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Who is joining physics and why? Factors influencing the choice of physics among Ethiopian university students

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This paper investigates the enrolment trends and the critical factors that impinge on students' choice of physics as major field of study. The data were generated from primary and secondary sources. Primary data was acquired based on a semi-structured interview with 14 sophomore and 11 senior students and five instructors of the department of physics at Hawassa University, Ethiopia. In addition, data on allocation of students to various major fields as well as quantitative data on academic achievement were obtained from the university's registar office. The results indicate that the rate of enrolment in physics is the lowest and applicants who were assigned to the physics undergraduate programs were those whose mean score in Ethiopian National Higher Education Enterance Examination was the lowest compared to any other group. Further, the findings show unprecedented gender gap in enrollment and graduation rates. The explanations given for the low enrollment rate were inadequate pre-university preparation, weak mathematics background, lack of job opportunity outside the teaching profession, and poor teacher qualification and pedagogical content knowledge. Finally, this article forwards policy recommendations to bolster the alarmingly declining state of physics education in Ethiopia.

Keywords: enrollment, gender balance, physics, Ethiopia

Introduction

The declining interest to study science on the one hand, and the lack of enthusiasm to take physics course in school or avoiding physics as a college major, on the other has been an international problem. The decline in enrollment and graduation rates in physics at all levels has been the case in many countries including the USA, UK, Germany, and the Netherlands (e.g., Tobias & Birrer, 1999; Osborne, Simon, & Collins, 2003, p. 1058). Existing research show that the erosion of interest in the subject found to emerge as early as lower high school (Hoffmann, 2002) to later result in compromising college enrolment (e.g., Tobias & Birrer, 1999). In this regard, a number of factors have been identified to underpin the low interest to study science in general and physics in particular. Recognizing the far reaching challenges, attempts have been made to bolster students' interest in Physics. These, among others, include introducing "innovative" physics curricula (e.g., Lawrenz, Wood, Krichoff, Kim, & Eisenkraft, 2009; Lorenzo, Crouch, & Mazur, 2006; Hoffmann, 2002), use of student-centered teaching strategies and implementing teachers' in-service professional development (Lawrenz et al., 2009), combining physics with other disciplines in undergraduate courses, and starting new graduate

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programs for physics graduates (Tobias & Birrer, 1999). More specifically, much of these studies focused more on identification of the factors that affect interest in physics among female students. These encompass introducing new learning experiences and methods of teaching to influence students' interest to learn physics beginning from early school years (e.g., Hoffmann, 2002; Häussler & Hoffmann, 2002).

More or less similarly, the plethora of research in the context of higher education institutions indicates not only the low enrolment rate in undergraduate physics programs, but also the apparent decline in the share of students opting for introductory physics courses (e.g., Tobias & Birrer, 1999). As a result, there has been considerable research attention (e.g., Hoffmann, 2002; Hazari, Tai, & Sadler, 2007; Lawrenz et al., 2009; Kost, Pollock, & Finkelstein, 2009) as to the state of physics education in the western context namely, in Europe and USA. However, to date, little is known about the underlying factors that affect interest to study physics among African students. Identification of the underlying reasons is of significance to widen our understanding of the problems related to physics education and uncover possible differences across cultures. Hence, the present study intends to capture these factors in African context taking Ethiopia as an example.

In the African context, notwithstanding the need for competent human capital in science and technology similar yet unwelcome developments are becoming a source of frustration to school teachers, researchers and policy makers. For instance, in Ethiopia a new policy that gives importance to science and technology has been in place beginning 2008 (Ministry of Education [MoE], 2008). According to this policy, universities are expected to enroll 70% of their students in science and technology, of which, natural science stream taking about 40%. Experiences in 2008-2009, however, reveal that the pool of high school completers who would be eligible for university study has been insufficient. Most importantly, the majority of students assigned to study physics were blamed for lack of interest, low achievement and lack of academic success (Getenet, 2006), and low academic self-concept (Admassu, Abdo, & Semela, 2005) even as compared to their counterparts assigned to Biology, Chemistry, and Mathematics (Shibeshi, Mekonnen, Semela & Endawoke, 2009). The trust of this study is, therefore, to generate empirical evidence as to the existing trend in terms of enrollment, gender balance, prior academic achievement, and factors that work against students' preference to study physics at university-level based on data obtained in an Ethiopian university context.

Science Education in Ethiopia

It doesn't give much sense to jump directly into the narratives of the history and development of science education in Ethiopia without a brief mention of how formal education has unfolded to the present day. Written sources on the history of indigenous education in Ethiopia (e.g., Amare, 1967; Zewde, 2002) adequately documented that formal church education has began in the 4^{th} Century A.D with the aim of spreading Christianity to be later joined by the Islamic mosque education in the 12^{th} Century A.D. The traditional church education despite its significant contribution to Ethiopian intellectual culture has not been enthusiastic about the study of scientific subjects (see Kebede, 2006; Wagaw, 1979) since doing so was viewed as inconsistent with the mission of religious education.

Nevertheless, officially modern education started 1898 with the opening of Minilik II School in Addis Ababa which is believed to have marked the onset of science education. The first few decades that followed the introduction modern education, the school curriculum actually focused much on the study of language and public administration in Ethiopia. Hence, little attention was given to the study of science in schools. The lack of adequate attention for science, however, informed by the increasing need for educated people who studied foreign languages to work as translators as well as to fill positions of public administration in the emerging modern bureaucracy. This, however, does not necessarily indicate an intentional exclusion of science and technological subjects from the school syllabus. To the contrary, there is evidence to suggest that the existence of strong desire among Ethiopian emperors even prior to the introduction of Western style education. For instance, during the period of *Zemne Mesafint,* Emperor Tewedros has made significant effort to acquire new scientific and technological knowledge and skills from European powers in which case he later succeeded in building state-of-the-art military hardware in *Gafat,* Gonder. One can, therefore, argue that there were sufficient indications of unreserved effort to keep abreast with the developed world in the use of science and transfer of technology. The other notable example which can be cited here is what was achieved during Minilik II, who was instrumental in the introduction of the telephone, rail transport, and other modern technologies of the time. Be that as it may, the science and technology fields have not been accorded equal importance in school curricula as language and administration did.

During the period of Emperor Haileselasse, however, science became a major component of the curriculum. The opening of the Faculty of Science under the University College of Addis Ababa in 1950 (Zewde, 2002, p. 221-222) is believed to have taken the study of science to the next higher level. According to Zewde (2002), by the mid 1950s, the College of Engineering and the Building College were established in Addis Ababa, while the College of Public Health and College of Agriculture were opened at Gonder and Alemaya (later upgraded and renamed as Haramaya University) respectively. During the period of the Military Government, diploma offering colleges in basic science fields namely biology, chemistry, and physics were also opened at the former Bahirdar Academy of Pedagogy (later upgraded and renamed as Bahirdar University), Alemaya College of Agriculture, and Kotebe College of Teacher Education. Graduates of these institutions were assigned to teach science and other subjects in junior and senior secondary schools throughout the country. According to the National Democratic Revolution Program (NDRP) of the Socialist Government, science and technology was given due emphasis in the school curriculum based on the communist principle of shaping of the “All-rounded Socialist Personality” though little was achieved in the education sector owing to internal political crises and armed conflict against the opposition forces in the northern part of the country. After the Ethiopian People Revolutionary Democratic Front (EPRDF) took over of political power in 1991, a new Education and Training Policy (ETP) was developed by the Transitional Government of Ethiopia (FDGE, 1994). The ETP stipulates that science and technology shall be one of the central aims of the education system (FDGE, 1994, p. 8). Hence, to cater to the human resource needs of the expanding school system, several higher education institutions have been opened and all have started undergraduate degree programs in basic science fields including physics. In 2007 the number of universities offering “bachelor of science” or “bachelor of education” in physics reached about 22. In 2008 again, the Ethiopian Federal Ministry of Education came up with a new policy whereby 70% of the overall higher education enrollment should be in science and technology, out of which, 40% to be allocated to science streams alone. This provides sufficient evidence as to the attention given in terms of producing more graduates in science fields. The rationale behind is that Ethiopia needs a huge workforce for its growing economy to ensure continues and sustainable development (see: MoE 2008). Though the World Bank is skeptical about the uncontrolled expansion of higher education enrollment in sub-Saharan Africa, it still encourages increased share of enrollments in the fields of science and technology in the loan recipient countries of the region (World Bank, 2008).

Problem Statement

The present study is alarmed by trends that are posing serious challenges to the future of science education in general and physics education in particular. Not withstanding the fact that increased importance has been placed to the study of science (MoE, 2008), a most recent study (Shibeshi, Mekonnen, Semela, & Endawoke, 2009) show that the quality of science education has been seriously compromised and the competence of applicants in physics is alarmingly declining. In addition, there are clear indications that students vanishing interest to study basic sciences in general and physics in particular is a source of concern not only to the institution but also to the nation which aspires to accumulate competent human capital in science and technology. Thus, it is in the best interest of science educators and policy makers to assess the extent, causes, and explanations of quality concerns in order to come up with provisional mechanisms of intervention as well as set agenda for further research. To that effect, the following research questions are developed to guide this study:

- Do students admitted to physics undergraduate programs vary in their achievement in the National Higher Education Entrance Examination (NHEE) scores as compared to students joining other science and engineering fields?
- Is the rate of enrolment and graduation in undergraduate physics programs comparable with other science programs at national and institution level?
- How balanced is the participation of females in physics as compared to males?
- Which factors affect the choice of physics as major field from the point view of students and instructors?

Factors That Shape the Study of Physics

The choice of physics as a major field of study or taking higher physics courses is shaped by students' interest, motivation, and prior achievement (Hoffmann, 2002), physics self-concept (Hoffmann, 2002; Hannover, 1991), self-efficacy (Porter & Umbach, 2006; Zuh, 2007), pre-college preparation (Shibeshi et al. 2009; Sadler & Tai, 2001), and teachers' in-service training on how to implement innovative physics curriculum (Lawrenz et al., 2009). Accordingly, in a study that attempted to find variables that affect physics achievement Lawernz et al. found out that students who underwent "Active Physics" scored higher for the greater part of the year compared to those who did not undergo the same experience. While at the same time, the study claims that the achievement gap between boys and girls narrowed for those groups who took "active physics".

On the other hand, the existing literature show that interest in physics strongly related to physics self-concept (Hoffman, 2002; Hannover & Kassels, 2002; Hannover, 1991) and physics self-efficacy (Zhu, 2007). In this connection, Hoffman's study among German school children ranging from grades 7 - 10 revealed that self-concept in physics is the best predictor of interest in physics as a school subject for both boys and girls. However, gender differences in interest emerge when other factors come into play which can compromise self-concept of performance in physics. According to Hoffmann, the gender difference in interest seems to be sufficiently explained by the gender differences of other variables, especially by differences in self-concept (p. 452). In a similar study, Ziegler, Broome, and Heller (1999) found out that interest and achievement in physics are also affected by parental cognition and gender stereotypic beliefs among boys and girls. The bourgeoning body of literature regarding the pattern of major choice as a function of gender shows a consistent pattern. For instance, an earlier study by Boli, Steinkemp, and Maehr (1984, cited in Ethington, 1988, p. 350) found out that men's achievement and attitude towards science to be higher than women while at the same time noting a discernable pattern of differences between the sexes in motivational orientation in particular areas of science. Accordingly, females are inclined more to life sciences while males are oriented towards physical sciences. Nonetheless, Boli, Allen, and Payne (1985; cited in Ethington, 1988, p. 350) indicated that women choosing quantitative fields were likely to major in physics and Engineering.

Further, there is evidence to suggest that intervention through curriculum innovation that addresses the interest and experiences of females positively impacted girls' motivation, achievement and interest in physics (Hannover, 1991). However, Hoffmann (2002) found that interest and motivation to study physics declined with increase in grade level for both sexes. Other studies which applied innovative curriculum that considered female interest and employed constructivist teaching methodology came out with conflicting results. In this connection, unlike Lawrenz et al. (2009) and Lorenzo et al. (2006), a similar study on a relatively larger sample failed to yield consistent results. Lawernz et al. (2009) further claim that males and females have significantly different prior understandings of physics and mathematics with females less likely to take high school physics and making more negative shifts in attitude towards physics.

Similarly, self-efficacy is viewed as an important factor of students' major choice. Porter and Umbach (2006) claimed a strong link between subject specific self-efficacy with the choice of a particular discipline such as high mathematics self-efficacy with a pursuit to major in mathematics; and high scientific and technical self-efficacy related with choosing engineering as undergraduate major. These findings offer a partial empirical support to Zhu's (2007) claim regarding the link between physics self efficacy (PSE) and personal experience in the form of the content of physics learning and knowledge structure as offered in school.

In the study of the role high school physics to succeed in introductory college physics, Sadler and Tai (2001) found out that students' high school preparation is an important predictor of achievement in college although those who were without a high school physics course, yet with strong academic background or have previously taken calculus, can also succeed in college physics. In another study, Schwartz, Sadler, Sonnert, and Thi (2008) found that students who covered few physics topics in-depth were found to be successful in college compared to those counterparts who had studied a wide range of topics in high school physics.

In the Ethiopian context, a questionnaire survey of the views and observations of academic staff and students of biology, chemistry, mathematics and physics shows that, students' current performance and ability to succeed in college meeting the minimum quality standards have been affected by the nature of pre-university preparation (Shibeshi et al., 2009). In this connection, Assefa et al. (2008) found out that the horizontal integration of the high school and university courses are weak. Consistent with Assefa and his colleagues, Shibeshi et al. (2009) revealed that the depth of treatment of pre-university courses lacks appropriate depth to enable students withstand the challenges of university study in science fields. These results concur with the findings of Schwartz et al. (2008) which examined the performance of 8310 college students in introductory biology, chemistry, and physics courses in 55 randomly chosen US universities. The study revealed that students who have reported an in-depth coverage of at least one major topic earned higher grades in college science than those reported to have no in-depth coverage. The finding specifically show that students who have reported to have an extensive study of chemistry or physics at high school course did not appear to have any specific advantage in their chemistry and physics at college; neither did they have any significant disadvantage in biology. In short, the research literature regarding the choice of physics as a major field of study largely focuses on making a comparison between males and female students' enrollment (Ethington, 1988) the interest and attitude of boys and girls towards physics as school subject (Hannover, 1991; Hoffmann, 2002; Häusler & Hoffmann, 2002) and the effect of parental influence and stereotypic beliefs (e.g., Zeigler et al., 1999). A related study in Ethiopian context also showed a pattern of parental influence towards gender-consistent choice of career or field of study (Semela, 2008).

Method of the Study

In this study, data were generated at two levels namely, at national level and institutional level. The national level data were meant to describe the enrollment and graduation trends, as well as the gender balance in ten major public higher education institutions in Ethiopia. These include: Adama, Addis Ababa, Arba-Minch, Bahir Dar, Dilla, Gonder, Jimma, Haramaya, Hawassa, and Mekelle Universities. The remaining 12 universities were excluded from the study because they were new institutions which only became operational in 2007. The institutional level data, however, specifically focused on Hawassa University which is one of the established universities running degree programs in various fields including in basic sciences. Thus, all primary data were collected from Hawassa University. The instruments of data collection were an (a) interview guide, (b) classroom and laboratory observation checklists, (c) students' achievement based on scores on the Ethiopian National Higher Education Entrance Examination (NHEE). The details are briefly described below:

Interview

The interview involved 14 sophomore and 11 senior year students who joined the department of physics at Hawassa University, Ethiopia. The sampling technique used was purposive sampling in that all the participants did not elect physics as their first or second choice during application for major choice. In addition, five physics lecturers including the department head out of the total of nine faculty members took part in the interview. The content of the students' semi-structured interview included: (1) students views about their previous knowledge, skills and interest in physics and (2) their career plan in relation to studying physics at college, and (3) reasons that are responsible for not selecting physics as their first choice or second choice from the list of four fields. Instructors were also asked to identify those factors that are responsible for declining interest among students in choosing physics as their major.

Classroom and Lab Observations

A total of ten class lectures and six laboratory sessions of second year and final year major area courses were observed by two physics education lecturers in the faculty of education of Hawassa University in november 12-30, 2008. Before their deployment to carry out the classroom and lab observations, the research assistants were provided orientation training.

The observations were meant to assess the extent to which the teaching methods used were student-centered, as well as to find out the degree to which students are given clear background regarding the objectives of the lectures and the lab sessions including their applicability to real world. The observers collected quantitative and narrative data as per the checklists. Theclassroom observation checklist was made up of 15 items relating to motivating students, introducing the topic and presentation, the level of students' participation through questions and answers, discussion, group or partner activities, and individual tasks. Sample items include: "The instructor give individual activity in class.", and "The Instructor facilitate discussion among the students". On the other hand, the laboratory checklist consisted of 7 items covering issues like laboratory space, adequacy of equipments, opportunities for individual level hands-on practice, the connection of theoretical lecture and lab practical tasks. The lab observation checklist included items like: "after explanation by the TA, students perform experiments individually?" Both checklists were rated in a five-point Lickert-type scale ranging from "very-frequently = 5" to "not at all" = 1.

Inter-rater reliability. In order to demonstrate the extent to which the two observers agree in assessing the classroom and laboratory activities, a bivarate correlations were computed based on the ratings of the two observers. To find the inter-rater reliability for the first six pairs, a bivariate correlation were computed to yield coefficients ranging between .78 - .84 (significant at $p <. 01$) and .90-.93, (significant at $p < .01$) classroom observation and laboratory observation respectively. Furthermore, the pairs of narrative reports of the six classroom observation and four laboratory observation sessions were compared to look for possible departures in content. However, closer inspection of the data did not reveal meaningful differences in essence except minor variations in style of presentation or language use.

Data on academic achievement

The present study estimated students' prior academic achievement using aggregate scores on the Ethiopian National Higher Education Entrance Examination (NHEE). The data regarding achievement scores on NHEE were obtained from Hawassa University Registrar's Office. However, data regarding the psychometric characteristics of the NHEE for the year 2007/8, on which the present study was based was not made available.

The rationale behind using NHEE scores is firstly,the allocation of students to various fields including science, engineering, medicine is based on the scores (GPA) obtained on NHEE. Secondly, educational psychology/educational measurement literature indicate the predictive usefulness of high school GPA and university entrance examination results in predicting success in college (e.g., Geiser & Studley, 2002; Cornwell, Mustard & van Parys, 2008; Al-Naser & Robertson, 2001; Sadler & Tai, 2001). For instance, high school GPA was found to be a strongest determinant of college pre-calculus and calculus courses (e.g. Cornwell, Mustard & van Parys, 2008). On the other hand, university entrance examinations such as SAT (scholastic achievement/aptitude tests) on specific domains such as mathematics, found to predict success in college (Gussett, 1974). Further, written science admission scores also predicted first year medical school performance (e.g., Al-Naser & Robertson, 2001). Most importantly, previous studies in Ethiopian context indicate that the (NHEE) predicts success at higher education institutions (e.g., Admassu et al., 2005; Semela, 2008). Hence, it is against this background that the present research used NHEE scores to compare the relative standing of students allocated into physics in relation to their counterparts assigned into Biology, Chemistry, Mathematics, and Engineering streams.

Secondary sources

For comparison purposes, secondary data on student enrollment and the number of graduates in undergraduate physics programs was obtained from Annual Education Statistical Abstract of the Federal Ministry of Education. This was done to determine the proportional share of physicsvis-à-vis other undergraduate programs in terms of student enrollment and graduation rates.

Data Analysis

In the present study qualitative and quantitative statistical analyses procedures were employed. Accordingly, the interview and observational data were presented in narrative format while quantitative data were analyzed using descriptive statistics, bivariate correlation and a univariate ANOVA.

Results and Discussion

In an attempt to provide empirical evidence regarding undergraduate training in physics in Ethiopia this part presents the findings with respect to (a) students' enrollment in undergraduate physics in comparison with other programs at national and institutional levels, (b) the balance between the sexes in enrollment and graduation in physics, (c) the average academic achievement of those applicants joining physics compared to other fields, (d) identification of the factors that undermine the attractiveness of physics as a discipline.

Enrolment Trends and Gender Balance

In this part, it is attempted to give answers to the enrollment trends in undergraduate physics programs at national level with special emphasis on Hawassa University. In addition, the extent of gender balance in terms of enrolment and graduation will be discussed. The data in Table 1 portray that in 2007/8 a total of 13, 606 students were enrolled in basic science and mathematics fields which consist of biology, chemistry, mathematics and physics. Out of the total enrollment in these fields, the share of physics was only 16.2% (n = 2208).

The closer look into the proportional share of male and female students' with respect to enrollment and graduation in the selected ten universities in Ethiopia, it generally concurs with the existing findings in European and North American contexts. As depicted in Table 1, of the total of 2208 physics undergraduates in the ten universities there were only 175 female students. According to the data gathered by the MoE in 2006/7 (MoE, 2008) at national level, for every 100 male students there were only between 7 and 8 females. Thus, this is a clear evidence to suggest an extremely alarming situation when it comes to bringing females into physics as well as

Table 1. Enrolment and graduation in physics(2007/8)

Institution	**All PhysicsUndergraduate Enrollment(2007/08)**			**Graduation(2008)**		
	N	**F**	**F(%)**	**N**	**F (%)**	**Total (Physics%)[a]**
Addis Ababa University	543	72	13.3	82	6(7.3)	2777(19.6)
Adama University	58	25	43.1	-	-	313(18.5)
Arbaminch University	221	10	4.5	30	1(3.3)	1271(17.4)
Bahir Dar University	221	13	5.9	56	2(3.6)	1774(12.5)
Dilla University	245	9	3.7	50	4(8.0)	1367(17.9)
Gonder University	142	1	0.7	44	2(4.5)	1,101(12.9)
Haramaya University	196	11	5.6	52	6(11.5)	1264(15.5)
Hawassa University	110	0	0	32	0(0)	1364(8.1)
Jimma University	279	31	11.1	94	8(8.5)	1268(22.0)
Mekelle University	193	3	1.6	67	0(0)	1104(17.5)
Total	**2208**	**175**	**7.9**	**507**	**29(5.7)**	**13,606(16.2)**

Source: Computed from: Education Statistics Annual Abstract: 2006/7, Ministry of Education, 2008

[a]figures in parenthesis are percentage of Physicsstudents in the undergraduate natural science streams

Table 2. Undergraduate enrolment in basic science fields at Hawassa University

Department	**Undergraduate program(2008/9)**								
	Year I		**Year II**		**Year III**		**Total**		
	BS	**F**	**BS**	**F**	**BS**	**F**	**BS**	**F**	**% F**
Biology	598	265	84	25	92	22	774	312	80.6
Chemistry	400	40	64	8	87	7	551	55	14.2
Mathematics	250	25	52	4	74	-	376	19	4.9
Physics	207	-	41	1	34	-	283	1	0.3
Total	**1455**	**315**	**241**	**38**	**287**	**29**	**1984**	**387**	**100**
% Total	**73.3**	**15.9**	**12.2**	**1.9**	**14.5**	**1.5**	**100**	**19.5**	**100**

Source: Computed based on data obtained from HwU Registrar's Office, April 2009.
Note: BS = Both Sex; F = Female

ensuring their inclusion in science and technology.

As can be discerned from Table 1, of the total of 2208 students enrolled in 2006/7 only 175 (7.9%) were females while the number of female graduates were 29 which only accounts for 5.7%. In some universities such as Hawassa and Mekelle there were no female graduates. The maximum proportion of females was reported at Haramaya University which accounts for about 11.5% (n = 6) while Arba-Minch and Bahir Dar Universities reported respectively 1 and 2 female graduates in the same academic year.

As shown in Table 2, the number of year I students (n = 1455) enrolled in 2008/9 academic year far exceeds the number of year II and III students added together. It accounts for over 73% of the total number of students that joined the programs. On the other hand, unlike the previous years, the size of female students enrolled in 2008/9 is far greater than in the previous two years. Nevertheless, consistent with the national scenario the percentage of females in the departments of chemistry, mathematics, and physics is very small. To make it worse, in 2008/9 no new female student was assigned to physics and no single female graduate in physics in the same academic year. Under such circumstances, it is naïve to assume that females are getting their role models anytime soon in the so called hard sciences. Paradoxically, the university considers relieving female students from joining these fields as an "affirmative action" which might as well be viewed as systematic marginalization of women from the main stream of science. Regarding this the head of the department at Hawassa University has to say the following:

> Girls are not encouraged to study physics like high achieving males have not been persuaded to do the same. Hence, often we have single-gender classrooms. As part of its affirmative action policy, the university wants to ensure fewer girls to join physics justifying its actions with what it called 'minimizing the attrition of female students'.

Interestingly enough, the underrepresentation of females is not resulted from their own lack of interest *per se*. But most importantly, their entry into physics and other so called hard sciences such as chemistry has been effectively discouraged at institutional level. The paradox is that as a matter of regulation, 30 % of the sits in all fields is reserved for female students. In the remaining 70%, male and female students compete for the sits based on their grades they scored in NHEE. According to this formula, majority of the female students join biology and the remaining few will join chemistry. As can be seen from Table 2, of the total 387 female students in the FNS, the salient majority (80.6%) were assigned to biology, followed by chemistry (14.2%), and Mathematics (4.9%) while only one female student (0.3%) was assigned to physics. This apparently presents a serious problem to physics as a field of study. Apparently, physics is viewed as an exclusively male preserve and this has unfortunately been perpetuated institutionally. Though this is actually reveals the case of Hawassa University, the same procedure is at work in all public HEIs, as can be verified from the data across all the institutions.

Who is Joining Physics? Student Enrollment in Physics

In order to get a sense of the student entry characteristics, it is important to look at the pre-university achievement which is used as the criterion to assigning students into the various programs. At this juncture, it is vital to note that students are allocated centrally by the Federal Ministry of Education in Addis Ababa to broader academic streams like natural sciences, engineering, medicine, social science, business and economics, teacher education and the like. The aforementioned allocations to specific academic programs are done by respective HEIs using students' aggregated test scores that combined NHEE and the two-year pre-university achievement each of which account for 50%. Table 3 below presents mean scores and the results of a univariate ANOVA.

The one-way ANOVA was run to compare the mean aggregated scores and the results show (see: Table 3) a statistically significant differences among the mean scores [$F(7,599) = 311.45$, $p < .0001$]. A further post-hoc mean comparison using the *sheffe'* procedure clustered the means into four distinct groups categorizing the science fields (biology, chemistry, mathematics, and physics) in the first two subsets while that of the engineering streams namely [civil engineering (CivilEng), electrical engineering (EleEng), irrigation engineering (IrrEng) and agricultural engineering and mechanization (AgeM)] into two separate subsets. The statistically significant variation ($p < .05$) among the mean scores in favor of engineering fields indicate that majority of the students joining the basic science streams were in deed the low achievers in NHEE.

It is interesting to note that the first two clusters containing the low mean achievement scores (see Table 4) identified the four basic sciences programs (physics, mathematics, chemistry, and biology) while the 3rd and 4th clusters contained engineering fields. The highest mean achievement is civil engineering (Mean = 765.63) while the lowest is physics (Mean = 589.35). The pattern in Table 4 below depicts the steady decline in the magnitude of the mean score as one

Table 3. F-test of mean scores on NHEE comparing natural science and engineering streams (2007/8 Academic year)

Field	N	Mean[a]	SD	Max	Min	F-test
Biology	100	613.5	30.76	690	558	
Chemistry	90	600.7	40.57	693	536	
Mathematics	60	591.7	22.70	638	538	
Physics	49	589.3	28.49	692	537	311.45*
Civil Engineering	83	765.63	44.55	905	689	
Electrical Engineering	81	751.93	59.14	880	629	
Irrigation Engineering	80	722.02	27.02	744	612	
Agricultural Engineering	64	701.06	17.69	742	628	
Total	**607**	**670.33**	**79.69**	**905**	**536**	

* $F(7,599) = 311$, $p < .0001$

[a] Aggregated mean score summing up scores on NHEE and mean scores on

Table 4. Sheffe' post-hoc test results of mean scores

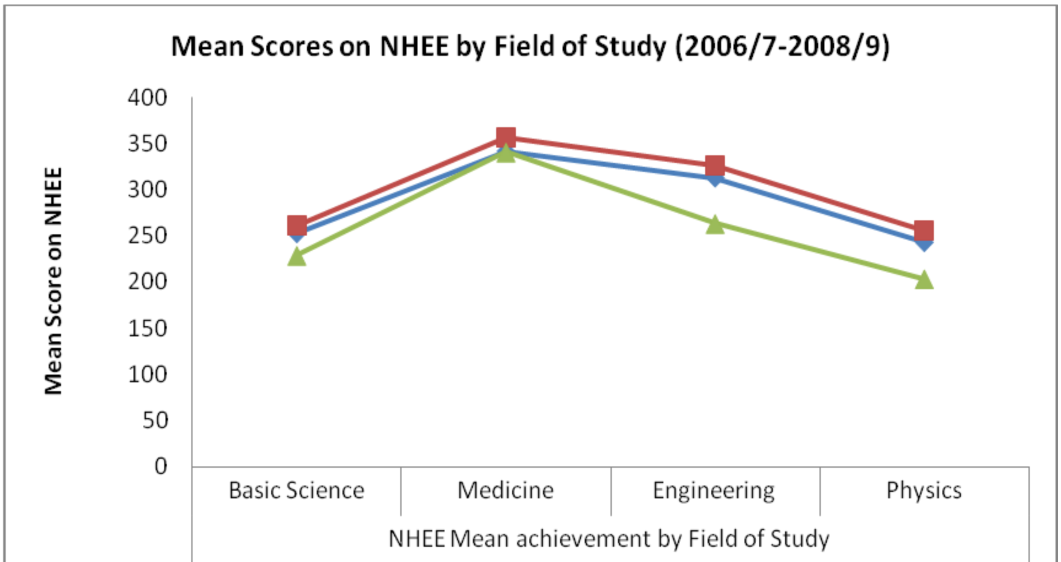
Fields of study	**N**	**Homogenous**	**Subsets (alpha = .05)[a]**		
		1	**2**	**3**	**4**
Physics	49	589.35			
Mathematics	60	591.73	591.73		
Chemistry	90	600.74	600.74		
Biology	100		613.50		
Agricultural Engineering	64			701.06	
Irrigation Engineering	80			722.15	
Electerical Enginerring	81				751.93
Civil Engineering	83				765.63
Sig		.846	.092	.177	.672

[a] The four homogenous subsets or clusters are designated by 1, 2, 3, and 4 have categorized the mean scores since there is a difference that achieved a statistical significance less than alpha . 05. On the other hand, as indicated in the last row, the significance level for means under the same cluster or homogenous group is far beyond .05.

move from engineering to science fields with the lowest mean being physics to be followed by mathematics, chemistry, and biology.

In order to capture the bigger picture as to where the science streams stand vis-à-vis other fields such as medicine and engineering, a three year (2006/7-2008/9) student allocation pattern was studied. As shown in Figure 1 below, the means score i.e. the mean scores in only the National Higher Education Entrance Examination (NHEE), basic sciences classified under the lowest achieving category compared with engineering and medicine. Again, it is interesting to note that the mean scores of those joining physics, chemistry and mathematics are categorized under the least achieving group of students compared to any other group included in the analysis. More importantly, the average score of those assigned to physics achieved the lowest vis-à-vis the students assigned to basic science and mathematics. This is a disturbing finding particularly for a country that thrives to build its human resource in science and technology.

Secondly, the data in Figure 1 also show that the mean NHEE scores have shown a significant decline for all groups in 2008/9 academic year. Thus, no matter in which field of study, the average mean score is the lowest for the student cohort enrolled in 2008/9 academic year. On the other hand, as depicted in Figure 1, the data over the past three years portrays a consistent pattern that confirms basic sciences are indeed for the low achievers. In particular, physics has been relegated to the least achievers as revealed by the group means in NHEE scores over the past three academic years (i.e. 2006/7 to 2008/9).



	Basic Science	Medicine	Engineering	Physics
2006/7	252.49	341.33	312.65	242.76
2007/8	260.71	356.94	326.11	254.9
2008/9	228.76	340.51	263.23	203.26

Source: Registrar's Office, April 2009. Note: Data on the table show mean scores on NHEE; The mean scores under "Basic Science" refers to Biology, Chemistry, Mathematics, and Physics.

Figure 1. Allocation of students to various disciplines by mean NHEE Score (2006/7-2008/9)

Factors Impinging on Choosing Physicsas a Major Field of Study

In order to find out the explanations behind low interest to join physics, interviews were conducted with second year and final year physics majors and Lecturers of the department of physics at Hawassa University. The results are presented below. The following summary in Table 5 shows the recurrent issues identified by majority of the students (60%; n=15) and at least three out of five faculty members in the sample cases for the study:

Physicsis too abstract and less applicable

Even though conflicting findings exist in the literature (e.g., Park & Lee, 2004; Schecker, 1992; Song & Black, 1991) regarding the use of context-based physicsproblems, there is evidence to suggest that the use of every day contexts helps to acquire interpretation skills (Song & Black, 1991)

Interview results show that students are of the opinion that physics is too abstract to make sense of it in relation to their life contexts. This distorted conception of physicsis not new in a sense that previous studies (Schecker, 1992; Redish, 1994; Ornek, Robinson, & Haugan, 2008) raised them as a long standing and still unresolved issue as long as physics education is concerned. For instance, Schecker's (1992) argued that "physicsis an idealized world and thus little to offer to the real world. However, there are obvious reasons to argue on the part of the students based on their own experience. It is interesting to note what a first year physicsstudent has to say in this regard.

> A new topic always starts with a formula and a definition. For example, as in the formula: velocity = distance/time what we were taught was how to calculate velocity by inserting the given values for distance and time. This however does not mean that we indeed know what velocity is. Neither the teacher nor the textbooks clearly explain why we learn the concept of velocity and how we should interpret the results in our day-to-day life. We are expected to learn all the formulas by heart and use

Table 5. Reasons for not choosing physics

	Students' reasons for not choosing physics	**Faculty members' reasons for students lack of interest to join physics.**
1	Limited job opportunities in the industrial sector that can employ physics graduates in Ethiopia. And if there is any, the curriculum we are being trained with could not make us competitive.	Students who have higher physics achievement and strong academic background do not want to join physics because the only job opportunity open for graduates is teaching career.
2	Physics is too abstract and theoretical such that one can not see the application in the day to day life.	The curriculum focuses on traditional undergraduate topics e.g.: Mechanics, heat, optics, etc…the learning of these topics is largely based on memorization of the laws of physics, formula, and definitions. And its applications to real world or the world of work is weak.
3	The knowledge and skills acquired in high school is inadequate to be a physics student. The major topics that are necessary for higher physics in college have not been treated in reasonable depth and breadth. Teachers only focus on covering the topic and just rush to finish the contents.	The demanding nature of physics in terms of requisite mathematical knowledge and skills discourage most students specially girls and force them to opt for biology where no quantitative knowledge and skills are very essential.
4	Weak background in mathematics which is very critical to study physics	The absence of sufficiently qualified physics teachers at high school level.
5	Lack of relevant and sufficient textbooks that helps students understand physics concepts and theories.	Absence of hands-on practical exposure in physicslaboratories due to lack of equipment and consumables.
6	The academic and professional qualification i.e. subject matter knowledge is very limited - most of them were not themselves well-qualified to teach pre-university school physics.	English is a foreign language though it is a medium of instruction in high schools and universities. Thus, poor English language skills have made important contribution for low performance and interest in physics.
7.	Teachers in high school did not cover all important topics of physics they have a tendency to spend half of the instructional time in one or two topics (e.g.; usually limited to problems and computations in areas like mechanics and optics) to the exclusion of others.	Physicstextbooks are just copies of those used in UK or USA or the same textbooks that do not consider specific geographical and cultural realities.

Source: Interview data

> them in the exam. I really don't know what my future look like if I am to graduate in Physics.

This fully concur with Redish (1994) analyses in that physics teachers failed to realize the fact that students may not understand equations and graphs since students come with their own conceptions. Hence, indeed teachers and students live in two different worlds. A similar study titled: "What makes physicsdifficult?" also concluded that faculty members have difficulty understanding what students' problems are (Ornek et al., 2008, p. 34). This actually calls for a closer analysis of what was observed in the classroom. Most importantly, the issue of pedagogical content knowledge (PCK) that physicsteachers in school and college need to understand regarding students' problems is discussed below.

Qualified and innovative teachers: Content and pedagogical knowledge and skills

The absence of qualified physics teachers/instructors both in secondary schools and higher education institutions is the other obstacle as identified by interviewing students as well as instructors (see Table 5). Further evidence is obtained from class room observations were made among sophomore and senior year physics majors. The narrative reports of the two observers (Observers: I and II) are strikingly similar in essence except for their differences in phrasing. To avoid redundancy, one of these narrative reports will be in order. Accordingly, the report by Observer II states:

> In class instructors rarely give chances to the students to respond to their questions. When they do they did not wait until students were ready to replay. They often prefer to give the answer and move on to the next topic at hand without clearing students' confusions or without making sure that the students are ready for the next lesson. It was only in one class that the instructor has told students what they will be doing by the knowledge they will obtain.

Hence, it can be argued that efforts to make class lectures attractive and student-centered is lacking as the obsession of most instructors is to cover the topic they planned for the semester. It is interesting to note once again that the instructors are to blame for making physics complex and unattractive as they are the ones who take them to the next topic without making sure that they have the pre-requisites. This scenario is a commonplace according to students' views revealing instructors' lack of both pedagogical as well as pedagogical content knowledge (PCK). This is consistent with Redish (1994) who referring to physics teachers, emphatically asks: "Is it any wonder why we don't understand most of our beginning students and they don't understand us?" (p. 802). At this point, he seem to underscore instructors' failure to understand their students' problem in the one hand, and their inability to allow the latter's participation via employing student-centered learning on the other. In turn, this indicates the absence of pedagogical knowledge and skills required to address students' concerns and persuade them to develop solid interest to study Physics.

Curriculum and job opportunities

With regard to the curriculum though the graduate profile indicates that its graduates can be employed in areas of metrology, nuclear medicine, and geophysics, there are no courses that validate the assertions. The review of the existing physicsundergraduate curriculum at Hawassa University (Debub University 2003) show that the declared profile of the graduates is not in par with the courses offered in the program. Accordingly, the closer look at the courses offered in the program refers to traditionally offered courses like mechanics, heat, optics, electricity, magnetism etc. Hence, there is no evidence to suggest that would be graduates have indeed undergone the required training. The other key problem identified as discouraging students to join physics include, the absence of sufficient depth and breadth of treatment of physicstopics. Both students and instructors agree that most students come with insufficient knowledge and skills from high school. These findings are consistent with a recent study among pre-university students in southern Ethiopia (Assefa et al., 2008). In this regard, the study by Schwartz et al. (2008) offers an empirical support indicating that students who had an in-depth coverage of high school physics were found to be successful in college compared to those who had a wider coverage of physics topics. Hence, it is not surprising if students refrain from joining physicssince they are certain that they have insufficient conceptual/theoretical knowledge and limited hands-on experience to be successful in college.

Limited job opportunities

The interview with students also identified lack of job opportunities for physicsgraduates outside of the teaching profession. One of the academic staff who took part in the interview has to say the following regarding job opportunities of physicsgraduates as related to the relevance of the curriculum offered to the existing labor market demand:

> The industry cannot employ graduates of all institutions who have the same specialization. For instance, physicsstudents should be allowed to vary in their concentration areas so that differentiated areas of specialization may open possibilities to take specific courses which might create new career paths for would be graduates and minimizes the risk of being redundant.

This is a very critical issue that needs to be addressed to attract promising students into physics. In some countries such as the Netherlands and the USA several alternative measures were taken to bolster the attractiveness of physics via introducing a range of alternatives in terms of course combinations. According to Tobias and Birrer (1999) for instance, introducing an unusual major/minor combinations such as physicsand finance which allow graduates to contribute to the system design and analysis or “regulation law” which would prepare graduates to work with engineers and managers in planning and design projects or with environmental safety or other regulatory bodies as possibilities to increase the attractiveness of physics.

Laboratory hands-on practice

The lab observation report reveals that students’ learning of practical physics have been affected by two major factors (a) lack of adequate laboratory instruments and equipment and (2) course structuring, which failed to consider alignment of theory and practice. Accordingly, the lack of adequate instruments and resources limited the direct hands-on practical exposure of students as revealed in the lab observation. In this regard, the narrative reports of both observers clearly show the shortage of equipments, and the extremely limited opportunities for hands-on practice individually. In this regard, observer I wrote:

> Though laboratory space is not a problem [resulting from low enrolment to other science streams], due to shortage of equipments students have to be divided into 5-member groups and take turns to look at the laboratory demonstration by the technical assistants. Hence, individual students have limited opportunities for direct contact with the equipments.

The laboratory observation further revealed how the lack of direct interaction with equipments impacted their understanding of practical physics lessons (see Figure 2). In this connection observer I reported:

> During demonstrations by the technical assistant (see: Figure 2) some students seem to understand what the equipments meant to do and the measurements that they are supposed to make during the experimentation. However, for most of the students this "understanding" of the use of the lab apparatuses did not translate into actual use.

Apart from lack of opportunities for direct physical contact with lab instruments the organization and the sequence of courses has its own bearing in terms of aligning theory and practical training. In addition, the two observers completely agree that majority students had difficulty recalling the theoretical lecture since they took these courses at least before at least one semester. Hence, the narrative report by observer II briefly describes the scenario:

> Even though the lab sessions and course works are designed in such a way that the lab sessions are a direct application of course works, it lacks integration due to inappropriate sequencing of the courses. The lab practical sessions that should directly follow the course work are not properly sequenced. In some cases, practical laboratory courses are offered after two or three semester. Hence, the lab technical assistants were forced to go back to the courses they have taken before.

Overall, the findings based on the laboratory observation are consistent with the results of students' and teachers' interview. Hence, there is adequate evidence to suggest that the abstract nature of physicsfurther complicated by the absence sufficient practical exposure. This can negatively affect students' attitude towards Physics.

Physics entails strong mathematical background

As shown in Table 5, both students and teachers agree that "physics requires strong mathematical background". Specifically, students argued that studying physics require higher mathematics

(a) (b)

Figure 2. Undergraduate physicsstudents in laboratory setting.

which most of them said to have lacked in their background. In quite the same way, teachers were of the opinion that student fail to understand physics concepts due to their poor mathematical knowledge and skills required. Surprisingly, these findings only partially confirm a recent study by Ornek et al. (2008) though it is consistent with Sadler and Tai (2001). Ornek et al. reported that students and technical assistants (TAs) disagreed with their instructors regarding the need for better mathematical background to study physics while Sadler and Tai (2007) have found that mathematics to be the single most important predictor of success in all science subjects in college which also included physics.

Poor background in physics

Again as reported by students and teachers, the other key factor that negatively impacts on the choice of physics as a major field of study is their deficient high school preparation. Students relate their poor preparation with the qualification of their teachers, lack of adequate and relevant textbooks, absence of an in-depth understanding of the major topics relevant to university study and lack of practical laboratory work. In the same manner, instructors admit that poor qualification of high school teachers and insufficient english language proficiency among students to read and understand physics concepts are some of the major factors that come into play. Furthermore, physics textbooks used in high schools and universities are just copies of those used in the UK and USA and have little connection to physical/geographical and cultural realities in Ethiopia. Therefore, the learning experiences selected and the examples used in these textbooks have limited relevance to Ethiopia. This serves as case in point to demonstrate the disconnection of western knowledge with realities of countries in Africa.

Conclusions and Implications

This paper attempted to answer three major questions. First, it set out to examine whether or not there exist differences in enrolment rate and gender balance. Second, it endeavored to find out achievement differences between students assigned to physics and other basic science and engineering fields using NHEE. Third, it was meant to identify the factors that affect the choice of physics as a college major based on primary sources. The findings indicate that the size of undergraduate students joining physics programs was low even compared to other basic science streams such as biology, chemistry, and even mathematics in all the selected public universities in Ethiopia. On the other hand, the study found out that the average achievement of students assigned to physics undergraduate programs was low compared to all groups in science and engineering streams. Specifically, those who have achieved higher in NHEE are assigned to streams such as engineering and medicine while the average achievements of physics students between 2005/6-2007/8 in NHEE found to be markedly lower than those assigned to biology, chemistry, and mathematics. Thus, physics is apparently left for less prepared and unmotivated students.

With regard to gender balance, the findings revealed that of the total 2208 students enrolled in 2006/7 only 175 (7.9%) were females. Further, of the total of 507 physics graduates at national level, the number of females was only 29 (5.7%) in the ten major public universities. At this juncture, though not surprising it is interesting to note to what extent females are underrepresented in the field of physics. It was also disclosed that institutional policies related to female affirmative action apparently played an unintended role by facilitating the exclusion of females from main stream science since they failed short of enacting institutional measures which boosts females' interest to join physics.

Regarding the factors that underpin low enrollment and lack of interest to study physics in college, a number of factors were identified by students and instructors participated in the study. The major factors include: the absence of employment opportunities for physics graduates other than teaching career, poor students' mathematics background which is indispensable to study physics, the abstract and theoretical nature of the courses offered in school and university, poor qualification of teachers, inadequate hands-on experience, limited learning resources (mainly textbooks), and generally irrelevant curriculum that can prepare students to work in science and technology.

Further, the findings showed that the qualification and pedagogical competence of physics teachers stands as another key challenge. It is indicated in the interview with students that their teachers lack the skills to concretize theoretical and mathematical notions of physicsin a manner that is comprehendible to them or linked to their everyday life situations. Not only that, the lack of an in-depth coverage of high school physics along with teachers' exclusive focus on specific topics was also partially responsible for eroding their confidence in physics as their future career.

As related to the undergraduate physics curriculum, the findings show that there is a mismatch between the declared graduate profile and the course offering in the program which implies that in some cases courses are assigned to match the intended profile. On the other hand, the intractable nature of the program that do not allow students to choose specific areas that goes along with future career aspiration in terms of elective courses has been the other key impediment for physics to attract better qualified candidates.

Policy Implications

As it is apparent, basic sciences in general physics in particular, has been increasingly marginalized and are virtually left for less competent and predominantly male students in Ethiopian universities. On the other hand, the Ethiopian Federal Ministry of Education has recently introduced a new policy that assigns 70% of its pre-university preparatory program completers to science and technology. Of these, 40% will go to natural and computational sciences (MoE 2008). Notwithstanding the fact that physics is the key discipline to produce qualified engineers, scientists, teachers, and researchers, as it stands, its compromised position to attract academically able students clearly undermines the policy that looks for more young people in these fields. Hence special emphasis should be given to adjust physics curricula to the needs of the students and of the world of work.

The lack of content and pedagogical content knowledge (PCK) among school teachers and college physics instructors have also been identified as reason not only for students' learning problems, but also for the low level of confidence demonstrated to elect physics as a major field of study. It is clear from the findings that poorly prepared students would join college and taught by less competent instructors and graduate with their deficiencies to teach in school or work as a physicist elsewhere. This portrays a vicious circle of incompetence that seriously affect human capital accumulation in the area of science and technology in general and in physics in particular.

The exclusion of women reached an alarming proportion where no single graduate in physics was to be found in some universities. At national level, the average share of females in physics undergraduate programs is 5.7%. Institutions seem to camouflage female underrepresentation in fields such as physics by only reporting overall institutional level female enrolment rate while at the same time failing to boost their entry into physics. To date, little attempt has been made to encourage women to join non-traditional subjects such as physics and limited work seem to have gone into getting female role models in such fields. In addition, universities cannot give a convincing justification not only for assigning only male students without their interest, but also for letting physics to be made up of exclusively low achievers.

This has to be changed should the new policy of professional mixes in Ethiopian higher education is to succeed in accumulating capable human capital in science and technology.

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Fiziği kim neden istiyor? Etiyopyalı öğrenciler arasında fizik tercihini etkileyen faktörler

Bu makale öğrencilerin fiziği esas çalışma alanı seçmelerini etkileyen faktörleri ve kaydolma eğilimlerini araştırmaktadır. Veriler birincil ve ikincil kaynaklardan elde edilmiştir. Birincil veriler yarı yapılandırılmış görüşmelerle Etiyopya Hawasa Üniversitesi fizik bölümünde okuyan 14 ikinci sınıf, 11 son sınıf üniversite öğrencisinden ve beş öğretim elemanından elde edilmiştir. İlaveten, veriler hem farklı tasniflere ayrılmış esas alanlardan hem de akademik başarı ile ilgili nicel veriler üniversite kayıt ofisinden elde edilmiştir. Sonuçlar fiziğe kayıt olma oranlarının en düşük, başvuruların da Etiyopya Milli Yüksek Eğitim Giriş Sınavında ortalama puanlarının karşılaştırılan herhangi bir gruba göre en düşük olduğunu göstermiştir. Ayrıca bulgular kayıt olma ve mezun durumu açısından örneği görülmemiş bir eşey uçurumunu göstermektedir. Düşük kayıt olma oranı; yetersiz üniversiteye hazırlık, zayıf matematik temeli, öğretmenlik dışında iş bulma olanağının kısıtlı olması, yetersiz öğretmen niteliği ve pedagojik içerik bilgisi ile açıklanabilir. Sonuç olarak bu makale Etiyopya da tehlikeli düzeyde gerileyen fizik eğitiminin durumunu desteklemek amacıyla gerekli politik önerileri adres göstermektedir.

Anahtar kelimeler: kayıt, eşey dengesi, fizik, Etiyopya