***Gender Differences in Retention of Information Shown in Science Video to Adolescents from Mexico***

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**ABSTRACT**

In this paper, adolescent gender differences in the interest in a non-fictional video about continental drift are presented. The study was based on students from 7th to 9th grade, from secondary public schools. A binary logistic regression model was used to compare how much information adolescents could retain immediately after seeing the video (hereinafter referred to as short-term retention), and 2-4 weeks later (hereinafter referred to as medium-term retention). This information is compared to results from international assessment tests. Our results show that girls perform significantly better in the short-term retention than boys in 7th grade (during the entry to puberty of boys), but performed equal to boys in 9th grade. Boys were observed not to have been paying attention when showing the video, which is reflected in their short-term retention results, yet significantly outperformed girls in the middle-term retention questionnaire in both 7th and 9th grade. The only significant difference between boys and girls is that boys retain better in the middle term, while girls retain better in the short-term.

**INTRODUCTION**

Are girls less interested in Science-Technology-Engineering-Mathematics (STEM) fields? In the case of the leading university in Mexico (UNAM: Universidad Nacional Autónoma de México), less than 25 % of women choose to study STEM careers (Engineering and Physics), however almost the same percentage of women (52%) and men (48%) gain admission to the university (UNAM, 2017).

Many studies try to answer why women are less interested than men in STEM fields; some of them look at whether this interest begins when they are young. Studies based on international assessment tests document that boys perform better than girls in science during the adolescent years. For example, Beller and Gafni (1996) documented gender performance of 9- and 13-year-olds on science exam results in the 1991 International Assessment of Educational Progress. A gender size effect was calculated from students of 9 and 13 years old across seven selected countries. Boys outperformed girls; the size effect was 0.16 (variance ratio 1.14, the variance of boys was 14% larger than that among girls) for 9-years-old and 0.26 (variant ratio 1.09) for 13-year-olds. Driessen and van Langen (2013) studied the gender differences in primary and secondary education in Dutch students in the past ten to fifteen

years. In cognitive competencies, from various international achievement tests, they found that the effect size is small, boys perform better in mathematics, world studies and English language, and girls dominate Dutch language and reading. They cited the 2006 Programme for International Student Assessment (PISA) measurement where the effect size for gender differences in science was 0.08 for 15-year-olds. They concluded that boys do better than girls in mathematics and science. Additionally, the 2015 PISA results, applied to 15-year-old Mexican students, showed that boys perform better in science than girls; in low-achieving students, the differences are not significant, with an average difference of 8 points, but among the highest-achieving students the differences are larger, with 20 points.

The adolescent time is relevant because, according to Kjærnsli and Lie (2011), one of the most important factors that lead to studying science at a higher educational level is the confidence in their intellectual abilities to understand science. This confidence in science can be reached during adolescence because, according to Blakemore and Choudhury (2006), the pick of synaptic density occurred during puberty and followed the elimination of infrequently used connections. Adolescents in this period decide what information supplied by their education will be retained. Girls usually begin puberty during 5$^{th}$ grade and boys during 7th grade, which means that for boys, many changes start to happen to them, psychologically and physiologically, two years after girls in secondary education.

In this study, we show a closer view of the beginning of the process to learn science in secondary education, with an original video. The lesson contains a scientific topic and many concepts novel for students, and we focus on short-and medium retention of the information provided (which most students see for the first time) after seeing the video. At this stage, we explore if boys (that are entering puberty at this grade), perform better than girls (that entered puberty one or two years before) and if the top performers are mainly boys.

**HYPOTHESIS**

- In secondary education, male students retain novel science concepts provided by an audiovisual instruction better than female adolescent students of the same grade.
- At higher test score levels, boys have better retention than girls.
- Boys and girls have different medium-term retention of information.

## METHODOLOGY

A "novel science instruction" was given through a scientific video about the movement of continents. The video "Continental Drift" was shown to groups of 5th to 9th graders; the students answered a questionnaire just before seeing the video. The retention of the information was calculated with the answers of the students the same day after seeing the video (short-term retention), and the medium-term retention with the responses from 2 to 4 weeks after seeing the video.

### *Instruction*

The instruction consisted of a 30-minutes video titled "Continental Drift" (https://www.youtube.com/watch?v=khDWDRbLSYs). The topic of how the continents move was chosen because the Plate tectonics theory that explained how the continents (plates) could move changed the way we understand the dynamics of the Earth (USG, 2018). Alfred Wegener proposed a century ago, the existence of Pangea, a supercontinent that assembled all the continents that existed 200-250 million years ago (Wegener, 1915), and since then, the continents move apart. The continental drift, as a part of Plate tectonics, was accepted as scientific theory 50 years after the Wegener publication, at the end of the 1960´s decade (Oreskes, 1999), when Dietz (1961) documented that the spreading of the ocean floor generates new ocean crust, and Tuzo Wilson proposed that the transform faults, which were discovered on the ocean floor, are directly related to the continental drift (Wilson, 1965).

The continental drift is barely taught in the school curriculums (SEP 2011). Thus, we used the explanation of this physical phenomena to englobe some concepts of Physic that are confused to students of secondary schools, especially the difference between mass and weight (Galili and Kaplan, 1996; Gönen, 2008, Taibu, Rudge and Schuster 2015; Bar, Brosh and Sneider, 2016), density and viscosity (Mastropieri, *et al.* 2001), buoyancy and sinking (Joung, 2009; Taşdere, and Ercan, 2011), heat and temperature (Sözbilir, 2003), and intensive and extensive properties of the matter (Krnel, Watson and Glažar 2005).

Half of the students saw the video in the auditorium of our research centre during their visit in the "Week of the Earth fair"; the other half saw the video in their classrooms during regular classes' periods.

***Retention test***

The pre- and posttest were identical, consisting of 22 items directly related to the video. Each item was a four-choice and weighted equally, providing a minimum achievement score of zero and a maximum score of 22. Five researchers of the University were asked to review the validity content of the video and test, the precision of the information provided in the video "Continental drift" and the pertinence of the questions in the test. The reliability of the test was determined by Cronbach´s Alpha procedure as 0.80. The questionnaire was piloted with 90 children in 6th grade under similar conditions. The questionnaire was modified, adding items related to daily life examples and simplifying the language of the questions to minimise the resistance of students having to answer a questionnaire that is not part of their regular curriculum.

***Participants***

Our sample consists of 1368 students (51% girls, 49% boys) from secondary public schools (Figure 1), 1172 were from schools in Querétaro, 99 from Zacatecas and 97 from Estado de México. 55 % of them were in the 7th grade, 16 % in 8th grade and 26.3 % in 9th grade. Ages varied from 11 to 18 years old (M = 13,6, SD =1,26). From these students, 407 7th graders and 35 of 9th graders answered the same questionnaire 2 to 4 weeks later.

Sample

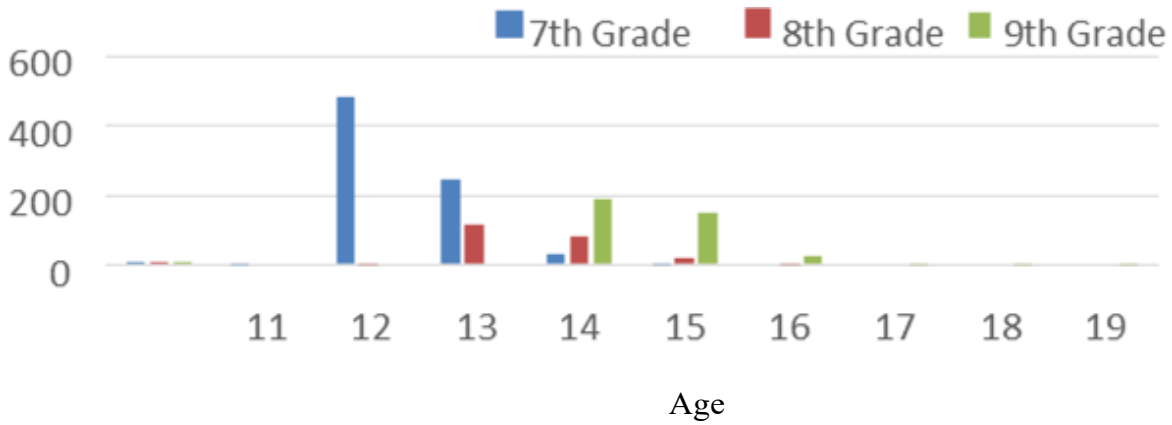


*Figure 1*. The graph shows the sample by age and grade

We chose our population from secondary school because students are admitted in 7th grade at the age of 11; when boys enter puberty and girls entered almost two years before, in elementary school. The ages of the entrance to puberty were obtained from Mexican-

American data because, as far as we know, there are no published data about the age of Mexican pubescent-population. Sun et al. (2002) consider that the mean age of the onset of puberty is when 50% of the children entered a Tanner stage 2 (see Marsahll and Tanner, 1969; Marshall and Tanner 1970). Euling et al. (2008) report that Mexican-American girls´ onset of puberty is around 9.8 years old (with a confidence interval of 9.4 to 9.9) and a median age of 9.4-10.4 years old according to Sun *et al*. (2002). The mean age of the onset of puberty in boys occurs between 10.3 years old (stage 1 to stage 2 of genitalia development) and 12.3 years (stage 1 to 2 when pubic hair appears).

***Statistical Analysis***

All analysis was conducted using IBM SPSS Statistics 19. The statistical analysis was done using binary logistic regression to predict a binary response based on one or more independent variables. We labelled "0" for an incorrect answer and "1" for a correct answer; "0" for girls and "1" for boys.

**RESULTS**

First, we analyse the scores acquired by students of 7$^{th}$ to 9$^{th}$ grades comparing the pretest (PreScore) with the posttest (PostScore) (Table 1). Later, we made a model using the binary logistic regression considering grade, sex, and age as variables. Then we analysed by grade but only with the sex variable to see if there is a gender difference in the short-term retention, and finally, we checked to see if there was a gender difference between the short (PostScore)- and medium term-retention (MPostScore) (Table 1).

*Table 1*. Basic statistics between boys and girls form 7$^{th}$, 8$^{th}$ and 9$^{th}$ grades

| Sex | PreScore M (SD) | PostScore M (SD) | Follow-up (2-4 weeks later) M (SD) |
|---|---|---|---|
| Girls | 47,81 (16,32) | 56,06 (17,11) | 56,23 (14,6) |
| N | 705 | 705 | 218 |
| Boys | 48,22 (16,97) | 54,62 (17,83) | 56,97 (16,03) |
| N | 663 | 663 | 225 |
| Total | 48,01 (16,63) | 55,36 (17,47) | 56,61 (15,35) |
| N | 1368 | 1368 | 443 |

*Table 2.* Logistic regression predicting >70% answers correct

| Short-retention (Postscore) | | | | | |
|---|---|---|---|---|---|
| Grade | Predictor | B | Wald $x^2$ | p | Odds ratio Exp(B) |
| 7th | Sex | -,662 | 8,381 | ,004 | ,516 |
| | Constant | ,138 | 142,655 | ,000 | ,193 |
| 9th | Sex | ,070 | ,087 | ,768 | 1,072 |
| | Constant | -,452 | 37,508 | ,000 | ,367 |
| Medium-retention (Mpostscore), | | | | | |
| Grade | Predictor | B | Wald $x^2$ | p | Odds ratio Exp(B) |
| 7th | Sex | ,092 | ,101 | ,750 | 1,096 |
| | Constant | -1,884 | 80,069 | ,000 | ,152 |
| 9th | Sex | 1,240 | 2,933 | ,087 | 3,457 |
| | Constant | -0,452 | ,874 | ,35 | ,636 |

A comparison of students´ short retention (Table 2) shows a significant difference between pretest and posttest scores (before and after seeing the video), $t_{1, 1368}$=7,34, p=,000. Also, we calculated the Hake gain "g"= (Posttest-score – Pretest-score)/100- Pretest-score). According to Hake (1998), a low gain is <0,29, a medium gain between 0,3-0,69 and high gain >0,7. We consider that in our case, a g>=0,3 g is very satisfactory considering the video lasts only 30 minutes and the questionnaire contains many aspects that were not taught in school. In the short term, 32% of the students reach more than 0,3 of gain. Students of 14 years old have the highest "g".

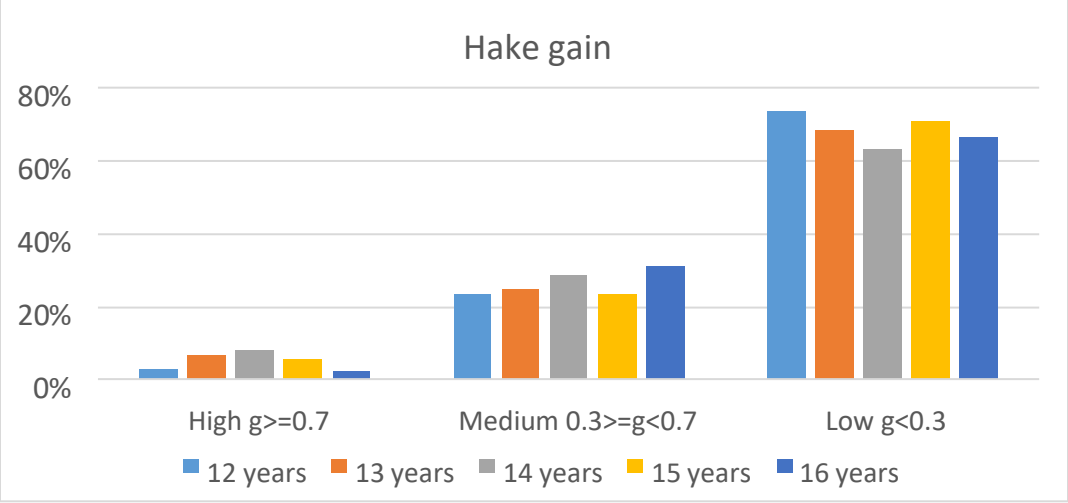


*Figure 2.* Three levels of the Hake gain distributed by age

We use binary logistic regression to build a model to predict what the influence of the following variables are: age, sex, and grade. The odds ratio predicted by the model is given by the Exp(B) for each variable in the equation. We introduced a dichotomic score variable labelled "1" to the student that obtained more than 70 % of the answers correct after seeing the video. The model, constructed with the students of 7th, 8th, and 9th grades, predicts 80 % of the cases. The age (Exp(B)= 0,75, p=,009) and grade (Exp(B)=2,390, p=,000) are the predicted variables that affected the results significantly; for sex, the Exp(B)=0,849, p=0,239 favoring the girls. In this model, gender does not change the results significantly.

Because we are dealing with students that are in the transition from puberty to adolescents, now we consider a simple bivariate logistic regression using the items separately as a dichotomous variable and sex as a single dichotomous predictor variable. The odds ratios are presented with a horizontal-bar graph sorted by greater value. As we mentioned before, the odds ratio that favoured girls are less than 1, so we inverted the Exp(B) values for a more straightforward interpretation, and we assigned a negative sign to the values that favoured boys (See Figure 3 in the Appendix).

The model with the responses of 7th-grade students showed that girls overcame boys in 16 out of 22 items, and in 6 of them, the differences were significant. In 8th grade, boys defeated girls in 13 items, only one of which had a significant difference. In 9th-grade, boys outperformed in 12 questions, of which only two were significant (Figure 3).

For the subsequent analysis, we used only 7thgrade students (when boys are entering puberty). We calculated the average normalised gain "g," comparing the total score before and after seeing the video. For short retention, 30% of girls obtained a "g" > 0,3, which was true for only 22% of boys. The mean "g" of boys is 0,05, while for girls it is 0,13. In the medium-retention situation (between 2-4 weeks after seeing the video), 30% of girls obtained "g" > 0,3, while 34% of boys did the same. To calculate the odds ratio for the higher-score students, "g" was labelled "1" when the student obtained a "g"≥= 0,3, and "0" when "g"<0,3. To the short retention score, with sex as a unique predictor, Exp(B)=0,65, p=0,01, significantly in favour of girls, while medium retention is in favour of boys Exp(B)=1,21, p=0,36. Now, we compare the odds ratio (being the dichotomous criterion variable "g > 0.3") between the short retention and the medium retention, and the sex as a dichotomous predictor variable, the value

of Exp(B)=1,82, p=0,01, is significantly in favour of boys.

Also, we obtain the odds ratio for the higher scorers, of the Postscore and MPostscore (labelled "1" with > 70% of the answers correct), between boys and girls, in 7th and 9th grade. It is evident that in 7th grade, the odds ratio is in favour of girls in short-term retention (Table 2), and in 9th grade, the odds ratio in medium-retention is in favour of boys. That means that the only significant difference between boys and girls is that boys retain better in the middle term, while girls retain better in the short-term.

**DISCUSSION**

Higher education in sciences is essential to the development of any country, but it was documented the world around that there are fewer women than men in STEM careers (e.g., Nature, 2013). Apparently, women and men are equally capable of graduating from a scientific field because there is a similar percentage of gender enrolled and egress from it (UNAM, 2018).

We wonder if the lack of interest of women in getting into scientific careers earlier than 15. In this study, we used the video "Continental drift" made by us to record the short- and middle-term retention of the information provided by the video, in secondary schools´ students.

Following that, we compare the results at the beginning of learning science (first retention of information) with the results of documental international achievement tests. Our study agrees with the Beller and Gafni (1996) results, where the gender difference in favour of boys increased with grade, but in 7th grade, when boys entry to puberty, girls perform better. According to PISA (2015) and Driessen and van Langen (2013), in the low achievement level, the difference between boys and girls is very small and not significant; in our study, medium retention is in favour of boys and short-term retention is in favour of girls.

In the high-achievement level, boys had lower short retention than girls, meaning that they did not pay as much attention as did girls when watching the video; in contrast, boys increased their score 2-4 weeks after seeing the video. Girls retain almost the same than on the first day. This happens with the analysis of 407 students of 7th and only 34 of 9th grade. Apparently, boys keep thinking about the content of the video after two or more weeks, as the middle term retention results show. This difference suggests that boys continue to think about

the themes of the video which may increase their interest and perhaps their confidence enough to choose a scientific career later on. In contrast, girls can retain the concepts well, but that does not increase their attention when they should choose their profession or major.

## CONCLUSIONS

1. The "Continental drift" video is a reliable source of information on this scientific topic to secondary school's students.
2. Girls retained more information the same day after seeing the video in 7th grade, and boys did it better in 9th grade. Students of 14 years old have the higher "gain."
3. Girls perform significantly better in short-term retention and boys in middle-term retention.
4. As boys continue to think about the contents of the video weeks after watching it, this increases their interest in this topic over time.

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## APPENDIX

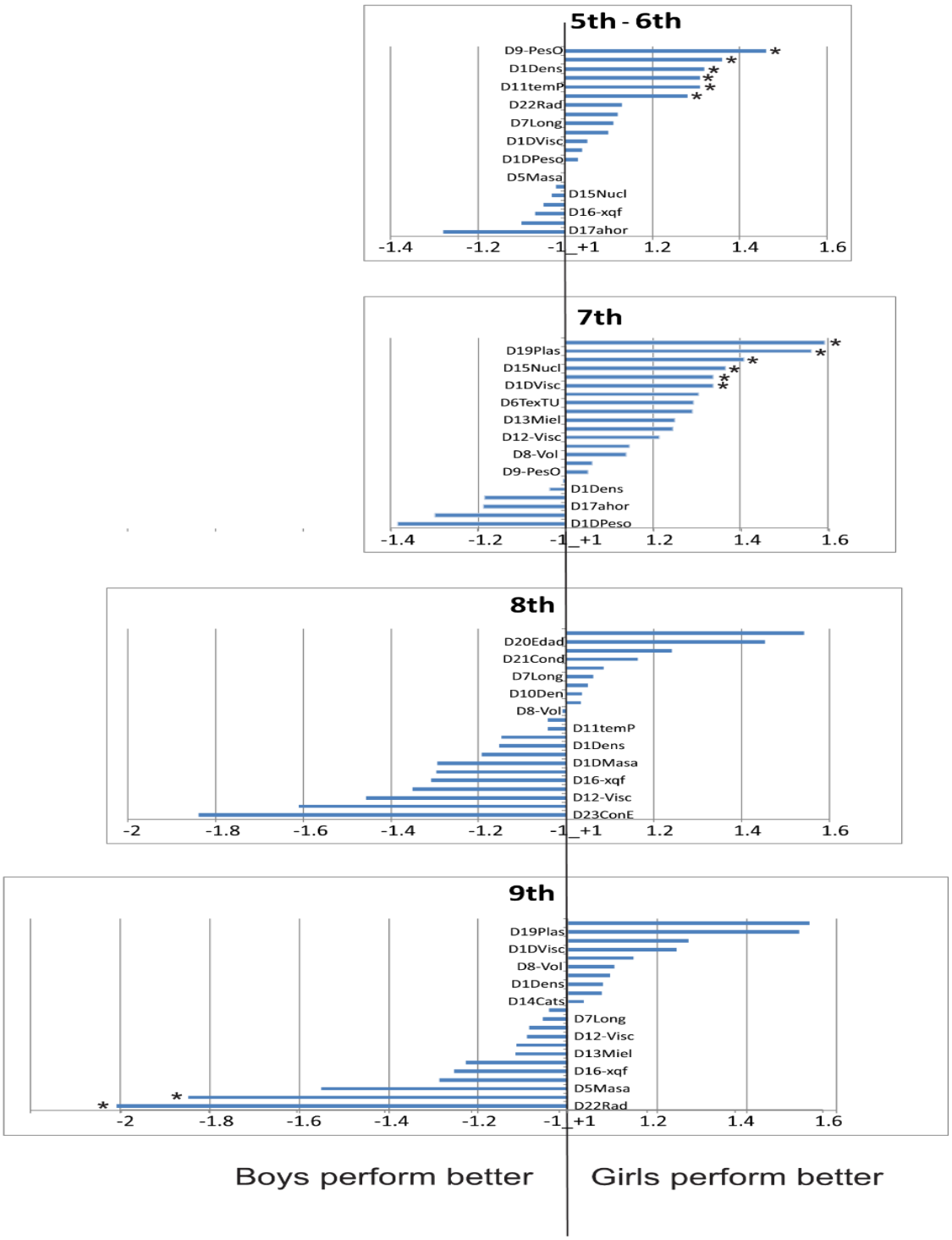


*Figure 3* Odds ratio (Exp(B) values) obtained for each of the 22 items of the posttest with binary simple bivariate logistic regression using sex as a unique predictor variable. The leftmost diagram was modified from previous study, and the subsequent diagrams correspond to 7th, 8th and 9th grades. * means that sex affects the model significantly.