

The upshot of availability and utilization of Science laboratory inputs on students' academic achievement in high school Biology, Chemistry and Physics in Ilu Abba Bora Zone, Southwestern Ethiopia.

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Abstract-Science laboratories have a paramount role in teaching and learning process of practical activities. Descriptive survey method was used to investigate the upshot of the availability and the extent of use of available biology, chemistry and physics laboratory inputs on students' academic achievement in high schools of the Ilu Abba Bora Zone, Southwestern Ethiopia. Multistage cluster sampling technique was used to select randomly a total of 408 students and 100 teachers from 12 high schools. Questionnaire, science laboratory input checklist and student result data sheet were used to gather data for the study. This study indicates that, shortage and ineffective use of science laboratories in the high schools correlates with poor achievements of students in standardized Ethiopian General School Leaving Certificate Examination (EGSLCE). The less availability, improper handling of available resources and the improper use of science laboratory items lead to the wastage of resources, less effectiveness of science laboratories and lower academic achievement of students in the high schools of the Ilu Abba Bora Zone, Southwestern Ethiopia.

Index Terms- Science laboratories, inefficient use, academic achievement, Ilu Abba Bora zone

I. INTRODUCTION

Science laboratories are the backbone of teaching practical activities. It is very difficult to teach as well as learn science practical activities in the absence of science laboratories. Learning science greater and the understanding level is best when students are involved in the science laboratory for practical experiments (Anderson, 2007; Hofstein & Lunetta, 2004). When science laboratories are effectively used for teaching and learning process, it improves students ability and skills which include: ability to pose scientifically oriented questions, ability to formulate hypothesis, ability to design experiments, ability to undertake scientific experiments, ability to formulate and revising scientific enlightenments, and ability to converse and defend scientific arguments (Hofstein, Navon, Kipnis, & Mamlok-Naaman, 2005)(Akçayir, Akçayir, Pektaş, & Ocak, 2016). Hence, science laboratory is a very important resource input for teaching science and is an important predictor of academic achievement besides other factors. However, the availability of resource inputs has no value for the attainment of academic objectives as until they are effectively utilized in teaching learning process(Glewwe, Hanushek, Humpage, & Ravina, 2013) (Dahar & Faize, 2011).

Ethiopia is one of the rapidly growing countries in Africa. This fast growing Ethiopian economy will demand high caliber manpower in the area of natural science and technology. For this reason, due attention is given more for training of students in the area of natural science and engineering. The intake of students in the higher learning institution in Ethiopia is based on 70:30 (70% natural science, engineering and technology, 30% social sciences) which fosters the need of trained manpower in the intended area (Molla, 2012). To this extent, qualities of education

in the country, especially in the areas of natural and computing sciences have required special attention than ever. Science laboratories are the basic input to deliver quality education in computational sciences. However, there is no report on the current situation of high schools in Ethiopia regarding to the status and use of science laboratory to improve students academic achievement in natural science subjects. To this end, this study aims to investigate the upshot of availability and use of science laboratories on the academic achievement of students in Ilu Abba Bora Zone raising the following research questions.

1. Are there sufficient science laboratory resources in the high school laboratories of Ilu Abba Bora Zone to teach practical activities?
2. Does the available laboratory resources properly used in the high schools for student learning?
3. Does the current availability and the way of the use of science laboratory resources in the high schools have an impact on students' academic achievement?

Delimitations of the Study

Students marks of Ethiopian General School Leaving Certificate Examination (EGSLCE) 2013 in Biology, chemistry and Physics are taken as academic achievement.

Limitations of the Study

This study did not measure the influence of socioeconomic status and family background of students on academic achievement of students. In addition, students personal initiative, like utilizing extra time for studying are not measured due to limited time and resources.

II. METHODOLOGY

Study area

The study was conducted in Ilu Abba Bora Zone having a total area of 15,135.33 square kilometers. It is located: 07°40' Lat and 36°50' Long, at an altitude of 1700-1750m above sea level.

Study population

The total number of secondary school students in Ilu Abba Bora Zone during 2012/13 academic year was considered as the study population. Accordingly the total number high schools students are 23,983 (male= 11595 Female=12388).

Sample size and Sampling technique

The two-stage cluster sampling technique was employed, which involves grouping of the schools into two clusters. Based on population size of the clusters proportional number of the total sample size was assigned to each cluster. The simple random sampling technique used to select schools from each cluster and students from each section of grade 10 at school level after assigning proportional number students in each section. Accordingly, 408 students were selected for the study. The study also included 100 teachers that have been teaching Biology, Chemistry and Physics and also school leaders and laboratory technicians in each school included in this study.

Research Instruments and data collection

The instruments used for this study were questionnaires, checklist and Student Result Data Sheet" (SRDS) as previously discribed by Dahar & Faize (2011) with minor modifications. Pre-evaluated questionnaires were distributed to biology, chemistry and physics teachers on the effective use of science laboratories. Similarly, questionnaires were distributed to students to assess to what extent they participate in the school laboratory. Checklist was prepared on the availability of necessary laboratory input to teach practical activities of the existing high school Biology, Chemistry and Physics curriculum. The extent of availability of the necessary laboratory input was evaluated out of 4 based on the checklist. Similarly, the extent of the use of science laboratory for the teaching learning process is also evaluated out of 4. Student Result Data Sheet (SRDS) was used to collect students' results of Ethiopian General School Leaving Certificate Examination (EGSLCE). The collected data were summarized at the school level.

Statistical analysis

Statistical package for the social science (IBMPSS) for windows (Version 20) software was used for the statistical analysis of the data. The data were analyzed as earlier described by (Dahar & Faize, 2011). Availability and extent of use of laboratories were evaluated out of 4 and summarized at school level, this was done to obtain continuous data for further analysis. The Pearson Correlation Coefficient was used to analyze and find out the value of the relationship (association) between the availability and the use of science laboratories (independent variables), and academic achievement of students (dependent variable). The stepwise regression analysis was used to analyze and find out the differential impact (causal relationship) of use and availability of science laboratories on the academic achievement of students. Accordingly, t-value was obtained to determine the magnitude of the differential impact (causal-relationship) of use and availability of science laboratories on academic achievement. Significance of t-value and the direction of t-value was used to estimate the magnitude of correlation. The negative direction of t-value was interpreted as a minor role in the education process and an inverse effect on academic achievement. The level of significance was set at 0.05.

III. RESULT AND DISCUSSION

The analysis of availability of science laboratory inputs (Equipment, apparatus and Chemicals) in the high schools

Although science laboratories are compulsory for teaching practical activities, in 4 (33.33%) high schools (Chewaka, Nopa, Borecha and Lalo) science laboratories are totally absent. The other high schools in the zone are also ill-equipped. Based on the survey made, only two (16.67%) of the high schools in Ilu Abba Bora Zone have sufficient biology laboratory inputs to teach the practical activities (Figure 1). Five high schools (Alge, Bedele, Bure, Gore and Nagaya) have sufficient chemistry laboratory inputs. Only three of the high schools have sufficient physics laboratory input while the others are badly equipped. The unavailability and shortage of science laboratory inputs in the schools create problems to cover portions related to practical activities that results in non-attainment of the curriculum objectives. Facilities are an important factor for the healthy functioning teaching learning process and their availability, adequacy and relevance influence academic achievement of students (Edwards, 2006).

Table 1. Availability of biology, chemistry and physics laboratory inputs, in the high schools of Ilu Abba Bora zone, southwestern Ethiopia.

Science laboratory inputs	N=12					
	Very sufficient (4)	Sufficient (3)	To some extent (2)	Insufficient (1)	Not at all (0)	
Availability of biology laboratory inputs	No.	-	4	2	2	4
	%	-	33.33	16.67	16.67	33.33
Availability of chemistry laboratory inputs	No.	-	5	1	2	4
	%	-	41.67	8.33	16.67	33.33
Availability of physics laboratory inputs	No.	1	3	2	2	4
	%	8.33	25	16.67	16.67	33.33
Availability of chemicals	No.	1	3	2	2	4
	%	8.33	25	16.67	16.67	33.33

N= total number of high schools included in the study

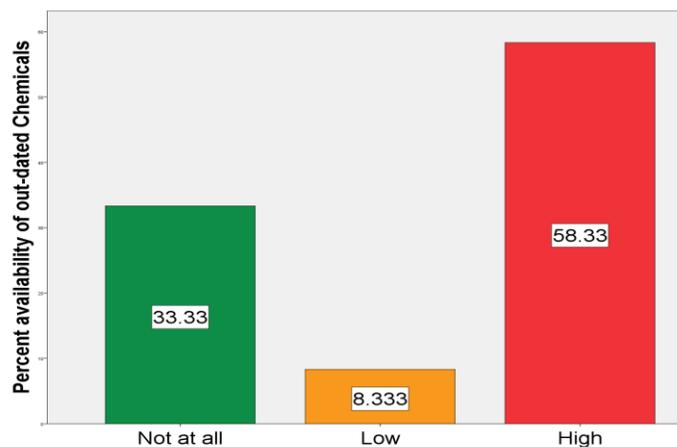
Further, the mean availability of laboratory inputs in each school was evaluated out of 4 based on the existing curriculum. Out of 4, the mean of the availability of biology input was 1.5 (table 2). The mean of the availability of chemistry and physics laboratory inputs was similar i.e. 1.58. This indicates that schools are highly deficient in science laboratory inputs to undertake the current curriculum, moreover, the distribution of laboratory facilities are not uniform. As stated earlier, the effectiveness of science education is based only the availability of teaching resources (Balogun, 1982).

Table 2. Analysis of the availability of science laboratory inputs (equipments, apparatus, material and chemicals) (indexed item)

Name of the Variable	Maximum	Minimum	Mean
Availability of biology laboratory inputs	4	0	1.5
Availability of chemistry laboratory inputs	4	0	1.58
Availability of physics laboratory inputs	4	0	1.58
Availability of chemicals	4	0	1.58

Outdated Chemicals

In majority of the schools that have science laboratories, outdated chemicals were high 7 (58.33%). In all the high schools 12 (100%) included in this study, laboratory equipments, glasswares, chemicals were poorly handled (figure 5).



a



b

Figure 1. Percentage distribution of availability of outdated chemicals in high schools of Ilu Abba Bora zone.

Descriptive of student academic achievement

The mean score of student results in biology, chemistry and physics in grade 10 General School Leaving Certificate Examination (EGSLCE) for the 408 students participated in this study was recorded and analyzed. Accordingly, biology had the highest mean score of 47.75 and least a standard deviation while physics had the least mean score. The highest standard deviation was observed in chemistry (table 6). The result shows that the student achievement in grade 10 General School Leaving Certificate Examination (EGSLCE) is below average.

Table 6: Statistical mean of the students' score in Grade 10 General School Leaving Certificate Examination (EGSLCE) score in the schools of Ilu Abba Bora Zone during the academic year 2012/13.

N=408	N	Mean	Std. Deviation
Grade 10 Biology, General School Leaving Certificate Examination (EGSLCE)Score	408	47.75	16.05
Grade 10 Chemistry, General School Leaving Certificate Examination (EGSLCE) Score	408	46	21.5
Grade 10 Physics, General School Leaving Certificate Examination (EGSLCE)Score	408	36.25	19.73

N= total number of students

The correlation of availability of science laboratories and academic achievement of students in high school biology, chemistry and physics

The present study revealed that, the availability of science laboratory equipment, apparatus and chemicals were positively correlated with students' academic achievement in Biology ($r= 0.896^{**}$, $p=0 .000$), chemistry($r= 0.959^{**}$, $p=0 .000$) and physics ($r= 0.884$, $p= 0.004$) (table 7). Similar study showed that, the relationship of equipment, apparatus, material and chemicals in the science laboratory with the academic achievement of students in Punjab schools were positive and significantly correlated (Dahar & Faize, 2011). Similarly, (Ogweno, 2015) explained that availability of school facilities has positive effect on academic achievement of students.

Table 7. Relationship of the availability of biology laboratory inputs (equipments, apparatus or material and chemicals) with the academic achievement of students in biology

Correlation		
No. of Schools: Science Students—N = 408		
Availability of Biology Laboratory Inputs (Equipments, Apparatus or Material and Chemicals)	Correlation	0.896**
	Sig.	0.000
Availability of Chemistry Laboratory Inputs (Equipments, Apparatus or Material and Chemicals)	Correlation	0.959**
	Sig.	0.000
Availability of physics laboratory inputs (equipments, apparatus or material)	Correlation	.884**
	Sig.	.004

** . Correlation is significant at the 0.01 level (2-tailed).

Although the regression analysis about the availability of science laboratory inputs on the academic achievement of students are significant (Table 13), the t-value remains negative for the three subjects, indicating that the shortage of science laboratory equipment, apparatus and chemicals in the high schools of Ilu Abba Bora Zone negatively affecting academic achievements of students in biology, chemistry and physics respectively. Similar study conducted elsewhere also showed that laboratory adequacy affects the academic achievement of students in chemistry (Tatli & Ayas, 2013). In another study, schools with well-equipped laboratories have better results in the school certificate science examinations than those that are ill-equipped (Owoeye & Yara, 2011).

Table 13. The regression analysis of availability of biology laboratory inputs (equipments, apparatus or material and chemicals) with academic achievement of students in biology.

Coefficients ^{a,b,c}

N= 408	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Availability of biology laboratory inputs (equipments, apparatus or material and chemicals)	-0.144	0.041	-0.170	-3.485	0.001
Availability of chemistry laboratory inputs (equipments, apparatus or material and chemicals)	-0.132	0.028	-0.230	-4.771	0.000
Availability of physics laboratory inputs (equipments, apparatus or material)	-.041	0.035	-0.057	-1.157	0.038

- a. Dependent Variable: Academic achievement of students in biology, N= number of students
- b. Dependent Variable: Academic achievement of students in chemistry
- c. Dependent Variable: Academic achievement of students in physics

The correlation of the use of science laboratories on academic achievement

The items of the use of biology laboratory indexed. The mean scores for the use of biology laboratory for each item shown in table 3. The proper use of biology laboratory for students learning positively correlated with the academic achievement of students in biology (table 10). However, the misuse of biology equipments in the school/s ($r= - 0.051$) was negatively correlated to academic achievements of students in biology and the association was significant ($p=0.031$). As stated earlier, the use of science laboratories has an enormous effect, if students are given opportunities to manipulate equipment and materials in order to be able to construct their knowledge of phenomena

and related scientific concepts (Hofstein & Mamlok-Naaman, 2007). This signify that if the school resource effectively utilized for the students learning, it enhance students to understand easily the scientific concepts that leads to better academic achievement. (Mfreke, 2016) also showed that the effective utilization of school facilities for students learnig is positively correlated to students achievement in standardized tests.

Table 3: Analysis of the use of biology laboratory

Questionnaire Items						
	BL Item 1	BL Item 2	BL Item 3	BL Item 4	BL Item 5	BL Item 6
Mean	2.03	1.49	2.26	1.67	1.74	0.98
Minimum	0	0	0	0	0	0
Maximum	4	4	4	4	4	4

BL –biology laboratory

Table 10. The correlation of the use of biology laboratory with academic achievement of students in Biology

Correlation		
N = 408		
Items		
Laboratory rooms are used in the school to teach practical activities in Biology(B L Item 1)	Correlation	0.051
	Sig.	0.301
Biology equipments, apparatus or material and chemicals are used in the school (B L Item 2)	Correlation	0.164**
	Sig.	0.001
Biology teachers have an instructional plan to teach practical activities (B L Item 3)	Correlation	0.842**
	Sig.	0.000
Biology teachers demonstrate and explain use of equipment to students (B L Item 4)	Correlation	0.183**
	Sig.	0.000
Students are actively participate in biology laboratory (B L Item 5)	Correlation	0.876**
	Sig.	0.000
Biology equipments, apparatus or material and chemicals are misused in the school (B L Item 6)	Correlation	-0.051
	Sig.	0.301

** . Correlation is significant at the 0.01 level (2-tailed). B L= Biology Laboratory

The items of the use of chemistry laboratory indexed and the mean scores for the use of chemistry laboratory for each item evaluated out of 4 (table 4). It is evident that, the extent of use of chemistry laboratory to teach practical activities, the degree to which students work with chemistry equipments, apparatus and chemicals, and the degree to which teachers assist students during practical activities were significantly correlated (table 11). The misuse and improper handling of chemistry laboratory equipment and chemicals in the schools were negatively associated with student academic achievement in chemistry ($r = -0.151, p = 0.002$).

Table 4: Analysis of the use of chemistry laboratory

Questionnaire Items						
	CL Item 1	CL Item	CL Item 3	CL Item 4	CL Item 5	CL Item 6
Mean	2.23	1.43	2.87	1.77	1.64	.69
Minimum	0	0	0	0	0	0
Maximum	4	4	4	4	4	4

CL –Chemistry laboratory

Table 11. The correlation of the use of chemistry laboratory with academic achievement of students in chemistry.

Correlation		
N = 408		
Items		
Laboratory rooms are used in the school to teach practical activities in chemistry (CL Item 1)	Correlation	0.216 ^{**}
	Sig.	0.000
Chemistry equipments, apparatus or material and chemicals are used in the school (CL Item 2)	Correlation	0.221 ^{**}
	Sig.	0.000
Chemistry teachers have an instructional plan to teach practical activities in chemistry (CL Item 3)	Correlation	0.509 ^{**}
	Sig.	0.000
Chemistry teachers demonstrate and explain use of equipment to students (CL Item 4)	Correlation	0.762 ^{**}
	Sig.	0.000
Students actively participate in chemistry laboratory (CL Item 5)	Correlation	0.879 ^{**}
	Sig.	0.000
Chemistry equipments, apparatus or material and chemicals are misused in the school (CL Item 6)	Correlation	-0.151 ^{**}
	Sig.	0.002

** . Correlation is significant at the 0.01 level (2-tailed). C L= Chemistry Laboratory

Similarly, the items of the use of Physics laboratory were indexed and the mean scores for the use of physics laboratory for each item shown in table 5. Teachers' having instructional plan to teach practical activities in physics, the use of physics laboratory equipments and apparatus to teach practical activities by teacher, the degree to which students work with materials, apparatus and the degree to which teachers assist students to work with physics laboratory equipments were positive and significantly associated with academic achievements of students in physics. Nevertheless, the misuse of physics equipments in the school/s ($r = -0.118$) was negatively correlated to academic achievements of students in physics (table 12). A study conducted in Nigeria showed that the poor state of performance as well as the mass failure of physics in senior secondary schools is linked to the level of availability and utilization of physics laboratory equipment in Nigerian senior secondary schools (Olufunke, 2012). It further revealed that available and utilized physics laboratory equipment depends largely on the ownership of the schools. The study concluded that science laboratory is a critical variable in determining the quality of output from secondary schools.

Table 5: Analysis of the use of physics laboratory

Questionnaire Items						
	PL Item 1	PL Item 2	PL Item 3	PL Item 4	PL Item 5	PL Item 6
Mean	1.87	1.79	1.50	1.67	1.94	0.59
Minimum	0	0	0	0	0	0
Maximum	4	4	4	4	4	4

PL –Physics laboratory

Table 12. The correlation of the use of physics laboratory with academic achievement of students in physics.

Correlation		
No. of Schools: Science Students—N = 408		
Items		
Laboratory rooms are used in the school to teach practical activities in Physics (PL Item 1)	Correlation	0.092
	Sig.	0.064
Physics equipment's, apparatus or material are used in the school (PL Item 2)	Correlation	0.509**
	Sig.	0.000
Physics teachers have an instructional plan to teach practical activities in physics (P L Item 3)	Correlation	0.412**
	Sig.	0.000
Physics teachers assist students with practical work in the laboratory (PL Item 4)	Correlation	0.031
	Sig.	0.539
Students actively participate in the Physics laboratory (PL Item 5)	Correlation	0.104*
	Sig.	0.036
Physics equipments, apparatus and material are misused in the school (PL Item 6)	Correlation	-0.118
	Sig.	0.711

** . Correlation is significant at the 0.01 level (2-tailed). P L= Physics Laboratory

The differential impact of the use of science laboratory on academic achievement of students.

The regression analysis about (BL Item 3), (BL Item 2) and (BL Item 5) were significant (P<0.05). The variable (BL Item 2) and (BL Item 5) have negative t-value while (BL Item 3) has positive. In the contrary, the regression analysis about (BL Item 1), (BL Item 6) and (BL Item 4) was insignificant (P>0.05) (table 14). This indicates that the proper utilization of laboratory inputs, teacher's guidance and planning to teach practical, the active participation of students during practical activities are the predictors of academic achievement of students in biology.

Table 14. Stepwise regression analysis of the use of biology laboratory on academic achievement of students in Biology

Coefficients ^a		
N= 408	t	Sig.
Biology teachers have an instructional plan to teach practical activities in (BL Item 3)	-3.997	.000
Biology equipment's, apparatus or material are used in the school (BL Item 2)	3.979	.000
Students actively participate in the biology laboratory (BL Item 5)	1.966	.030
a. Dependent Variable: academic achievement of students in biology		
Excluded Variables ^a		
	t	Sig.
Laboratory rooms are used in the school to teach practical activities in biology (B L Item 1)	-1.948	.052
Biology equipments, apparatus or material and chemicals are misused in the school (BL Item 6)	-.714	.476
Biology teachers assist students with practical work in the laboratory (BL Item 4)	-1.694	.091
a. Dependent Variable: academic achievement of students in biology		
b. Predictors in the Model: (Constant), Biology teachers have an instructional plan to teach practical activities in biology, Biology equipment's and apparatus are used in the school, Students actively participate in the biology laboratory (BL Item 5).		

N= number of students, BL= biology laboratory

Similarly, the regression analysis about (CL Item 2) (CL Item 3) and (CL Item 4) has a significant and positive relationship. The value of t is negative for (CL Item 2) and (CL Item 3) while positive for (CL Item 4). However, the regression analysis about (CL Item 1), (CH L Item 5) and (CH L Item 6) are insignificant (p>0.05) and t-value is negative for (CL Item 1) and (CL Item 6) and positive for (CL Item 5) (table 15). This shows that the proper utilization of chemistry laboratory inputs, teacher's guidance and planning to teach practical, the active participation of students during practical activities are the predictors of academic achievement of students in chemistry.

Table 15. Stepwise regression analysis of the use of chemistry laboratory on academic achievement of students in chemistry

Coefficients^a		
	t	Sig.
Chemistry teachers have an instructional plan to teach practical activities in chemistry (CL Item 3)	-1.975	0.049
Chemistry equipment, apparatus and material are effectively used in the school (C L Item 2)	-2.252	0.025
Chemistry teachers assist students with practical work in the laboratory (CL Item 4)	4.627	0.000
Students actively participate in chemistry laboratory (CL Item 5)	0.517	0.015
Excluded Variables^a		
	t	Sig.
Laboratory rooms are used in the school to teach practical activities in chemistry (C L Item 1)	-0.796	0.427
Chemistry equipment, apparatus or material and chemicals are misused in the school (CL Item 6)	-0.140	0.889
a. Dependent Variable: academic achievement of students in chemistry		
b. Predictors in the Model: (Constant), chemistry teachers have an instructional plan to teach practical activities in chemistry, chemistry equipment, apparatus /material are used in the school, chemistry teachers assist students with practical work in the laboratory, Students actively participate in chemistry laboratory		

N= number of students, C L= Chemistry Laboratory

The regression analysis about the extent of students work with materials, apparatus and instruments in the school laboratory (PL Item 5) and teachers having an instructional plan to teach practical activities in physics (PL Item 3) are positively correlated ($p < 0.05$). Both (PL Item 3) and (PL Item 5) have negative t- value. All the other items are insignificant and negative t-value (table 15). This shows that, teacher’s guidance and planning to teach practical and the active participation of students during practical activities are the predictors of academic achievement of students in physics according to this study.

Table 15. Stepwise regression analysis of the use of physics laboratory on academic achievement of students in physics

Coefficients^a		
Model	t	Sig.
Students actively participate in the physics laboratory (PL Item 5)	-2.991	0.003
Physics teachers have an instructional plan to teach practical activities (PL Item 3)	-2.128	0.034
a. Dependent Variable: Academic Achievement of students in Physics		
Excluded Variables^a		
	t	Sig.
Laboratory rooms are used in the school to teach practical activities (P L Item 1)	-1.186	0.236
Physics equipment, apparatus and materials are used in the school (P L Item 2)	-0.343	0.732
Physics teachers assist students with practical work in the laboratory (PL Item 4)	-0.552	0.581
Physics equipment, apparatus or Material are misused in the school (P L Item 6)	-0.140	0.889
a. Dependent Variable: Academic Achievement of students in Physics		
b. Predictors in the Model: (Constant), physics teachers have an instructional plan to teach practical activities in physics, Students Work with materials, apparatus and instruments in the school laboratory.		

N= number of students, P L= Physics Laboratory

In conclusion, the availability and effective utilization of science laboratory resources has a positive influence on the academic achievement of students in biology, chemistry and physics. Poor state performance of students in biology, chemistry and physics in secondary schools of Ilu Abba Bora Zone is significantly associated with the level of availability and utilization of science laboratory resources in the schools besides other factors. To this extent,

concerned governmental and non-governmental institutions should take necessary interventions to overcome the current problem in the high schools of the Ilu Abba Bora zone.

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