet the educational standards demanded by the society. Teachers and schools should also recognize that students come to school with diverse backgrounds and provide constructive educational experiences, including science-related experiences, which build on those backgrounds.

In addition, the implications of this study are clear for textbook publishers and TV programmers. As indicated by Sjoberg (1993) the textbooks, mass media such as magazines, newspapers, and televisions, especially TV, play an important role in the formation of students' images of scientists the students at primary school level textbooks influence students' images of science and scientists. Publishers and TV programmers must take care to promote gender-neutral and positive images of science and scientists represented in their publications and programs (Silversten, 1993).

Although, in this study, the participants in both gender groups have been educated through the same curricula, the results of this study show that they hold different images of scientists who do chemistry in terms of some aspects. The reason for this different result may be interpreted as providing unequal opportunities for gender groups in schools or outside of school. Knowing students' images by gender is important to build an effective learning and teaching environment in science and chemistry education for all. Teachers at the primary school level play a vital role in creating students' images of science and scientists. In this context, the results of this study provide useful information to those engaged in primary school science education. A clearer understanding of primary school students' images of scientists has implications for the science teachers of primary school students. Once teachers know what images of scientists who do chemistry may possess by gender, teachers can modify their teaching, perhaps by including visitors who represent science and chemistry related occupations, organizing field trips to see "science/chemistry in action," involving more equal hands-on science/chemistry activities in terms of gender, and bringing more science books and stories about female scientists in science/chemistry to the classroom. These experiences should provide exposure to a variety of role models, including female scientists, scientists from different cultures, and scientists conducting research in both field and laboratory settings.

In light of the results of this study, we suggest to investigate the relationship between students' images and attitudes toward chemistry and their subsequent decisions about secondary school science majors and university chemistry programs. There are, of course, limitations to this study. The assertions made cannot be generalized from this small sample to all Turkish primary students. The assertions generated can provide an indication only of the images of science and scientists related to chemistry held by the wider population of primary school students. In conclusion, this study extends the literature on students' images of chemical scientists. The general impression gained is that there is a need for improvement in students' images of chemical scientists. In today's scientifically and technologically expanding science and technology age, it is important for teachers and other educators to be aware of students' existing images of chemical scientists and to provide appropriate avenues for change.

References

American Association for the Advancement of Science (AAAS). (1990). *Science for all Americans.* New York: Oxford University Press.

Chambers, D. W. (1983). Stereotypic images of the scientist: The draw-a-scientist test. *Science Education, 6*, 255-265.

De Boer, G. (2000). Scientific Literacy: Another look at Its Historical and Contemporary Meanings and Its Relationship to Science Education Reform. *Journal of Research in Science Teaching*, 37(6), 582-601.

Driver, R., Leach, J., Miller, A., & Scott, P. (1996) *Young people's images of science.* Buckingham: Open University Press.

Fensham, P.J., & Harlen, W. (1999). School science and public understanding of science..*International Journal of Science Education, 12*, 755-763.

Finson, K. D., Beaver, J. V., & Cramond, V. L. (1995). Development and field test of a checklist for the draw-a-scientist test. *School Science and Mathematics, 95*, 195-205.

Gounselin, Walter. B. Jr (2001). "How Do Middle School Students Depict Science and Scientists?" Ph.D. thesis, Mississippi State University, Publication Number: AAI3005589; ISBN: 9780493146751; Source: Dissertation Abstracts International, Volume: 62-02, Section: A, page: 0444.; 80 p.

Losh, S. C., Wilke, R., & Pop, M. (2008). Some methodological issues with "draw a scientist test" among young children. *International Journal of Science Education, 30*, 773-792.

Luehmann, A.L. & Markowitz, D. (2007). Science teachers' perceived benefits of an out-of-school enrichment programme: Identity needs and university affordances. *International Journal of Science Education* 29(9) 1133-1161.

Manzoli, F., Castelfranchi, Y., Gouthier, D., & Cannata, I. (2006). Children's perceptions of science and scientists. *Proceedings of the 9th International Conference on Public Communication of Science and Technology.* Seoul, Available at http://www.pcst2006.org/

National Research Council. (1996). *National Science Education Standards.* Washington, DC: National Academy Press.

OECD. (2000). *Measuring student knowledge and skills: The PISA 2000 assessment of reading, mathematical and scientific literacy*. Paris: Organisation for Economic Cooperation and Development.

Scherz, Z. & Oren, M. (2006). How to change students' images of science and technology. *Science Education, 90***,** 965–985.

Salta K and Tzougraki C (2004) Attitudes toward chemistry among 11th grade students in high schools in Greece. *Science Education*. 88(4) 535-547.

Silversten, M.L. (1993).State of the art: Transforming ideas for teaching and learning science, a guide for elementary science education. (GPO #065-000-00599-9). Washington DC: U.S. Government Printing Office.

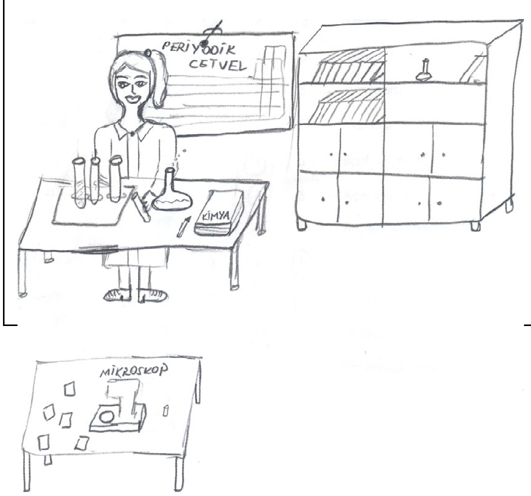
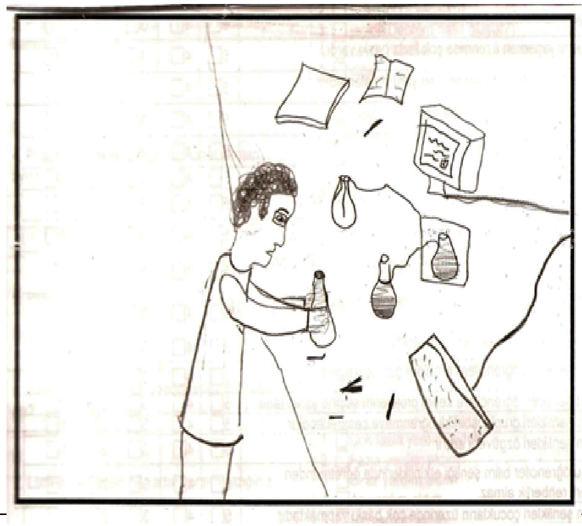
Sjoberg, S. (1993) Gender equality in science classrooms. In B. J. Fraser (Ed.)Researchimplications for science and mathematics teachers. Volume 1. Key center monograph number 5(pp. 31-36). (ERIC Document Reproduction Service No. Ed 370 767)

Song, J., & Kim, K.-S. (1999). How Korean students see scientists: the images of the scientist. *International Journal of Science Education*, *21*, 957-977.

Thomas, J.A.., & Hairston, R. (2003) Adolescent Students' Images of an Environmental Scientist: An Opportunity for Constructivist Teaching . *Electronic Journal of Science Education*. [Online] 7(4), 1-25

Turkmen, H. (2008). Turkish primary students' perceptions about scientist and what factors affecting the image of the scientists. *Eurasian Journal of Mathematics, Science and Technology Education, 4*, 55-61.

Appendix 1-

<table>
<tr><th>A sample for a girl’s drawing</th><th>A sample for a boy’s drawing</th></tr>
<tr><td>
</td><td></td></tr>
</table>