Use of Humour to Diminish the Gender Gap of Women in STEM Careers

Susana Alicia Alaniz-Alvarez, Senior Researcher, Angel Francisco Nieto-Samaniego, Senior Researcher and Yuria Cruz-Alaniz, Postdoctoral Fellow, National Autonomous University of Mexico

Abstract

In the elementary education curriculum, the concepts of mass, weight, gravity, velocity, and acceleration are taught in the 5th and 6th grades, around the ages that girls are entering puberty and roughly one or two years earlier than boys enter puberty. Empirical evidence shows that few women choose to study for careers in Science, Technology, Engineering, and Mathematics (STEM) fields. We hypothesize that few women opt to pursue a STEM career because they had less capacity or interest to retain basic science concepts during puberty compared to boys. To study this, we showed a video featuring a specific science topic to 92 classrooms for 5th and 6th graders at 17 public schools in Mexico (N = 1175). The instructional strategy was a 30-minute video about "the continental drift."[1] Immediately after viewing the video, 585 girls and 590 boys answered a multiple-choice questionnaire with 22 questions directly related to the video. We used a binary logistic regression analysis. The answer to each question was considered a dichotomous variable (correct or incorrect) and the dichotomous predictor variable was the gender. The model predicted that the odds of correctly answering the questions on a retention test are slightly higher for girls than they are for boys. The odds ratio considering equal or more than 50% of correct answer per group favoured to girls are: for global score .846 (p=.167, 95% CI .667-1.072), for definitions .815 (p=.092; 95% CI .643-1.034), for classification of intensive or extensive properties .847 (p=.22; 95% CI .649-1.105), and for physical explanation of daily phenomena .967 (p=.778; 95% CI .760-1.231), while in distinguishing scientific evidence the odds ratio favoured boys with a ratio of 1.091 (p=.471; 95% CI .474-1.091). The overall odds ratios obtained indicate that the effect of gender is very weak and does not support our hypothesis that girls in puberty are not interested in science topics. Curiously, the only statistically significant results were for questions that involved humour in the explanation.

We also analysed the responses to 4 questions related to two new concepts introduced to students. Density was explained in the video without humour, while viscosity was explained with humour. In these cases, the model predictors are gender, age, grade and federal or state schools. The model predicts that humour increases the effect of gender substantially and could elevate the confidence of girls to learn STEM topics.

Introduction

Many studies find men outperform women in Science, Technology, Engineering and Mathematics (STEM) disciplines (Larivière et al. 2013; Elsevier, 2017). Halpern et al. (2007) reviewed these previous studies to explain the possible reasons that women are less interested in STEM careers.

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[1] (https://www.youtube.com/watch?v=khDWDRbLSYsandt=942s)

They classify the arguments as follows: early experiences (misconceptions); biological constraints, including effects of brain organization, evolutionary pressures (e.g., Hatemi, et al. 2009), or hormone differences (e.g., Finegan et al. 1992); educational (school) policy; gender stereotypes and cultural (family) context. Even recently, there have been many studies to propose strategies to reduce the gender gap in science (e.g., Miyake et al. 2010). Many of these studies have focused on instructional methods that are inconclusive as causes of the gender gap in choosing STEM careers. Simon et al. (2017) proposed that the origin of the gender gap can be found in the motivation of girls to choose a STEM career in college. In developing countries, the data is dramatic. For example, admissions to the National Autonomous University of Mexico in 2015 show that women only made up 22.5% of applicants to the Mathematics department, 22% of applicants to the Physics department, and only 14.72% to the Engineering department (UNAM 2017).

Here, we report a large-scale classroom study that tested the effectiveness of a video with humour to increase short-term retention of scientific concepts. With humour, we consider the communication of multiple, incongruous meanings that are amusing in some manner (Martin 2007). This video tutorial is useful as a didactical tool and is a complementary strategy in science class.

At the end of elementary school, the basic concepts of STEM classes are challenging. During those years, girls are at the onset of puberty, while boys are not. Thus, we hypothesize that girls pay less attention to those concepts because of the overall changes in their bodies, including constant changes in mood. It is well known that the physical and psychological changes during puberty and adolescence generate many disturbances in mood (Kessler 2001). Smith (2013) documented that anxiety affects cognition during the onset of puberty. Smith argues that during puberty, anxiety affects how the brain learns. Blakemore and Choudhury (2006) proposed that during puberty, there is a period of synaptic reorganization during which the environment plays a major role in learning.

Marshall and Tanner (1969 and 1970) documented physical changes during puberty and found that the age of the onset of puberty varies between ages 9 to 11 in girls, and they usually start puberty one or two years earlier than boys. Parent et al. (2003) document changes in the age of the onset of puberty around the world; in Venezuela, the age at the start of breast development is 10.4 years (they do not report cases of Mexico).

According to the international school programmes, during the 5th and 6th grade (between ages 9 and 11), students are taught most of the basic science concepts such as mass, weight, volume, gravity, longitude and time, velocity and acceleration, etc. that are relevant for later STEM careers. Euling et al. (2008) document that for Mexican-American girls, the mean age of breast development (as a characteristic precursor of puberty) was 9.8 years old (with a confidence interval of 9.4 to 9.9), and pubic hair initiates at approximately 10.3 years old (with a confidence interval of 10.1 to 10.6). That means that at the end of elementary school, girls are in puberty, although boys are not. We can potentially identify a problem in girls' capacity to learn science concepts if we assume that learning is diminished because of the early onset of puberty and the high levels of anxiety that come with it.

The general question is whether girls are less interested in basic science concepts than boys, and we hypothesize that girls have less interest in retaining basic science concepts during puberty compared to non-pubescent boys of the same grade (or age).

Sample

A total of 1.175 Mexican students participated in this study, 590 boys (M=10.36 years, SD=.64) and 585 girls (M=10.38, SD=.62). All of them are in the 5th (47.6%) and 6th (52.3%) grades from 92 different classrooms in 17 public elementary schools in central Mexico. We choose these grades because many of the basic concepts related to space (length, area, and volume), time (velocity, acceleration), and geography (plate tectonics) are in the scholars programme. The children in the study are all a part of the same general scholars programme, they are all between 9 and 12 years old and attend urban public schools within the same geographic region (Guanajuato state), and they all receive the same instruction.

Methodology

A 30-minute video about a scientific topic was shown to a class. After the video, the students answered 22 multiple choice questions about four activities of research: definitions, classification, physical explanation of daily life and natural phenomena, and evidence recognition. All the correct answers to the questions were shown and mentioned in the video.

We used a binary logistic regression to analyse the results. The answer for each item was considered a dichotomous variable (correct or incorrect) and the dichotomous predictor variable was the gender.

Instruction procedure

Participating schools were selected through an agreement with the National Autonomous University of México and the Ministry of Education of Guanajuato. The instructional strategy was a 30-minute video about the "continental drift."[2] The video was produced by the Mexican Academy of Science and the Coordination of Scientific Research at the University of Mexico. It lasts 30 minutes and covers five themes that are essential to understanding how the continents move: Evidence of Pangea, Density, Viscosity, Isostasy and Heat transfer. None of these topics are included in the 5th or 6th-grade curriculum. The concept of viscosity was introduced with humour (in the sense proposed by Martin, 2007; McGraw and Warren, 2010) where a serious scientific concept is taught using an unusual method, including with informal definitions, jokes and comic jabs in a party competition. On the other hand, the density concept is explained with the traditional method using measures, diagrams and the formal definition.

Retention questionnaire

The questionnaire, consisting of 22 questions, was divided into four categories with four to eight questions each. It was designed to assess student perceptions of science activities: definitions (mass, weight, density, and viscosity), classification in extrinsic or intrinsic properties, physical examples of everyday life and natural phenomena, and evidence recognition. It is a multiple-choice test. Each item has four choices. Five researchers review the questionnaire to be content valid based on the information provided by the video "continental drift." Reliability was determined by the Cronbach´s Alpha procedure. A reliability coefficient of □=.803 was obtained using the post-test score.

Results

A binary logistic regression analysis was used to determine whether boys and girls showed differences in short-term retention after seeing the "continental drift" video. The answer for each item was considered a dichotomous variable (correct or incorrect) and the dichotomous predictor variable was the gender, age, grade, and state or federal school administration. All analyses were conducted using IBM SPSS Statistic v. 19.

The odds ratio of each question indicates no significant difference in student achievement by gender, but most of the odds ratios favoured girls (Figure 1). For example, question 11 has a

[2] The video is available on YouTube: (https://www.youtube.com/watch?v=khDWDRbLSYsandt=942s).

+1.3, meaning that the model predicts that the odds of obtaining a correct answer are 1.3 times higher for girls than for boys. The negative values mean that boys outperformed girls. A1 means there aren't any differences between boys and girls. The results show that pubescent girls outperform non-pubescent boys. The margin of this difference is small and contrary to our hypothesis -pubescent girls do pay attention to scientific issues.

We wonder in what situation is the gender difference significant? We analysed the results with two approximations: one for each research activity and one with two modes of teaching, including explanations with and without humour.

Figure 1 shows the odds ratio per question per group: definitions (in green), classification (in yellow), explanations of everyday phenomena (in orange) and evidence recognition (in blue). The last one is the only group in which boys outperform girls; however, the differences are not significant. The odds ratio to getting correct more than the 50% of the questions related to definitions is .815 (p=.092; 95% CI .643-1.034), for classification of intensive or extensive properties is .847 (p=.22; 95% CI .649-1.105), and for physical explanation of daily phenomena is .967 (p=.778; 95% CI .760-1.231), while in distinguished scientific evidence the odds ratio favoured boys with an odds ratio of 1.091 (p=.471; 95% CI .474-1.091). For the global score is .846 (p=.167, 95% CI .667-1.072).

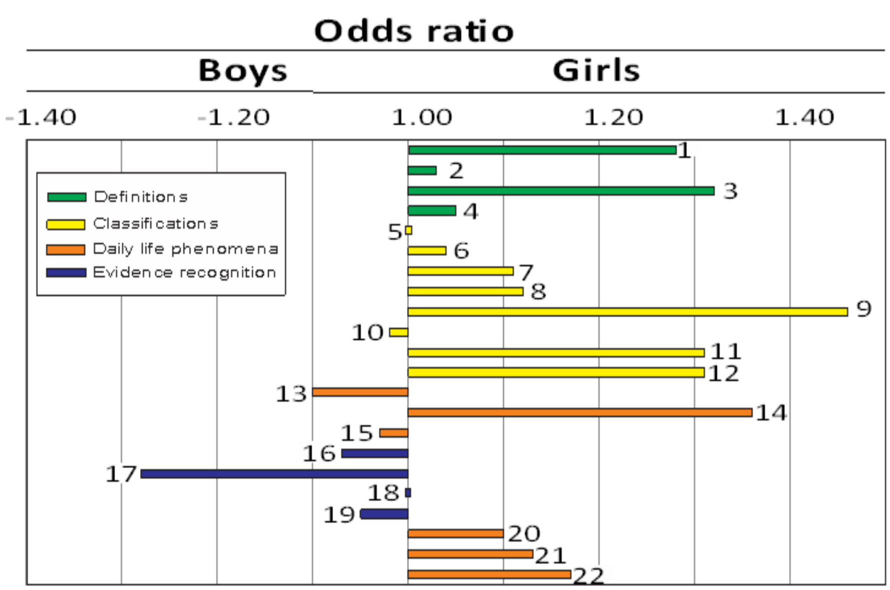

Figure 1. The odds ratio between girls and boys for each item and for each category of activity of research: definition, classification, examples in the daily life and in nature phenomena, and evidence recognition. The statistically significant differences (p< .05) between girls and boys were in questions 1,3,9,11,12 and 14. The odds ratios less than one were inverted to use the same scale in the graph.

The humour effect in the video tutorial "continental drift" leads us to explore two different kinds of teaching. The viscosity concept was explained using jokes and humour, while the density concept was explained with measures, diagrams, and formulas. Considering that there are positive effects in this change of humour, we propose an additional hypothesis: The humour contained in the explanation of viscosity and density concepts could show us if the humour captures the attention of pubescent girls more than in non-pubescent boys.

We calculate the odds ratios by items related to density and to viscosity (Tables 1 and 2). In both cases, there are questions about the definitions of density (3) and viscosity (4), and about classification, whether density and viscosity are intensive or extensive property (10 and 12, respectively). Examples of everyday life, whit the question which ingredient is denser (13), and which ingredient is most viscous (item 14). Whether the concept could be applicable in nature the question of density which layer of the earth is denser (15), and for viscosity, the question is about the plastic layer (with low viscosity) where the continents move.

Table 1 is the model obtained with the responses of the students regarding the density items. It predicts the odds of a student getting more than 50% of the answers correct. Employing a 0.05 criterion of statistical significance, the grade had significant effects. That means that when holding all other variables constant, a 6th-grade student is two times more likely to obtain more than 50% of the answers correct than a 5th grader. In this model neither sex, age, nor school administration (Federal or from the Guanajuato State) had a significant effect.

Table 1. Logistic regression predicting retention of the density topic.

Predictor	B	S.E.	Wald χ^2	df	p	Exp (B)
Gender	.018	.126	.020	1	.888	.754
Age	-.121	.156	6.606	1	.436	.886
Grade	.712	.198	12.940	1	.000	2.038
Fed/State school	.133	.126	1.119	1	.290	1.143
Constant	-3.258	1.05	9.600	1	.002	.038

Gender: Girls coded 0, boys 1; Grade: 5th coded 0, 6th 1, State school coded 0, Federal school 1.

Table 2 is the model obtained with the responses of the students about viscosity items. It predicts the odds of a student getting more than 50% of the answers correct. Sex had significant effects, employing a 0.05 criterion of statistical significance. The odds ratio here is much more favourable to girls, which was .718; inverting this odds ratio for easier interpretation, girls are 1.39 times more likely to answer more than 50% of the questions correct compared to boys. In this model, neither age, nor grade, nor school administration had any effect.

Table 2. Logistic regression predicting retention of the viscosity topic.

Predictor	B	S.E.	Wald χ^2	df	p	Exp (B)
Gender	-.332	.142	5.487	1	.019	.719
Age	.264	.153	2.974	1	.085	1.302
Grade	.217	.184	1.397	1	.237	1.243
Federal/State school	-.184	.141	1.693	1	.193	.832
Constant	-2.551	1.142	4.994	1	.025	.078

Gender: Girls coded 0, boys 1; Grade: 5th coded 0, 6th 1, State school coded 0, Federal school 1.

DISCUSSION

Many studies document that stress during puberty diminishes the learning capacity in both sexes (Hodes and Shor 2005; Blakemore and Choudhury 2006), while studies about learning with positive influences (amusement, joy, cheer) are very few or non-existent. Beller and Gafni (1996) documented the achievements of girls and boys, ages 9 to 13 years old, in science and found that boys outperform girls. They use the effect size in a random sample of more than 3,000 students from 14 countries for 9-year-olds and 20 countries for 13-year-olds. The gender differences were obtained on standardized tests from the second International Assessment of Education Progress. In these cases, humour was not used in either the instruction or the test. Our results for students between the ages of 9 and 12, in the case of the concept of density taught with a similar traditional teaching method (without humour), were consistent with Hodes and Shor's (2005) conclusion that boys outperform girls slightly in science. In contrast, in the case of viscosity, which had been taught with humour, girls outperformed boys significantly. These results strongly suggest that the use of the humour in the instruction improved girls' retention in science topics at the end of their elementary education.

Kjærnsli and Lie (2011) used the Programme for International Student Assessment (PISA) of 2006 to analyse 15-year-old students' considerations of studying for a scientific career. Some of their main conclusions were that if they felt prepared in science or able to master science topics were considered more important factors than the student's level of competency in science.

We propose that if we can add humour to teaching the basic scientific concepts at the end of elementary education, it is possible that pubescent-girls will outperform boys and thus they will improve their self-confidence in science in the future when they have to choose a career.

CONCLUSIONS

- We cannot prove the hypothesis that pubescent girls are less interested than boys in scientific issues. In contrast, we find that with this video, pubescent girls can retain scientific topics better than boys.

- The girls are less interested than boys when the explanations include diagrams and measurements, i.e., when the teaching method is traditional (without humour).
- We suggest that instruction with humour could improve girls' achievement and thus reduce the gender gap in the STEM fields.

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REFERENCES

Beller, Michal, and Naomi Gafni. "International Assessment of Educational Progress in Mathematics and Sciences: The gender differences perspective." *Journal of Educational Psychology* 88, no.2 (1991 and 1996): 365-377.

Blakemore, Sarah-Jayne, and Suparna Choudhury. "Development of the adolescent brain: implications for executive function and social cognition." *Journal of Child Psychology and Psychiatry* 47, no. 3-4 (2006): 296-312.

Elsevier. "Gender in the Global Research Landscape." *Eleviser,* 2017. https://www.elsevier.com/__data/assets/pdf_file/0008/265661/ElsevierGenderReport_final_for-web.pdf).

Euling, Susan Y., Sherry. G. Selevan, Ora Hirsch Pescovitz, and Niels E. Skakkebaek. "Role of environmental factors in the timing of puberty." *Pediatrics* 121 (2008): S167-S171.

Finegan, Jo-Anne K., G. Allison Niccols, and Gabriel Sitarenios. "Relations between prenatal testosterone levels and cognitive abilities at 4 years." *Developmental Psychology* 28 (1992): 1075–1089.

Halpern, Diane F., Camila P. Benbow, David C. Geary, Ruben C. Gur, Janet Shibley Hyde, and Morton Ann Gernsbacher. "The science of sex differences in science and mathematics." *Psychological Science in the Public Interest* 8, no. 1 (2007): 1-51.

Hodes, Georgia E., and Tracey J. Shors. "Distinctive stress effects on learning during puberty." *Hormones and Behavior* 48, no. 2 (2005): 163-171.

Larivière, Vincent, Chaoqun Ni, Yves Gingras, Blaise Cronin, and Cassidy R. Sugimoto. "Supplementary Information to Global gender disparities in science." Nature 504, no.7479(2013): 211-213.

Marit Kjærnsli, and Svein Lie. "Students' preference for science careers: International comparisons based on PISA 2006." *International Journal of Science Education* 33, no. 1 (2011): 121-144.

Martin, Rod A. *The psychology of humor: An integrative approach*. Oxford: Elsevier Academic Press, 2007.

Marshall, W. A., and Tanner, J. M. "Variations in pattern of pubertal changes in girls." *Archives of Disease in Childhood* 44, no. 235 (1969): 291-303.

Marshall, W. A., and Tanner, J. M. "Variations in the pattern of pubertal changes in boys."*Archives of Disease in Childhood* 45*,* no. 239 (1970): 13-23.

McGraw, A. Peter, and Caleb Warren. "Benign violations: Making immoral behavior funny." *Psychological Science* 21, no.8 (2010) : 1141-1149.

Miyake, Akira, Lauren E. Kost-Smith, Noah D. Finkelstein, Steven J. Pollock, Geoffrey L. Cohen, and Tiffany A. Ito. "Reducing the gender achievement gap in college science: A classroom study of values affirmation." *Science* 330, no. 6008 (2010): 1234-1237.

Parent, Anne-Simone, Grete Teilmann, Anders Juul, Niels E. Skakkebaek, Jorma Toppari, and Jean-Pierre Bourguignon. "The timing of normal puberty and the age limits of sexual precocity: variations around the world, secular trends, and changes after migration." Endocrine reviews 24, no. 5(2003): 668-693.

Ronald C. Kessler, Shelli Avenevoli, and Kathleen Ries Merikangas. "Mood disorders in children and adolescents: an epidemiologic perspective." Biological Psychiatry 49, no. 12 (2001): 1002-1014.

Simon, Richard. M., Ashley Wagner, and Brooke Killion. "Gender and choosing a STEM major in college: Femininity, masculinity, chilly climate, and occupational values."*Journal of Research in Science Teaching* 54, no. 3 (2016): 299-323.

Smith, Sheryl. S. "The influence of stress at puberty on mood and learning: Role of the α 4 βδ GABA A receptor." *Neuroscience* 249 (2013): 192-213.

UNAM. "National Autonomous University of Mexico, Portal de Estadística Universitaria." http://www.estadistica.unam.mx/perfiles/.