

Improving Biology Students Understanding of Basic Biological Concepts through Diagnostic Testing and Early Tutorial Support for Quality Education; Experience from Dire Dawa University

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Abstract

Ethiopia has given great emphasis to education access; but its quality has been claimed to be poor. Regardless of supports and efforts by universities, most newly joining students have limitations of prior concept, English language and studying skills. This study was conducted to identify gaps and improve biology students' understanding of basic biological concepts through diagnostic testing and early tutorial support. An action-based study was done on first year biology students using diagnostic test followed by early tutorial support before starting normal classes. About 176 (80.733%) of registered students took the pretest. Two sets of one hundred multiple choice questions were prepared for pre and post test from high school biology textbooks on key basic biological concepts and accepted by exam approval committee for its completeness and appropriateness. Pre-test was followed by interactive tutorials for 16 hours for whom scored below 50%. Both results were quantified by pre/post gains and calculated as gain-index ($\text{Gain-Index} = \frac{\% \text{Post-test} - \% \text{Pre-test}}{100 - \% \text{Pre-test}}$) to estimate the sought change. About 45% male and 97.91% female students who took the pre-test failed to score above 50%. After tutorial support, 90.77% of students improved their previous score (95.74% out of females and 77.78% out of males). Average gain index of average pre-test (33.41%) and post-test (58.79%) was 0.3812 indicating improvement. It helps them revise basic biological principles. Diagnostic testing and early tutorial support could improve students' poor knowledge and concept on basic biological topics before students start the course they register. The female students' result was lower in pre-test; but highly improved after tutorial support compared to males for unknown reasons. This approach would be advisable to implement in all colleges and universities. Further related applied studies should be done to increase educational quality early in their admission and test whether it works for English skill improvements.

Keywords: Action Research, Competency, Ethiopia, Gain Index, Higher Education

1. Introduction

Ethiopia has given great attention to general, vocational and higher education among the top priority developmental sectors (Ministry of education, 2010). However, quality of education has been claimed to be lower compared to the expected standard in terms of graduates skill, knowledge and attitude. Graduates quality and their competency are lower. Dropping out and attrition rate is higher in universities; especially in natural science, engineering and technology fields in which precedence and more emphasis has given. The government does so to fulfill the huge demand and needs for adequate and skilled manpower in these sectors (Ministry of education, 2010).

Public universities in Ethiopia receive students for regular undergraduate programs who complete secondary and preparatory level. They must Ethiopian Higher Education Entrance Examination and score the minimum set for placement depending mainly on all public Universities intake capacity. Natural science stream students will join natural computational sciences and agricultural sciences, engineering and technology, medicine and other health sciences. Most students' choose engineering and technology, medicine and other health sciences. Placement is by students' prior choice but almost determined by national higher education entrance exam scores. Better scorers more likely placed their first to third choices. Agriculture, natural and computational sciences become among the last choices. Except some rare cases, students placed in these two streams are low scorers around the cut point. Students placed in this band to study agricultural fields, mathematics, physics, chemistry, biology, statistics and sport sciences are low achievers compared to others placed in any other programs.

In fact, students need to understand basic concepts of subject matters they had learned in secondary and preparatory levels. Students placed to agriculture, natural and computational sciences are supposed to have the basic science knowledge and conception. However, most of them found to have low prior knowledge and concept, poor English language (language of instruction in all Ethiopian higher education institutions) skills and study habit for various reasons.

Approaches difference, motivation and parent- students-teachers communication limitations could be another reason in addition to lack of educational facilities and qualities (Chong Teoh, 2015; Heikkilä & Lonka, 2006). Different individual student uses different learning styles to interpret and analyze the information in order to absorb Learning approach has also relationship with academic achievement of students (Chong Teoh, 2015).

Students placed to university supposed to have the basic knowledge, concept and know how as they passed the entrance exam. However, most students' low prior knowledge and concept, poor language efficiency as well as poor study habits were identified among other poor academic backgrounds. Although, students get support during admission and delivery of courses; dropping out and attrition rate has become higher. Effective study strategies used in secondary and preparatory school level as well as for matriculation may not work at University that differs in terms of the focus and the academic demand of different learning phases of higher education syllabi(Heikkilä & Lonka, 2006), Yip & Chung, 2005, Zhao, 2013).

All students placed in biology unit joined by their first choice among other departments in the college. Despite the departments' hard working academic staff and unreserved support through their cooperative learning teaching and quality education, attrition rate in the department is the highest compared to other departments. To develop students' basic science background and biological concepts, special mode of interventions need to introduce before commencing regular courses. Therefore, study was conducted to identify gaps and improve biology students' understanding of basic biological concepts through diagnostic testing and early tutorial support.

2. Methodology

Action based study/action research was done among first year Dire Dawa University biology students. Diagnostic testing(Antonio Robles-Gómez, Salvador Ros, Roberto Hernández, Llanos Tobarra, 2015) was followed by early tutorial support after immediate registration before starting normal classes. Totally, 218 students (92 males and 126 females) were expected and announced to take the diagnostic exam. About 176 (80 males and 96 females) students took the pre-test. Two sets of one hundred multiple-choice questions were prepared for pre and posttest from high school biology textbooks across all topics on key basic biological concepts and accepted by exam approval committee for its completeness and appropriateness. Students scored above half were advised and motivated and exempted. Those scored below fifty were participated early tutorial sessions. Student centered and interactive tutorial classes were arranged for about 16 hours for those scored below 50% for the pretest. After the tutorial, similar numbers of questions were prepared from same topics having the same level of difficulty. The pre- and post-tests were administered through tight supervision. Finally, students result was quantified by pre/post gains and calculated as gain-index ($\text{Gain-Index} = (\% \text{Post-test} - \% \text{Pre-test}) / (100 - \% \text{Pre-test})$) that is modified from economics principles of changes by indices(R G D. Allen, 2009).

3. Result

Totally, 218 students (92 males and 126 females) were expected and announced to take the diagnostic exam. About 176 (80 males and 96 females) took the pretest. About 73.86% were scored below fifty percent. From the total number of students, 45% of males and 97.92% of females were failed. Generally, 73.86% of students who took the pre-test failed to score fifty and above. Interviewed students said the major cause of their language background that they would face difficulty of understanding English. Major causes of their problems were poor English language background, lack of study habit, free riding and grade pass copying from others including the entrance exams.

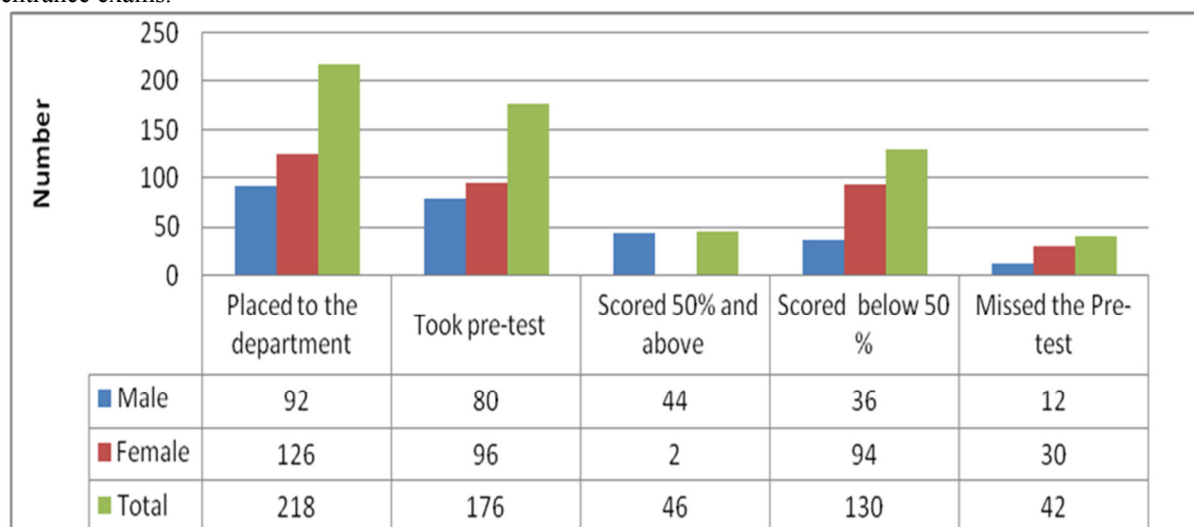


Figure 1: Target students' statistics on their pre-test result

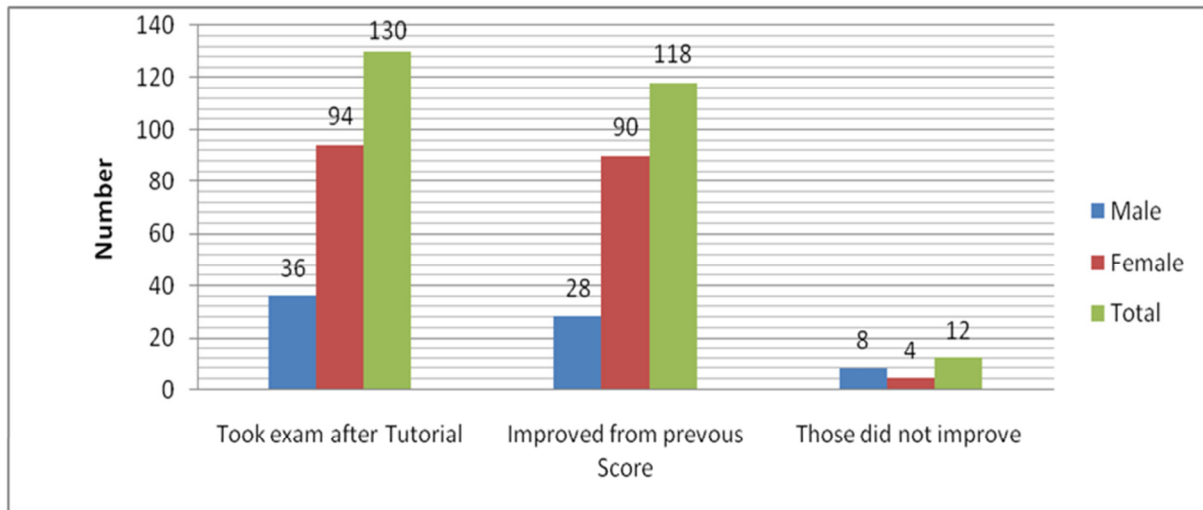


Figure 2: Students and their statistics on post-test result

The average gain index of average pre-test (33.41%) and post-test (58.79%) was 0.3812. After tutorial support, 90.77% of students who took the post-test improved their previous score (95.74% out of females and 77.78% out of males). The average gain index of average pre-test (33.08%) and post-test (56.53%) for male was 0.3504. The average gain index of average pre-test (33.74%) and post-test (61.06%) for female was 0.4123. It indicates that the designed approach improved students' knowledge and concept. The students score improved by more than 38.12% in general, by 35.04% for males and by 61.06% for females in particular (figure 3).

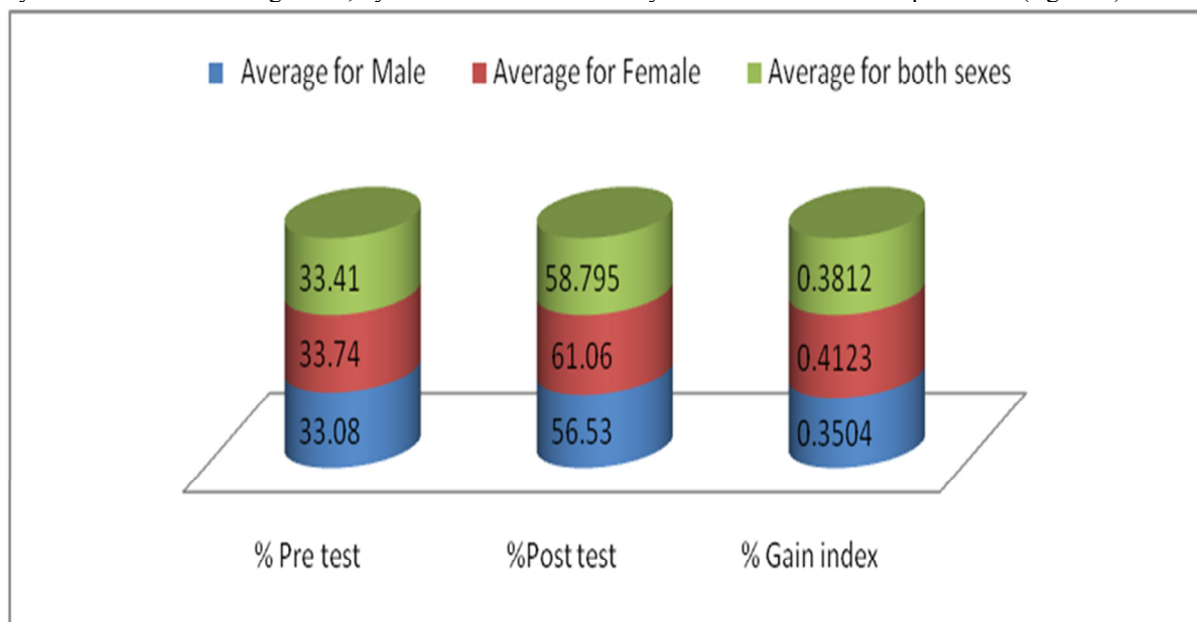


Figure 3: Average pre-test and post-test results and percentage gain Index (gain of the averages)

Students' percentage pre-test and post-test results shown by scatter plot (figure 4) their score improvement. Each score indicated similar horizontal coordinate shows percentage pre-test and post-test score of a student clearly demonstrated improvement after early tutorial support.

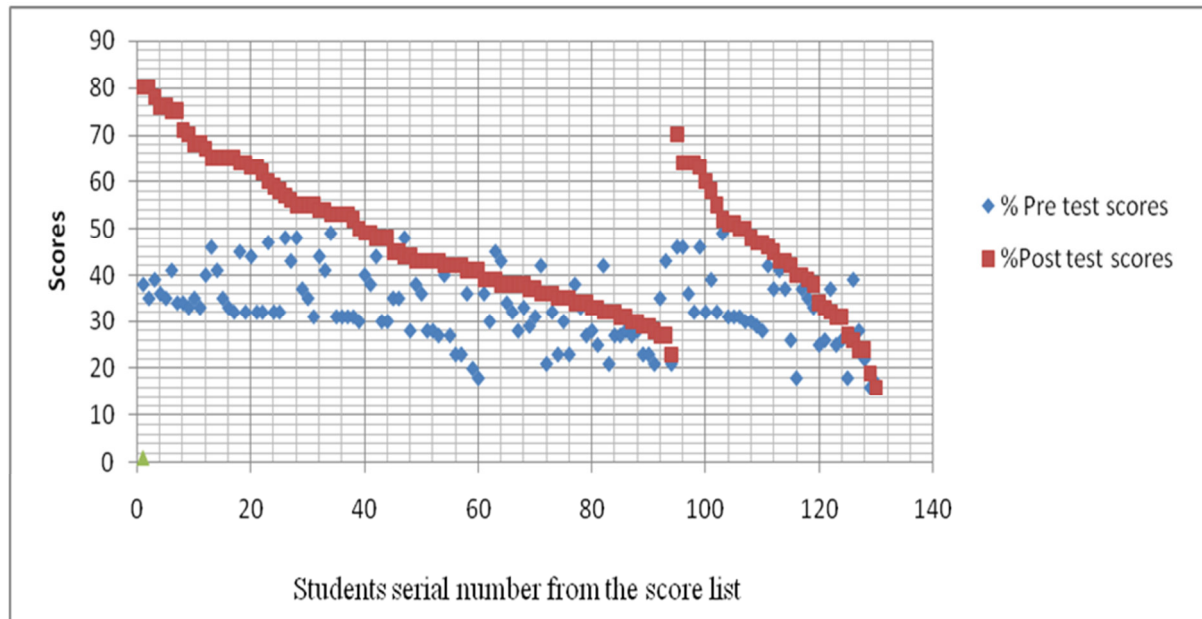


Figure 4: Pre-test and Post-test results distribution (scatter plot)

Table1: Pretest and post test score and average of gain (average of the gains) for each students failed the pretest (score <50%)

S.No	Sex	% Pre Test	%Post Test	% Gain Index	S.No	Sex	% Pre Test	%Post Test	% Gain index	S.No	Sex	% Pre Test	%Post Test	% Gain Index
1	F	38	80	0.6774	45	F	31	53	0.3188	88	F	43	38	-0.0877
2	F	35	80	0.6923	46	M	49	52	0.0588	89	F	34	38	0.0606
3	F	39	78	0.6393	47	F	31	52	0.3043	90	F	32	38	0.0882
4	F	36	76	0.6250	48	M	31	51	0.2899	91	M	33	38	0.0746
5	F	35	76	0.6308	49	M	31	51	0.2899	92	F	28	38	0.1389
6	F	41	75	0.5763	50	M	31	50	0.2754	93	F	33	38	0.0746
7	F	34	75	0.6212	51	M	30	50	0.2857	94	F	29	37	0.1127
8	F	34	71	0.5606	52	F	30	50	0.2857	95	F	31	37	0.0870
9	M	46	70	0.4444	53	F	40	49	0.1500	96	F	42	36	-0.1034
10	F	33	70	0.5522	54	F	38	49	0.1774	97	F	21	36	0.1899
11	F	35	68	0.5077	55	F	44	48	0.0714	98	F	32	36	0.0588
12	F	33	68	0.5224	56	F	30	48	0.2571	99	F	23	35	0.1558
13	F	40	67	0.4500	57	M	30	48	0.2571	100	F	30	35	0.0714
14	F	46	65	0.3519	58	F	30	48	0.2571	101	F	23	35	0.1558
15	F	41	65	0.4068	59	M	29	47	0.2535	102	F	38	34	-0.0645
16	F	35	65	0.4615	60	M	28	47	0.2639	103	F	33	34	0.0149
17	F	33	65	0.4776	61	M	42	46	0.0690	104	F	27	34	0.0959
18	F	32	65	0.4853	62	M	37	45	0.1270	105	M	25	34	0.1200
19	M	46	64	0.3333	63	F	35	45	0.1538	106	F	28	33	0.0694
20	F	45	64	0.3455	64	F	35	45	0.1538	107	M	26	33	0.0946
21	M	36	64	0.4375	65	F	48	44	-0.0769	108	F	25	33	0.1067
22	F	32	64	0.4706	66	F	28	44	0.2222	109	F	42	32	-0.1724
23	M	32	64	0.4706	67	M	41	43	0.0339	110	M	37	32	-0.0794
24	M	46	63	0.3148	68	F	38	43	0.0806	111	F	21	32	0.1392
25	F	44	63	0.3393	69	M	37	43	0.0952	112	F	27	32	0.0685
26	F	32	63	0.4559	70	F	36	43	0.1094	113	F	27	31	0.0548
27	F	32	62	0.4412	71	F	28	43	0.2083	114	M	25	31	0.0800
28	F	47	60	0.2453	72	F	28	43	0.2083	115	M	26	31	0.0676
29	M	32	60	0.4118	73	F	27	43	0.2192	116	F	28	31	0.0417
30	F	32	59	0.3971	74	F	40	42	0.0333	117	F	27	30	0.0411
31	M	39	58	0.3115	75	F	27	42	0.2055	118	F	28	30	0.0278
32	F	32	58	0.3824	76	M	26	42	0.2162	119	F	23	29	0.0779
33	F	48	57	0.1731	77	F	23	42	0.2468	120	F	23	29	0.0779
34	F	43	56	0.2281	78	F	23	42	0.2468	121	F	21	28	0.0886
35	F	48	55	0.1346	79	F	36	41	0.0781	122	M	18	27	0.1098
36	F	37	55	0.2857	80	F	20	41	0.2625	123	F	35	27	-0.1231
37	F	35	55	0.3077	81	F	18	41	0.2805	124	F	43	27	-0.2807
38	M	32	55	0.3382	82	M	18	40	0.2683	125	M	39	26	-0.2131
39	F	31	55	0.3478	83	M	37	40	0.0476	126	M	28	24	-0.0556
40	F	44	54	0.1786	84	M	35	39	0.0615	127	M	22	24	0.0256
41	F	41	54	0.2203	85	F	36	39	0.0469	128	F	21	23	0.0253
42	F	49	53	0.0784	86	F	30	39	0.1286	129	M	16	19	0.0357
43	F	31	53	0.3188	87	F	45	39	-0.1091	130	M	17	16	-0.0120
44	F	31	53	0.3188										

From the total number of students sat for the post test, about 52 (13 males and 29 females) scored greater than fifty. Five students scored lower than their pretest score that their individual gain index became negative.

4. Discussion

Currently, science, mathematics, Engineering and technology subjects have greater emphasis in the school curriculum. The basis for these areas is natural science which requires students need to understand the basic science concepts(Adeyemo, 2005a).

Despite of the department and academicians hard working and unreserved support through their cooperative learning teaching and quality education; attrition rate in the department was highest compared to other departments especially for female students. To develop students' basic science background and biological concepts, special mode of intervention was introduced before students commence their regular courses. Students' background on basic prior biological knowledge and concepts was identified through diagnostic testing and improved by early tutorial support.

Diagnostic test in education is defined as a design and process of measuring specific knowledge structures and processing skills in students and particularly attracting a great deal of attention and used to gather information to inform teachers of their students' strengths and weaknesses(Zhao, 2013), (Heikkilä & Lonka, 2006; Zhao, 2014). It is used to determine the level of students' understanding or skill ranks before instruction is given(Antonio Robles-Gómez, Salvador Ros, Roberto Hernández, Llanos Tobarra, 2015). Proper diagnostic tests could measure students' understanding of a subject area or acquisition. Discipline-specific conceptual diagnostic tests bring out whether students hold common misconceptions about a subject matter or not.

Diagnostic tests measure students' understanding of a subject area or skills base. Teachers typically administer diagnostics and using the results to provide remedial instruction or place students within appropriately leveled classes. Some schools also diagnose concepts as a whole, aiming to reveal commonly held misconceptions in specific subjects. These tests are designed to identify strengths and weaknesses in a learner's knowledge background concept. The basic features of diagnostic tests include, focus on weaknesses than on strengths, leading to remediation in further instruction, providing detailed feedback(Zhao, 2013). Nadia Archuleta explained that multiple-choice exams could spark off common misconceptions about subject matter concepts and would indicate students' understanding of the concept using gain-index that is adopted from concept of economics expressed as index numbers expressing economic data time series for comparison on the base value of hundred expressed as hundred times the ratio to the base value(Adeyemo, 2005b). The context is used for this study purpose taking pre-test as baseline. Therefore, the main objective of the study was to identify students' background on basic prior biological knowledge and concepts and improve through diagnostic testing and early tutorial support.

Most of the students who took the pre-test scored below fifty percent. Students said the major cause of their failure was their language background that they faced difficulty of understanding English. They also added that lack of study habit, free riding and simply for grade copying from peer students even during the entrance exams. The essence of diagnostic testing lies in a comprehensive and creative feedback system and it could improve learning outcomes(Zhao, 2013). Thus, feedback was concentrated mainly on their weaknesses, would help students more when coupled with concrete descriptions about tips how they could perform better. Feedback given to students could assist them more when given in the form of guidance and consistent advice on next steps.

Gain index is comparison of data values on the base value of hundred expressed as hundred times the ratio to the base value(R G D. Allen, 2009). The average gain index $(\%Posttest - \%Pretest)/(100 - \%Pretest)$ of the average pretest (33.41%) and post test (58.79%) was 0.3812. After tutorial support, about 90.77% of students who took the post-test improved their previous score (95.74% out of females and 77.78% out of males). The average gain index of average pre-test (33.08%) and post-test (56.53%) for male was 0.3504. The average gain index of average pre-test (33.74%) and post-test (61.06%) for female was 0.4123. It indicates that the designed approach improved students' knowledge and concept. The students score improved by more than 38.12% in general, by 35.04% for males and by 61.06% for females in particular (figure 3).

Impact of parental involvement, interest in schooling and school environments would have tremendous effects on fresh students. Similar studies showed that fresh students' background has significant effects on their academic self efficacy in university(Kember, 2000). Other factors that have impacts on students' subject conceptual understanding include poor students' approaches to learning, self - regulated learning and cognitive strategies(Heikkilä & Lonka, 2006),(Chong Teoh, 2015). Random memorization and passive forms of learning could be another factor(Kember, 2000).

Effective study strategies used in articulation may not work at University. Effective study strategies used in secondary and preparatory school level as well as for matriculation may not work at University that differs in terms of the focus and the academic demand of different learning phases of higher education syllabi(Yip & Chung, 2005). Approaches difference and parent- students-teachers communication limitations could be another reason in addition to lack of educational facilities and qualities. Different individual students uses different

learning styles to interpret and analyze the information in order to absorb and conceptualize information (Chong Teoh, 2015). Learning approach has also relationship with academic achievement of students (Heikkilä & Lonka, 2006).

5. Conclusion and recommendation

Most of the students engaged in this study had poor knowledge and concepts about the basic biological topics. Diagnostic testing and early tutorial support could improve background towards basic biological knowledge and concepts before they start the course they register. Score of female students was lower in pre-test; but highly improved after tutorial support compared to males for unknown reasons. It may be due to the gender discrimination effect that efficiency of affirmative action and women empowerment in schools needs to get reconsideration in its implementation. It is recommended to implement this approach in all colleges and universities. Further related applied studies should be conducted to increase educational quality early in their admission and test whether it works for English skill improvements.

6. Limitation of the Study

The major limitation of this study was mainly questions were not calculated for their difficulty level and discrimination power of alternatives; though taken into consideration. Some students missed the first diagnostic test for various pretexts and excluded from analysis, but they took the retest after attending tutorial classes.

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