GENDER-BASED DIFFERENCES IN SCHOOL-AGED CHILDREN'S DIVERGENT THINKING

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Abstract. This study examines whether the shortage of females in science and engineering possible gender-based differences in school-aged children's divergent thinking. Divergent thinking is a direct measure of creativity and an important characteristic in science and engineering. A survey instrument designed to measure divergent thinking was administered to 8th and 11th graders in a mid-western United States school district. Results showed that there were no difference between girls and boys on measures of divergent thinking: fluency, flexibility, and originality. These results indicate little reason as to why participation in science and engineering is male dominated, and support the notion that additional exposure to science and engineering through divergent-thinking activities will provide girls with the self-knowledge that they are capable of solving open-ended problems and engineering tasks.

Keywords: *Divergent thinking, Gender, Creativity, Science and engineering, Wallach and Kogan Creativity Test (WKCT)*

1. INTRODUCTION

The topic of this paper the shortage of females in science and engineering is linked to possible gender-based differences in school-aged children's divergent thinking. Creativity is associated with the highest levels of achievement in many fields, and certainly this is true in science and engineering. New systems, tools, processes, and equipment are the concrete result of creative acts (Tornkvist, 1998). In science and engineering, creativity can result in new predictive theories, new materials, more efficient energy sources, and safer products. The list is endless.

Today the shortage of skilled workers in science and engineering makes it imperative that young students from all segments of our diverse society, particularly those who are currently least engaged, be attracted into these fields. During this time of significant shortage, women are underrepresented in science and engineering, and constitute a large untapped resource that has the potential to ease the urgent need for skilled.

History reflects a gender difference in significant creative accomplishments. There have been far more accomplishments, particularly at the highest level, by males in science, literature, arts, music, and technical development than females (Eysenck, 1995). Researchers have determined factors that influence creativity but the inconclusive nature of the current collection of research emphasizes the fact that more research is needed to understand gender differences in creativity.

Divergent thinking is defined as an idea-generating process wherein an individual is faced with problems or questions for which there is not just one answer (Guilford, 1950; Runco, Dow, Smith, 2006).

The majority of creativity tests divergent thinking, a key component of creativity (Clapham, 2004). Tests of divergent thinking evaluate the test taker's quality and quantity of creative ideas.

The Wallach and Kogan Creativity Test (WKCT) is one of the most widely used divergent thinking tests (Cheung, Lau, Chan, Wu, 2004). The WKCT has been in use over many decades, and researchers within the field of creativity have recognized and accept this test as generally reliable and valid. The WKCT is thought to effectively test abilities attributed to creative persons. The WKCT has been noted as cross-culturally fair in the measurement of divergent thinking because of its use of common daily objects familiar to most people.

Society has a general idea of gender differences in educational trends, work, and cognitive functioning and an awareness of variations in performance, annual salary, and general aptitudes. However, little is known about gender differences in creativity and original

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thinking. Research in these areas has developed over the years but is still fairly limited with respect to gender.

Today's homogeneous male engineering teams may no longer the increasingly diverse needs of the customers (Ihsen, 2005). The lack of diversity and the issue of women in engineering holds more and more political and economic relevance worldwide. A diverse workforce blending genders, cultures, and ages has the advantage of representing a wider customer base in order to translate customer requirements into new and useful products.

Women comprise approximately 50% of the population, yet according to Science and Engineering Indicators (2014), women held only 28% of non-academic science and engineering occupations in 2010. DeBartolo and Bailey (2007) point out that women comprise fewer than 20% of engineering majors and stress that it is essential for our nation's high-tech industries to increase the diversity of engineering graduates. As business leaders and policy-makers seek to address talent shortages, it is becoming increasingly urgent to close this gap and leverage the talents of both men and women.

2. MATERIALS AND METHODS

The survey instrument study is based on the Wallach and Kogan Creativity Test (WKCT), and examines divergent thinking characteristics in the study's participants. The general instructions for administering these tests were based upon instructions provided by Wallach and Kogan (1965).

This research questioned whether there are gender differences in the solution of creativity tasks with respect to fluency of responses, flexibility of responses, and originality of responses. Quantitative analysis there are gender differences in divergent thinking among 8th and 11th grade students. The researcher used a framework developed by Wallach and Kogan (1965) to measure divergent thinking within the sample. The instrument was comprised of three sections: uses, similarities, and instances. Each of the three sections contained three questions.

The WKCT is available in both verbal and figural components (Wallach and Kogan (1965); this research implemented the verbal questions.

Responses for each of the three sections were measured for originality (an atypical or novel response), fluency (total number of responses), and flexibility (the ease with which mindset changes).

Measures of fluency, flexibility, and originality were applied in scoring the WKCT questions. Fluency is defined as the total number of responses given by a participant to a particular item. The participant's responses were totaled, which became the participant's fluency score for a particular question.

Flexibility is the number of categories into which the responses could be grouped. As a flexibility scoring example, if a participant is asked to name things with wheels and the responses are a car, a truck, a bike, and your mind, the participant would get a flexibility score of two points. One point is awarded for the response in the category of transportation and the other point for the non-transportation response of "your mind." Originality or uniqueness can be defined as one's capacity to think independently or be inventive. Based on this definition, an answer is dubbed original as determined by the three judges. As an example, a participant may all the ways in which an orange can be used. A rare response like "as ammo for a slingshot or catapult" would receive a higher originality score than a common response like "to eat." Again, an average of the judges' scores was calculated to obtain the participant's originality score.

Multiple judges were selected from various backgrounds, and their individual scores were averaged to reduce subjectivity and increase validity. Each of the three judges went through the same scoring process: the three scores were averaged to become the participant's flexibility score for that question.

The population for this study was 8th and 11th grade students from middle and high school classrooms within a mid-western United States school district. The average age of the 8th grade students who participated was 14.17 years and the average age of the 11th grade students was 16.92 years. (See Table 1.)

Table 1. *Gender and Grade Level of Participants*

	Male	Female
Grade 8	34	11
Grade 11	42	79
Total	77	90

3. RESULTS

Results were presented in two categories: The first was ANOVA (analysis of variance) and the second was mean scores.

Three one-way ANOVAs were computed to answer the research question "are there gender differences in fluency of responses, flexibility of responses, or originality of responses?" No gender differences these three measures: Between-subjects effects of fluency and gender, between-subjects effects of gender and flexibility, and between-subjects effects of gender and originality.

To further analyze the research question, separate ANOVAs were run based on the fluency, flexibility, and originality scores in each of the three sections of the survey (uses, similarities and instances). There were no significant relationships in the average scores between gender and fluency in the uses section, the similarities section, or the instances section of the survey.

The same procedure was used for flexibility scores. Three separate ANOVAs were computed for flexibility in each of the three survey sections (uses, similarities and instances). There were no significant relationships in the average flexibility scores between gender and flexibility in the uses section, the similarities section or the instances section of the survey.

Originality scores were also broken down into the three survey sections (uses, similarities, and instances) and ANOVAs computed. Again, there were no significant relationships in the average originality scores between gender and originality in the uses section, the similarities section, or the instances section.

Further analyses were conducted to determine if individual survey questions revealed a relationship between gender and fluency, flexibility, and originality scores. Separate ANOVAs were computed based on the fluency, flexibility, and originality of individual questions to test the effect of gender. After running separate ANOVAs for fluency of each question, results showed there is a relationship between gender and fluency on the question "name all the uses you can think of for an orange." The females had a higher mean score (7.2556) than did the males (6.2468). The analyses determined that there were no effects between flexibility of a particular question and gender.

ANOVAs were conducted for originality scores for each survey question to determine if a relationship exists between originality on an individual question and gender. The analyses revealed a relationship between originality and gender for the question "uses of a brick," for which males provided more original responses than females.

The remainder of this section presents the second category of findings: mean scores. Mean scores were calculated for each of the survey's measures (fluency, flexibility, and originality), and those measures were further broken down by each of the survey's sections (uses, similarities, and instances). Overall survey scores, when broken down by grade level and gender, showed that fluency and flexibility increased from 8th grade to 11th grade for both males and females, while the mean originality score in 11th grade students was less than that of 8th grade students. Fluency is higher among 8th grade females than 8th grade males; this is reversed in the 11th grade, where males are more fluent than females.

To further describe the data, fluency has been broken down by the three survey sections (uses, similarities, and instances). In the uses category, both males and females increased their fluency from 8th to 11th grade. Males showed a larger increase (7.20 to 8.46) than females (8.00 to 8.33). Males in 11th grade scored higher than females, whereas for 8th grade the opposite is true, so females scored higher than males. Overall in the similarities category, females (5.97 to 6.00) scored higher than males (5.18 to 5.70). Eighth grade females (5.97) had a higher mean score than 11th grade males (5.7). In the instances category for there is little difference in the mean score between 8th grade females (10.61) and males (10.67). The same is true for the 11th grade females (10.54) and males (10.70).

Flexibility has also been broken down by the three survey sections (uses, similarities, and instances). Flexibility scores in the uses section reported that 8th grade females (2.85) had a higher mean score than did 8th grade males (2.63); the opposite was true for 11th graders. In the similarities section, the flexibility scores were slightly higher among females at the 11th grade level than females at the 8th grade level. The instances section showed very little difference between 11th grade females (2.85) and 11th grade males (2.86); whereas in the 8th grade, females (2.96) scored higher than 8th grade males (2.72).

Originality has also been broken down according to the three survey sections (uses, similarities, and instances). Originality scores in the uses section recorded 8th grade females

(2.53) had a higher mean score than 8th grade males (2.16), where the opposite was true in 11th grade when males (2.19) had a higher mean score than females (2.01). In the similarities section, 8th grade females (2.25) scored higher than did 8th grade males (1.93). The 11th grade originality scores in the similarities section reflected only a small difference between male (1.90) and female (1.86) mean scores. In the instances section, 8th grade females (2.40) scored higher than 8th grade males (2.27); there was little difference between males (2.04) and females (2.03) in the 11th grade.

4. DISCUSSIONS

Students in 8th and 11th grade from a mid-western school district were surveyed to examine whether the shortage of females in science and engineering is linked to possible gender-based differences in school-aged children's divergent thinking.

Based on the results of this research, the most important finding of this study is that there is no difference between girls and boys on the three measures of divergent thinking (fluency, flexibility, and originality).

Studies of gender and divergent thinking have provided mixed results. Klausmeier and Wiersma (1964) found gender to be of major influence on divergent thinking tests. The results of their research on 320 fifth and sixth graders showed that the mean divergent thinking test scores for girls were higher than for boys. Reese et all. (2001) found negligible results in establishing a connection between gender and divergent thinking after studying 400 adults ranging in age from 17 and older. Thomas and Berk (1981) that gender differences were predictive in their study on the effects of school environment on the development of creativity.

This paper's findings contradict Klausmeier and Wiersma (1964) study of 320 fifth and seventh graders of high IQ that revealed girls generally scored higher on tests of divergent thinking. Dudek et all. (1993) tested 1,445 children from grades 5 and 6, using the Torrance Tests of Creative Thinking (TTCT) in agreement with Klausmeier and Wiersma's findings; girls in general scored higher than males on tests of divergent thinking. Another study in Hong Kong that used the WKCT found that boys had higher fluency scores (Chan et all., 2000-2001). Overall, Linn and Hyde (1989) may have been correct in stating that gender differences are not general but specific to situational and cultural frameworks.

It is important to note that the accuracy of measurements of creativity and the divergent thinking process, even after years of research, is still open to differing opinions. The tests reviewed above are still scrutinized. Many critics propose that these tests have nothing in place to account for the many factors that cause variation within a person's creative production, nor for the variation within and between tests of creativity. They also question whether domain-specific questions impact the measurement of creativity (Brown, 1990).

5. CONCLUSIONS

The major finding that came forth from this body of research is that there are no gender differences in divergent thinking. These results indicate little reason as to why participation in science and engineering is male dominated. It should be of key concern for science and engineering educators to continue to focus professional development and curriculum on attracting all potential talent. As educators become more informed as to the diverse jobs of today's scientists and engineers they will be better equipped to develop engaging curriculum.

In view of the fact that women are less likely than men to enroll in engineering related courses, this finding supports the notion that additional exposure to science and engineering through divergent-thinking activities will provide girls with the self-knowledge that they are capable of solving open-ended problems and engineering tasks.

In addition to providing more opportunities in order to attract a more diverse population, it would be beneficial for science and engineering curriculum to stress non-technical competencies, such as creativity skills and communication skills (Linn and Hyde (1989).

Stereotypes that girls do not have the divergent thinking skills required in science and engineering professions are not supported by the findings in this paper. During a visit with my high school guidance I was informed about a trip to the local cosmetology school for all the girls. This gender-based stereotype led some of my girlfriends to select cosmetology training without hearing other options. The good thing is they got an education. The bad thing is that stereotypes set their course for life. Educators, guidance counselors and principals must know that creativity (divergent thinking) is not gender specific, and should not set artificial limits to girl's opportunities as future scientists and engineers.

Conflict of interests

Author declares no conflict of interest.

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