FULL-LENGTH ARTICLE

Biology and Physics School Performances: The Gender Perspective Case Analyses Along Grades 7-10 in Addis Ababa

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ABSTRACT
Examining Biology and Physics performances from a gender perspective and checking whether or not either of the sexes performs better than the other from grades 7 to 10 were the main objectives of this study. Four years' school rosters showing the two subjects' performances of the same 74 participants (32 boys and 42 girls) were used as data sources. Means, Standard Deviations, and the independent samples t-test were employed for the analyses. The findings revealed that, at least for this specific sample, although girls performed slightly better than boys in Biology at all grade levels and at the first three grade levels in Physics, no statistically significant difference between boys' and girls' performances in the two subjects was observed either at a specific time point (grade level) or overtime (across the four grade levels). However, as grade level increases, the performance difference narrows in favor of boys: a potential signal for any gender-related academic intervention.

Keywords: Biology; Gender; Grades 7-10; Performance; Physics

INTRODUCTION
Many countries around the world seek to increase the number of students who pursue further study and careers in Science, Technology, Engineering, and Mathematics (STEM) (Neidorf et al., 2020). In doing so, an ever intensified attention is being paid to the importance of gender equity in STEM (Chine, 2022; Jones, 2013), as gender disparities in science education continue till these days (Isaak et al., 2022; Bizimana et al.,2022), as women remain underrepresented in STEM fields (Vela & Miles, 2022) although their representation varies based on the type of the subject matter or course in this field (Chine, 2022), and as researchers assessed the gender effects on students' attitude towards science and their own ability and discovered that boys were more confident than girls in science (Adu, et al., 2018), girls were less confident than boys about their relative ability (Niederle & Lise 2011), girls and women expressed lack of desire to pursue STEM careers (Swafford & Ryan, 2020), and girls reported less positive attitude than boys toward science (Jones, 2013). The gender gap is said to be particularly remarkable in certain disciplines such as physics, where there is serious underrepresentation of females (Rosenzweig et al., 2020; Jones, 2013) - a situation that called for interventions such as passing bills in the United States that fund special programs as a means to enhance the participation of girls and other minority groups in STEM fields (Chine, 2022).

This gap is the result of many years in the making beginning from the family and further portrayed in schools. In elementary schools, according to Jones (2013), studies showed that, even before any gender differences in participation in mathematics and science classes appear, children of both sexes already associate mathematics more strongly with males than females, boys on average have a higher perceived competence in mathematics compared with girls. By middle schooling, the situation gets more pronounced and by early adolescence and secondary schools, male and female students already express different attitudes toward STEM subjects.

There are empirical evidences in agreement with this. Ingels and Dalton (2008), as cited in Amelink (2009), found that, in the U.S.A, content mastery assessments revealed that performance differences between males and females in K-12 education begin in elementary school and continue at the high school level. This does not look the case in Europe, where girls' achievement lead becomes established in upper secondary attainment: more boys leave schools without any qualification, while more girls acquire an upper secondary school certificate that allows continuation of education at tertiary level (Eurydice, 2012).

Physics and Biology are among the core subjects in science and/or STEM (Neidorf et al., 2020), that are the focus of this study. Physics, according to Allen (2007), was incorporated in the U.S.A high school curriculum, especially after Harvard University started taking physics as a requirement for college entrance. In a bold remark about Physics, Nkwo, et al. (2021:336) suggested that “any persons who plan a career in science and its fringe disciplines should acquire fundamental ideas, concepts and principles of physics”. Biology on the other hand, was said to be labeled a science when zoology, botany, and different agriculture-related courses were merged around 1920 (Allen, 2007). With an indirect remark that associated Biology to women, Howes (2002:17-18) noted that “the only science in the index of The Feminist Classroom is biology; no chemistry, no physics, no mathematics”.

The global literature regarding gender and performances in Biology and Physics can be summarized in two ways: participation and performance. These two concepts may not be mutually exclusive. But one does not imply the other, i.e. high performance cannot guarantee high participation, or the other way around. As to participation, the overall picture is that women are represented at a higher rate in the biological sciences and men in the physical sciences. Physics is a male-dominated field. The gender gap in physical science remains noticeable (Chine, 2022; He et al., 2020; Rosenzweig et al., 2020; Hill, et al., 2010). Women earn considerable proportions of the bachelor’s degrees in math and the sciences, except in physics, and they are more likely to complete biology whereas a greater percentage of boys complete physics (Halpern et al., 2007).

Biology has been accessible to women with relatively a great deal of women in the life sciences (He, et al., 2020; Blume-Kohout, 2014). Possible explanations include, females likely use more appropriate learning strategies to learn biology than men (Isaak, Kleinert, & Wilde, 2022), compared with the other sciences, “biology is open to verbal expression” (Howes, 2002:18) and a number of researches have proven that females are more advantageous in various verbal capabilities (Qian et al., 2017). Empirical evidence disclosed that nearly twice as many males as females reported plans to major a field in Science, Technology, Engineering, and Mathematics (STEM) (29% of males compared to 15% of females) and the gap would have become even wider if biology was not considered in the data, with 20% of first year male students reporting plans to major in STEM fields as compared to just 5% females (Jones, 2013).

However women’s higher representation in the biological sciences may decline at graduation and as they proceed from the bachelor’s degree to the doctorate and further to the world of work. In the United States of America (U.S.A), research results found that more men than women were graduated in nearly every science, and in physics the difference is dramatic, with women receiving only 20 percent of bachelor’s degrees (Hill, et al., 2010). According to Blume-Kohout (2014), too, women’s share of bachelor’s degrees has progressively increased in the 2000s representing about 57% including degrees in behavioral and social sciences along with allied health fields, but it was around 37% in the natural sciences, engineering, and mathematics. The situation in the European Union (EU) looks a bit different. In 2012, while computing and engineering were heavily male-dominated and life science was women-dominated, the physical sciences had a fairly equal participation rate of males and females (Pirra, et al., 2020).

Beyond the bachelor’s degree level, in the USA there is an apparent gender convergence in earned PhDs in STEM and this is largely attributed to the biological and medical sciences (Blume-Kohout, 2014) where women receive about one-half of doctorates (Hill, et al., 2010). In her study, Jones (2013) also found that by the year 2006, women earned approximately 50% of the doctoral degrees in biological and agricultural sciences, 30% of the doctoral degrees in mathematics, and 20% of the doctoral degrees in computer science, engineering, and physics (Jones, 2013). Likewise women in the world of work comprise over 50% of biological scientists, but roughly one in ten professionals among traditional engineering professions (Swafford and Ryan, 2020).

Performance difference among genders is the other way to explain the gender gap in Biology and Physics subjects. Although the problem is not new, the gender-related achievement gap and the challenges to close it is one of the most perplexing problems confronted by educational systems today (Clark, 2014**)**. While OECD (2009), as cited in Teklu (2013), noted that the latest international assessment studies agree that female students tend to have an inclination of lower academic achiever than male students regardless of their educational level, others claimed that the findings regarding gender difference in science performance are not definite. Gender-related achievements in science subjects and mathematics are not conclusive because of apparently incompatible research reports in the literature (Nkwo, et al., 2021). National trends in the U.S.A also exposed mixed results with regards to the gender gap in science achievement (Amelink, 2009). And those who suggest differences do exist stated that the differences are the smallest and perhaps the most important finding from the literature and analyses is that sex-differences in achievement, even in subjects like mathematics and science, are small and have been decreasing steadily over the last 20 years (Eurydice, 2012). Careful examination of studies on the performances in Biology and Physics, came up with different explanations.

When performances in both subjects are compared together, some researchers found boys outperforming girls in both subjects, apparently less so in Biology. Fewer girls than boys take advanced placement exams in STEM subjects, and when they take, on average they earn lower scores than boys (Hill, et al., 2010), male students have a tendency to take the science tests in larger percentages than females and to score higher, with the exception in biology, where the rates are comparable **(**Amelink, 2009), girls lag behind boys in achievement in all of the sciences, with biology showing the least difference (Howes, 2002), boys performed significantly higher than girls overall in science, scoring higher in biology and physics **(**Amelink, 2009), wider gender gaps recorded on physics than on biology (Qian et al., 2017), and in International Mathematics and Science Study (TIMSS), females did significantly less well than male students in the United States (Qian et al., 2017). Natz et al. (2017:1) also found a statistically significant gendered performance difference and concluded "In particular, men earned relatively higher grades than women in biology, chemistry, physics, accounting …".

Again when performances in Physics are considered separately, as males' advantage is significant in quantitative ability from high school years onwards (Qian et al., 2017), boys are found outperforming girls. Trends in TIMSS indicated that on average across five countries, male students outscored female students on nearly all the items in a given Physics subtopic at all three grade levels (grades four, eight, and TIMSS Advanced) (Neidorf et al., 2020).

The other group of scholars stressed that while boys perform better than girls in Physics, girls do the same in Biology. Research on performance at the end of compulsory schooling showed that boys outperformed girls in general science, chemistry and physics, and girls outperformed boys in biology (Murphy, 2005). A study involving 24,000 grade 9 students also determined that males performed better on items that require significant spatial processing and females outperform males on items that need memorization (Halpern et al. 2007). It seems that girls are apparently more interested and be more successful in biology (Howes, 2002).

Other scholars affirmed that the size of the gaps and the severity of the problem vary from culture to culture and from one country to the other (Clark, 2014**).** Neidorf et al. (2020), for example, established that gender performance patterns differed across countries and grades. Similarly, as to Qian et al. (2017:2), findings of international comparison studies indicated that in Chinese Taipei, Japan, and Singapore, "there was no significant gender difference in science achievement at the middle-school level". In their study on a Physics subtopic taught in a learner-centered classroom, Achor, et al. (2019) found that, although male students in this study benefited more from the approach, there was no significant difference between the mean performance scores of male and female students. Chine (2022), also came up with the finding that there was no practically significant relationship between gender and student achievement.

Gender-based stereotypes apparently dominate the discourse in Africa. According to Rathgeber (2003), as cited in Robsan (2014), in all parts of Africa, natural sciences and engineering are systematically precluded as attractive courses of study for women. Instead of being encouraged to study science, females are covertly and sometimes overtly told repeatedly by their teachers, schools, universities, and the various bureaucracies that science is not a suitable area for them to study. Females' inability to perform well in the sciences is said to be one of the major factors for their underrepresentation in STEM fields (Robsan, 2014).

In Ethiopia, Physics and Biology are being taught in the middle (grades 7-8) and secondary schools (MoE, 2016). Similar to the global literature, the situation in Ethiopia can also be stated from two angles: participation and performance. The document by the Ministry of Education (MoE, 2016) shows that there is decreased participation in post-compulsory science subjects, especially the enabling sciences of biology and physics. Fewer students elect physics at the undergraduate levels (Shewangzaw, 2016). As to females, local studies indicated a low enrolment rate in the STEM disciplines. For instance, according to Semela (2010), in 2007/08, of the total 2208 undergraduate physics students enrolled at ten relatively well-established universities, only 175 (7.9%) were female. Regarding student performances, a study found that the majority of students assigned to study physics were blamed for low achievement as compared to their counterparts assigned to Biology (Shewangzaw, 2016).

The researcher has made an intensive search for related literature in the Ethiopian context –theoretical and/or empirical literatures that deal with both Biology and Physics school performances simultaneously from a gender perspective with a longitudinal approach in both junior to secondary schools. The result indicated that, some studies focused only on secondary schools and mathematics performance (for instance, Adem et al., 2020 and Seleshi et al., 2019), others focused only on secondary schools, excluding junior secondary schools (For instance, Asrat, 2017; 2018), and the rest focused only on secondary schools and physics performance (For instance, Shewangzaw, 2016). This study is different from these instances in that it focuses on both junior (grades 7 & 8) and general secondary (grades 9 &10) schools and on both Physics and Biology performances. Besides, these research works utilized a one-shot (cross-sectional) data. As far as my knowledge and review is concerned, no research in Ethiopia attempted to study physics and biology performances of the same students (the same participants) from grades 7 to grade 10 longitudinally.

Generally, as stated above, first, the findings and/or conclusions regarding the gender gap in Biology and Physics performances are mixed. The other issue is, what will the trend look like when performances are examined across different grade levels? According to Amelink (2009), although they were not analyzed for statistical significance by gender, results revealed that males outperformed females in science achievement at all three grade levels (grades 4, 8, and 12). But, more importantly, the author concluded, "The gender gap in scores grew with age so that females were at an increasing disadvantage by high school" (Amelink, 2009:14), and although "females had a slight advantage in life science" (p.14), including biology, "females do not perform as well in physical science" (p.14). It is these core issues that were investigated in this study. Thus, the basic questions were:

- Do boys outperform girls in Physics? Is the outperformance significant? Does it replicate overtime (along grade levels)?
- Do girls have better advantage in Biology than boys? Is the advantage significant? Does it replicate overtime (along grade levels)?

By answering these questions, the main objectives of this study were to examine Biology and Physics performances from a gender perspective and to check whether or not either of the sexes performs better than the other along the four grade levels (grades 7-10). These answers can locate gender-related potential strengths and weaknesses while studying the two subjects at a given grade level and across the four grade levels. This may encourage teachers to adjust or modify the strategies they employ in the Biology and Physics instructional process from junior to secondary schools. Moreover, gender stereotypes about Biology and Physics may discourage girls, and boys for that matter, from actively participating in classrooms and from pursuing STEM education or occupations if they perceive it as not being consistent with their gender roles (Jones, 2013). This study examines if this stereotype holds true. If not, the finding can change parents' and teachers' gender stereotypic beliefs that have considerable influence on children's self-confidence in both subjects. Finally, the global literature on who outperforms who in Physics and/or Biology is inconclusive. This study, although it is narrow in its scope, can add the Ethiopian context to that debate.

METHODS AND MATERIALS

This study was quantitative and longitudinal case in its design and thus four consecutive years' school rosters were used as data sources. Two schools in Addis Ababa were chosen purposively. One primary school (teaches K.G - 8) and one secondary school (teaches grade 9-12). The purpose behind choosing these schools was both schools are located in the same compound, where the primary school teaches up to grade eight and then feeds students into the secondary school as they promote to grade nine. This made accessing the four grade levels consecutive years' performances of students manageable. Then four academic years (for the four grade levels), where student performances were recorded without COVID 19 interruption (before 2019/20 academic year or 2012 Ethiopian Calendar) were chosen. This was so because, schools were closed during the pandemic and students got free promotion to the next grade level, with no recorded exam results. The year was selected in such a way that the sample size will allow statistical analysis involving at least a third of the population.

The selected year was 2009/10 (2002 E.C). Those students who reached grade 7 during this academic year joined the school as grade 1 in 2003/04 (1996 E.C). And the total number of these students was 235. Out of these 235 students, 147 of them completed grade 6, and of these 111 students completed grade 8. By the time they completed grade 10 (2012/13 or 2005 E.C), they were 74, Most of these students ended their schooling at grade 10 (general secondary), and about 35 students promoted to grade 11, of whom only 23 students joined the natural science stream: the subjects this study aimed to examine. Thus, it was data from the 74 students (32 boys or 43% and 42 girls or 57%), who passed through grades 7-10, that were used in this study. Grade 7 as a starting point was chosen since in Ethiopia Physics and Biology are offered as separate subjects starting from this level. The analyses did not include the situation through to grade 12 since the sample size (23 students) was too small to compute meaningful statistical significance. Data were analyzed using means, standard deviations, and the independent samples *t-test.* The four years' data were analyzed using SPSS and, in accordance with the basic questions, analyses were made for each subject.

For the purpose of this study, Biology and Physics performances were measured by the annual mean scores of each subject for every grade level. Although some causal explanations may be given for performance differences between boys and girls, in primary and secondary schools of Ethiopia, academic achievement is always measured by students' examination results (Asrat, 2018) and achievement within schools is signaled primarily by marks or grades (Nyström, 2014).

RESULTS AND DISCUSSION

Physics Performance: grades 7-10

Table 1 below presents the Physics performances of boys and girls. The Leven's Test for Equality of Variances (*F-value*) for all the grade levels was not significant ($p > .05$) and thus the Equal Variance line values for the *t-test* were used in the analyses and interpretation.

Table 1. Physics performances overtime and t-test values

Grade	Boys		Girls					
	Mean	Std. Dev.	Mean	Std. Dev.	Mean diff.	t-value	df	Sig.
7	53.00	12.68	58.12	16.31	-5.12	-1.468	72	.146

8	64.86	9.74	68.59	11.56	-3.73	-1.469	72	.146
9	57.69	9.96	59.85	9.78	-2.16	-.933	72	.354
10	56.84	6.77	56.02	8.35	.82	.453	72	.652

Note: Std.Dev. = Standard Deviation; Mean diff, = Mean difference; *t*-value = *t*-test value; df. = degree of freedom; Sig. = significance level

The descriptive statistics in Table 1 shows that for both sexes, while the highest mean performance was at grade 8 (Middle school), and this may have resulted from additional preparation to take the primary school leaving examination and promote to secondary schools. However, when the standard deviations were closely examined, there was greater variability in girls' performances than that of boys, 11.56 and 9.74 for girls and boys respectively. The lowest performance for both was at grade 10 (secondary school), which was unexpected as at this level as well students need to perform better to proceed to the preparatory level. As in grade 8, there was greater similarity between the performances of boys than that of girls with a standard deviation of 6.77. Moreover, the mean performances of both sexes declined from grade 8 all the way to grade 10, more so for girls than boys.

Table 1 also depicts that at nearly all the grade levels, with the exception at grade 10, the mean performances of girls was better than that of boys. However, what is visible was that this difference (gap) narrowed up the grade levels from grade 7, even where boys performed slightly better than girls at grade 10, though it was not significant, $t = .453$, $p > .05$.

Regardless of who performed better at which grade level, the results showed that the mean differences at all grade levels were too small to be statistically significant ($p > .05$). The finding was that, at least for this specific sample, neither the boys nor the girls performed significantly better than the other in Physics along the four grade levels. While this finding is consistent with the conclusion by Noble, et al. (1999), as cited in Amelink (2009) that gender plays a marginal role in explaining science achievement differences between boys and girls, it challenges the findings of Natz et al. (2017) that there is a statistically significant difference in Physics performance of the two genders and the assertion by Jones (2013) that the male-female performance gap between boys and girls is particularly striking in physics. Moreover, although the difference was not significant, even unlike the expectation by many, girls have a slight advantage over boys, at least at the first three grade levels (grades 7-9), which contradicts the conclusion that boys outperformed girls in physics, and girls outperformed boys in biology (Murphy, 2005).

Biology Performances: grades 7-10

Table 2 summarizes the Biology performances of both sexes along the four grade levels. Here as well, the *F-value* was not statistically significant and so the *t-values* were used accordingly.

Table 2. Biology performances overtime and t-test values

	Boys		**Girls**					
Grade	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean diff.**	**t-value**	**df**	**Sig.**
7	57.56	9.78	60.65	13.27	-3.09	-1.108	72	.271
8	51.18	9.93	53.69	12.10	-2.51	-.952	72	.344
9	57.09	11.99	60.00	11.24	-2.91	-1.071	72	.288
10	55.94	10.06	58.29	11.00	-2.35	-.945	72	.348

Note: Std.Dev. = Standard Deviation; Mean diff, = Mean difference; *t*-value = *t*-test value; df. = degree of freedom; Sig. = significance level

The descriptive statistics in Table 2 shows that the highest and the lowest mean Biology performances for both sexes were at the middle school level (grades 7 and 8), Mean = 57.56 and 60.65 for boys and girls, respectively. Especially at grade 8, both sexes, particularly boys were close to score near the half a percent mark. At this grade, although boys' performances seemed to be lower than that of girls, they were highly clustered around the mean with a 9.93 standard deviation than did girls' performances. Although both results did not reach statistical significance, girls' performances at least touched the 60 points area twice (at grades 7 and 9) where t = -1.11, p = .27 and t = -1.07, p = .29 for grade 7 and grade 9, respectively, whereas those of boys' were in the lower, mid, and upper 50s.

The results in Table 2 disclose that in fact girls have a slight advantage across the four grade levels. This result supported a finding referenced in Amelink (2009) that females were found to have a slight advantage in the life sciences. It also coincides with the findings of Kessels et al. (2014) as narrated by Isaak et al.(2022:588) that "Although biology belongs to science, females generally exhibit better grades and choose biology as a subject more often than boys do". However, similar to the case in Physics, the performance gap between boys and girls narrowed up the grade levels - a finding that proves the finding by Amelink (2009:14) that performance differences grew with age "putting females at an increasing disadvantage by high school". Nonetheless, the mean difference along every grade level was not statistically significant ($p > .05$). In Biology, too, neither of the sexes did significantly better than the other. This finding contradicts the findings of a study that concluded a statistically significant gendered performance difference in Biology (Matz et al., 2017), a study in which girls outperformed boys in biology (Murphy, 2005), and many other conclusions that found boys outscoring girls in science in general and in physics in particular. On the other hand, it supports the findings by Qian et al. (2017) and Achor et al. (2019) who found no significant gender difference in science achievement.

CONCLUSION AND IMPLICATIONS

The main objectives of this study were to examine Biology and Physics performances from a gender perspective and to check whether or not either of the sexes performs better than the other along the four grade levels (grades 7-10). From the analyses it was concluded that, although females performed slightly better in Biology than boys at all grade levels and in Physics at the first three grade levels, for this specific sample, Physics and Biology performances do not significantly differ between boys and girls either at a specific time point (grade level) or overtime (along the four grade levels). This probably sends an important message to parents, teachers, boys, and even girls themselves as well as the larger society that the widely held gender-specific stereotypes that appear to link physics with boys and biology with girls do not always prove true. Besides, if 'the narrowing the gap overtime' trend continues in a similar manner in favor of boys (observed from grades 7 to 10) to grade 12, girls might really be at a disadvantage and this might serve as an indicator for any gender-specific academic intervention. However, as this study involves case analyses, a similar longitudinal study of broader scope is recommended to come up with concrete empirical evidence.

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