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GENDER DIFFERENCE IN THE SCIENCE CLASSROOM

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ABSTRACT: Much of the discussion and research about "equality of educational opportunity" has concentrated on the differences associated with class, socioeconomic status, region and race. Somewhat less attention has been paid to research on gender differences in science than in mathematics. Several years after the initial intervention programs in math, researchers began to examine the disparities in the science achievement of girls and boys. The low percentage of women in science- and mathematics-related professions has led to widespread research aimed at understanding this phenomenon and introducing more women into scientific and technological fields. Although the issues of why women do not select science as a career or the issues of why boys perform better than girls are complex and very controversial, the purpose of this paper is to examine the factors underlying the differential participation and achievement of boys and girls in school science; then discuss the ways to eliminate gender bias in the classroom.

KEY WORDS: *Science education, gender, science achievement, international studies.*

ÖZET: "Eğitimde fırsat eşitliğine" yönelik tartışma ve araştırmaların çoğu, sınıf, sosyo ekonomik statü, bölge ve ırk farklılıkları üzerine yoğunlaşmıştır. Fen alanındaki cinsiyet farkı ile ilgili araştırmalar, matematik alanındaki araştırmalara göre daha az dikkat çekmektedir. Matematik programlarındaki ilk düzenlemelerden birkaç yıl sonra, araştırmacılar kız ve erkek öğrencilerin fen derslerindeki başarı farklılığını sorgulamaya başlamışlardır. Kadınların fen ve matematik ile ilgili iş sahalarında daha az yer alması, bu durumu anlamak ve daha çok kadını bilimsel ve teknolojik alanlarda çalışmaya yöneltmek için geniş çaplı araştırmalara yol açmıştır. Kadınların bilimi meslek olarak seçmemesi ya da erkeklerin kadınlara nazaran daha başarılı olması her nekadar karmaşık ve de ihtilaflı bir konu olsa da, bu makalenin amacı, erkek ve kız öğrencilerin fen derslerindeki başarısını ve katılımını etkileyen faktörleri incelemek ve sınıflardaki cinsiyet ayırımlarını ortadan kaldırmanın yollarını tartışmaktır.

ANAHTAR KELİMELER: *Fen eğitimi, cinsiyet, fen başarısı, uluslararası çalışmalar.*

1. INTRODUCTION

The under-representation of women in professional scientific communities is a disturbing and is not a disputable fact. This differential representation of men and women in the scientific community was foretold by "achievement patterns already evident in the elementary and secondary levels" [1]. Indeed, the schools are sometimes blamed for this state of affairs, although it is by no means evident that this is a viable attribution. In this regard the following question can be addressed: Is gender difference evident in elementary and secondary school science achievement?

1.1 Achievement and Science

The issue of female underachievement in science has received some welcome attention in recent research in science education. With increasing evidence that the achievement levels of girls and women in science are considerably below that of their male counterparts, especially in postsecondary enrollment and employment in scientific occupations, a number of scholars have directed their attention toward understanding this phenomenon and toward suggesting methods to reduce the inequalities. In doing so they have begun to look at results of science test performance in order to understand the general phenomenon of differences in achievement [2]. For example, the most extensive data on this have come from the cross-cultural survey of science achievement done by the IEA (International Association for the Evaluation of Educational Achievement). The international tests conducted by IEA were used to assess the

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achieved curriculum of each country and to compare outcomes among countries. The results of these comparisons and the identification of good policies and practices were expected to provide guidelines for the future development of science education programs within countries. The results of three IEA Science Studies (FISS, SISS and TIMMS) can be summarized as:

1. It is seen that sex differences have been found at every grade level and in every subject area in the written science achievement tests. Most of the time, this sex difference favoured males.

2. In the First International Science Study (FISS) in 1970 and 1971 boys consistently performed better than girls in all countries and the gap increased as students ascended the school system and with age. The sex difference was shown to increase as students progressed through the school system, and to be greatest for physics, somewhat smaller for chemistry, and smallest in biology [3].

3. The Second International Science Study (SISS) was conducted from 1983 to1984 in 24 countries, and showed differences in science achievement favouring boys in biology, chemistry, and physics for all grade levels (5 to 12), although these differences were smaller than that reported from the first IEA Study (FISS), and less consistent across countries. These differences not only exist at all grade levels, but they also exist in every nation involved in the SISS. For example, it was found that the U.S. had the fourth largest sex difference out of 15 countries for grade 5 [3]. The SISS showed that fifth-grade boys did better than fifth-grade girls on physical science items in U.S. However, the fifth-grade girls did better on biology items [4].

4. The 1995-96 Third International Mathematics and Science Study (TIMMS) is the largest and most comprehensive international study ever conducted. Students from 41 nations at five different grade levels were tested in 30 languages to compare their achievement in mathematics and science. Findings showed that boys had significantly higher mean science achievement than girls at both the seventh and eighth grades internationally and in many countries. For many countries the seventh grade gender differences were somewhat smaller. In only seven countries were there no statistically significant differences in science achievement between boys and girls in both grades-Cyprus, the United States, Singapore, Australia, Romania, Thailand, and South Africa [5]. However, gender differences at the third and fourth grades were much less pervasive than at the seventh and eighth grades [6]. The science content area data also revealed that gender differences vary depending on the science subject. In the seventh, eighth, fourth and third grades, gender differences in earth science, physics, and chemistry reflected advantages for boys. For example, in earth science, the boys had significantly higher averages than girls in 17 countries at the fourth grade and in 16 countries at the third grade. In life science for the items covering environmental issues and the nature of science, girls and boys had similar performances at each grades. In life science, there were very few gender differences in average performance [5, 6].

Similarly, the 1986 NAEP (National Assessment of Educational Progress) in the U.S. reported few gender differences at age 9, but boys outperformed girls in science achievement and the gender gap increased as students progressed in school. By grade 11, the areas of largest male advantage were physics, chemistry, earth science, and space science [7].

Beller and Gafni [8] analyzed gender differences as revealed by the second International Assessment of Educational Progress (IAEP) of mathematics and science assessment of 9- and 13-year-olds. They found that the gender effects for science across all participating countries were substantially larger than those for mathematics due to the fact that a relatively greater effort has been made by the various educational systems to narrow the gender gap in mathematics. In both

age groups, boys out-performed girls, but the gender gap was larger for 13-year-old students. In addition, the largest gender differences were found for earth and space sciences and physical sciences; the smallest difference was found for questions involving the nature of science.

Kahle and Meece [7] present comprehensive reviews of the factors contributing to the differential achievement and participation of boys and girls in science. They consider individual, cognitive, attitudinal, sociocultural, home and family and educational variables. They analyzed many studies on mathematics and science achievement and found that the gender gap is closing in mathematics achievement but not in science achievement, especially during the middle school years. Although most boys and girls are enrolled in similar courses during those years, Kahle and Meece [7] found that the gender gap in science achievement increases from age 9 to 13. They concluded that many girls do not have opportunities to learn science equal to those of boys. These findings were corroborated by many other studies [9, 10, 11].

However, findings reveal that gender difference is not homogeneous across measures, age groups, and content areas, which makes it difficult to draw any general conclusions. For example, magnitude of gender difference may depend on many variables such as ability level of the student, the content area assessed, geographic location of the school, student's socioeconomic background. [7, 12]. In terms of sex differences in science achievement, it is also important to look at how certain factors influence the presence and magnitude of the differences: single-sex vs. mixed-sex schools, female vs. male teachers, centralized vs. decentralized school system, and tracking vs. generalized curricula to name a few. There is some evidence that some type of gap is due to the nature of the test as well as to the types of test items used to assess achievement in science. For example, males on average score higher on objective tests, whereas females as a group score better on essay tests. Furthermore, many test items contain references to games, sports, and other activities that are based on boys' interests (eg. baseball averages, motorcycle mileage, automobile engines).

1.2. Socialization Factors

Since students are a reflection of the values of our society, they may enter schools with preset stereotypes already built into their personality. Without a doubt, family and societal influences already have made impressions on children before they start school. Research attributes lower achievement of girls in science to lower parental expectations and encouragement, manifested by a lack of stimulation and opportunity to explore scientific phenomena at home as well as at school. This stereotyped socialization may lead to girls' lack of understanding in specific content areas of science.

Socialization in the home is one of the factors that may prevent girls from developing the characteristics that have been associated with those of scientists, including independence, convergent thinking, logic and experimentation. Girls are often socialized into opposite characteristics such as dependence, nurturance, and passivity [9]. It is clear that parents can influence their children's achievement in science in a variety of indirect and direct ways. That have important implications for their academic interest, skills, and attainment. For example, parents structure the social and physical environment for boys and girls differently and tend to buy more scientific games and toys for their sons than for their daughters [13].

Moreover, another factor limiting girls' experience in science may be sex stereotyped careers, in that children perceive various activities as masculine or feminine [14]. Kelly [15] explains how the masculine image of science is constructed in schools. According to her, this masculinity of science is often the prime reason that girls tend to avoid the subject at school. She notes three ways in which science is seen as masculine: (1) school science is masculine in terms of the disproportionately large numbers of males who study and teach it, (2) the bias toward males in the way in which curriculum materials are presented and packed offers an image of science as exclusive to males, (3) a male-oriented pattern of classroom inte-

raction contributes to the masculine image of science. She argues that image, largely defined by sociocultural influences, is reproduced in schools, where it discourages girls from active participation in science. In society at large, female scientists have had very low visibility. Young children thus tend to believe that scientists should be male. For example, when researchers have asked to children to draw pictures of scientists, most of children think of scientists as men.

1.3. Classroom Experiences

Both inside and out of classrooms, males have more opportunities to experience science [9]. A number of studies have suggested that even within the classroom, males and females receive very different education [10,16]. This causes development of low self-esteem among girls. Since low self-esteem hampers girls' aspirations and actions, girls often dream less, risk less, and try less when the time comes to make crucial decisions about courses of study and choices of careers. It is clear that adults, including teachers, demonstrate less faith in girls' abilities than they do in boys' abilities, causing girls to lose their sense of academic self-esteem as they grow [17].

It is claimed that schools, teachers, and school curriculum encourage girls to adopt passive and dependent behaviour and males to adopt aggressive and independent behaviour. Differential treatment by teachers and the ways that boys and girls interact and participate in the science classroom have also been shown to contribute to gender differences in performance and interest in science. One explanation for the differential treatment by teachers is their perception that boys have stronger scientific abilities than girls. Girls receive significantly less praise, direct questions, and behavioural warnings from their teachers [18]. They also call out less often in class and ask fewer procedural questions [9]. Furthermore, research also showed that boys received more feedback from their teachers as compared to girls [19,20]. Through observations in the classrooms, Sadker and Sadker (20) found the type of feedback given by the teacher to be significantly different based on the sex of the students: "Boys were more likely to be praised, corrected, helped and criticized-all reactions that foster student achievement. Girls received the more superficial 'okay' reaction, one that packs far less educational punch" [20, p.55]. Not receiving an equal share of teacher attention and quality responses eventually inhibits the girls' willingness to volunteer to answer questions or led a demonstration. These classroom interaction patterns result in greater opportunities for boys than girls to learn in science and may reflect favourable achievement expectations for boys [7, 9].

More than 20 years of research on teachers' interactions with children show that teachers do treat girls and boys differently and those differences have startling effects on the children [11]. Becker [10] proposes a three-step pattern to explain the observed gender differences in classroom interactions. She suggests that teachers hold different expectations for their students based on genders; they subsequently treat their students differently based on these expectations, and the students respond differentially in class in accordance with the sex-role expectations of their teachers and society. Unfortunately, most teachers are unaware of their differential treatment of students based on gender.

Another classroom factor that differentially affects girls and boys is the type of instruction. Tobin and Garnett [21] report that whole-class activities tend to be dominated by high-achieving boys. Research consistently shows that most girls prefer and take a more active role in cooperative, rather than competitive, learning activities, while males expressed a stronger preference for competitive learning and for individualized learning [22]. In addition, boys and girls have vastly different science-related experiences outside school, which contribute to the gender gap in science achievement [14]. Visits to science museums, science activities associated with scouting and enrollment in extracurricular science classes are more common among boys than girls [23].

In addition, girls generally develop a set of attitudes and beliefs that do not promote high levels of achievement and participation in science. Attitudinal factors are one of the contributing factors to the lack of women in science courses and careers. Girls' attitudes toward science, science classes, and science careers are the result of their educational experiences and activities as well as other social and cultural factors. For example, compared with boys, girls often have less confidence in their academic abilities, lower achievement expectations, less interest in challenging achievement activities, and more debilitating patterns. Studies showed that when boys and girls are paired to do science experiments, the boys might do most of the work while the girls watch. In addition, boys may volunteer and be selected for science demonstration but girls may not because of less confidence [14, 7].

Research reported that particularly in the physical sciences, the illustrations, examples, and applications presented in resource materials are more familiar in general to the experiences and interest of males than those of females. For example, there are many examples used in science that contain references to games, sports, and automobile engine based on boys' interest.

Further, the most gender-balanced associations result from the use of language which specifies both "he" and "she" rather than the gender-unspecified "they" [24].

2. IMPLICATIONS AND RECOMMENDATIONS

In the1980s, intervention programs and research studies, for example, in the U.S., Australia, and U.K. were done focusing on (a) demasculinizing and demystifying science, usually by exposure to role models and career information, (b) improving girls' self-confidence and self-perceptions of their ability to do science, (c) implementing teaching strategies that actively involved girls in science lessons, and (d) developing girls' skills of doing science [7]. For example, during the 1970s and early 1980s as many as 600 programs aimed at improving the quality and quantity of science and mathematics education for females were developed and implemented in the United States [24]. Generally, intervention programs have been fairly successful in identifying specific factors that influence girls' self-confidence and retention in science courses. However, they have been less successful in identifying specific factors that contribute to the continued and growing achievement gap between girls and boys in science.

Nowadays, we also know that in the developing world greater intervention to improve girls' self-confidence and achievement in science is taking place. All young people should be given the opportunity to be part of the pool of future scientists and technologists and to be scientifically literate citizens.

In order to improve gender equity in science education, Parker et al. [24] propose that a broad-based science course, including physics, chemistry, biology, astronomy, geology, and health, should be compulsory in the school curriculum since gender biases influence the choices made. Further, curriculum structure should allow time for young people to reflect on, and to challenge, gender stereotypes within their culture. In addition, the school curriculum should include consideration of gender stereotypes and career education aimed at breaking down these stereotypes. Curriculum development must be informed by the research evidence because gender bias can enter curriculum materials through the type of language used, the choice of examples, the background experiences, interests, the learning style implied, and the way in which the subject field is projected. In particular, it is suggested that career education materials include case studies of successful women scientists and technologists. Further, to facilitate policy implementation, education programs could be established to enable administrators, school governors, teacher educators, and teachers, first, to become aware of the ways in which gender stereotyping can cause disadvantages in scien-

ce education and, second, to develop skills to help counter gender stereotyping. For example, the study of gender and education interactions could form a component of teacher education courses at both preservice and in-service levels. It is also necessary that data on any sex differences in achievement in science and course participation at all levels of academic, professional, and vocational education should be collected systemically and published. This provides useful information for curriculum development and revision and for the design of teacher-constructed tests and formal external examinations. Where the education system employs inspectors or advisors to monitor educational practice, such persons need to be aware of gender interactions with teaching, learning, and assessment.

An understanding of the role of the teacher in contributing to sex differences in science achievement is critical. If teachers treat students differently in science classes, this differential treatment may affect the decisions the students make about their future coursework and careers. Teachers may be unaware of bias in their interactions with boys and girls and deny that it exists. Therefore, teacher evaluators and preservice educators should watch for teaching styles that reflect gender bias and assist teachers in recognizing differential student treatment. In cases where students are perpetuating sex-role stereotypes in the science classroom, the teacher can intervene and insure that girls participate equally in laboratories and other classroom activities. The underlying issue is not only educational equity but also recognition of the need for scientifically literate members of both sexes in the twenty-first century [9].

3. CONCLUSION

The encouragement (or discouragement) girls receive at home and at school, and their perception of science classes, activities, and careers as masculine, their lack of extracurricular activities and their narrow view of science all contribute to their perception of science as something relatively useless in everyday life and an unlikely future career choice [14].

The results of studies showed that males are favouring, especially in the physical science. However, issues such as why women do not select science as career or why boys perform better than girls are not yet well explained. If gender difference in science learning is to be explained and not merely described, it is necessary to consider not only manifest differences in science achievement, but differences in determinants of achievement as well.

Science educators at all levels, curriculum developers, teacher trainers, and teachers should make a special effort to relate science areas to girls' fields of interest and should challenge false stereotypes at home, in school, and in the society at large. Motivating curricula, deliberate teacher attention to girls in science and technology and success of females in science should be our immediate goals for the coming years in science education everywhere [12].

Parents and educators need to understand the importance of improving performance in science. Role models, both in and out of school, are a crucial factor in encouraging the greater involvement of girls in the sciences, thereby improving their performance in this subject. The more women assume roles of instruction and leadership in the exact sciences and conduct research in these fields, the more likely that young girls will follow in their footsteps.

In Turkey, women were under-represented for a long time because of cultural factors. Women's ideas, positions, and ways of knowing and thinking have traditionally been devalued by our society. However, this situation has been changing over time.

Unfortunately, educators, curriculum developers, academicians and teachers do not make too much special effort to increase girls' participation and achievement in science. All of these recommendation proposed by Parker et al., [24] can be easily implemented in Turkey. In order to be successful, there is need for a strong academic emphasis, financial support, strong leadership and committed teachers and reliable data showing sex difference in students' participation and achievement in science classroom.

For educators, pre-service and in-service activities should be prepared to show the importance of gender issues in the schools. In order to truly remove gender discrimination within our schools educators should examine their attitudes, beliefs and practice within their classrooms.

Teachers should examine how gender bias is found not only within curricula and instructional material they use, but also in their daily interactions with students. Effective teachers are aware of gender differences and are able to establish classrooms wherein neither gender is at an disadvantage. On the other hand, if the value and position of Turkish women in society and at home does not change, it is difficult to be successful in schools. The problem should be considered not only in schools but also in society, since children reflect values of our society. The most important message that educators can relate to their students seems to be that anyone can achieve anything in their lives, regardless of sex.

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