ETHIOPIAN STUDENTS' ACHIEVEMENT CHALLENGES IN SCIENCE EDUCATION: IMPLICATIONS TO POLICY FORMULATION

Oli Negassa
Adama Science and Technology University, Ethiopia
Email: oli.negassa@astu.edu.et

ABSTRACT

The purpose of this study was to investigate challenges on students' academic achievement in science education across selected preparatory schools of Ethiopia. The participants were students, teachers and principals from three regions and nine schools. The participants of the study were 801 students and 118 science teachers from preparatory schools. A mixed case study research and multiple case research method were employed. Purposive and stratified sampling methods were used. The study examined the data generated through questionnaires, academic achievement tests, interviews and document analysis. Regression, Path-analysis, ANOVA, T-test, correlation, standard deviation and other statistical tools were used for data analysis. The results showed that strong relationship existed between science achievement and school resource, family income, family occupation, family education, and teachers' factors. Moreover, this study showed that the teaching-learning process of science education in Ethiopian schools failed to meet the requirements of policy expectation. It is recommended that due consideration should be paid to improving school conditions, teachers' capacity, and student-related factors for effective implementation of science curriculum. *[AJCE 4(1), January 2014]*

INTRODUCTION

In our modern world, science occupies an ever-expanding place in our everyday life and is the basis for development. It is essential for increasing science literacy and cultivating a generation of scientists(1). Therefore, it is evident that education with science is the major component that contributes to the level of prosperity, welfare and security of a nation. In this sense, science education is believed to serve as the foundation of technological development, and it is a key factor in economic growth (2).

It is as a result of the recognition given to physical sciences in the development of the individual and the nation that these subjects are considered core - subjects among the natural sciences and other science- related courses in the Ethiopian education system. The inclusion of physics and chemistry as core subjects in science in the secondary school calls for the need to teach them effectively. Therefore, in this modern society, education in general, science education in particular is not only a dominant factor for the formation of citizens and their complete realization as humans, but it is also emerging as a strategic means with key importance for the competitive global economy.

Furthermore, like any other developing country, Ethiopia needs rapid improvement of science education and appears to have been prepared to resolve issues of development in science and technology through its education and training policy. To make this practical, the policy provides for a 70:30 admission ratio in tertiary institutions in favor of science and technology by Ministry of Education (3).

However, the implementation process of science education is limited in Ethiopian schools. For instance, students in Ethiopia generally perform poorly in science subjects (4). The

main factors that contribute to the poor performance of students in science may include problems associated with attitude, methods, teachers' capacity and resources.

To this end, a basic question that this study puts forward is: 'To what extent are Ethiopian preparatory schools (grades 11 and 12) ready to meet these policy expectations from different perspectives such as students' readiness, teachers' capacity and provisions of materials and human resources based on student academic achievement in general?'

THEORETICAL FRAMEWORK

The theory used as basis for this study was constructivist. Particularly, the two aspects of constructivist theory, that is, individual constructivist theory and social constructivist theory where used. There are some proponents of individual constructivist theory (5-8). According to these groups of advocators knowledge is considered to be mainly an individual's construct. Social and cultural phenomena are also personal constructs.

On the other hand, social constructivist theory scholars such as (9-11) and others advocate social construction of knowledge. According to these groups knowledge is mainly a social construct. Learners construct their knowledge through interactions with teachers, other learners, materials and observing and exploring things. Learning in general and academic achievement in particular occurs in a social context and that much of what is learned is gained through observation. In the view of these authors, individual, social, environmental, cultural and material factors play roles in human learning and should be given due consideration.

The implication here is that both theories are equally necessary if learning is to be understood more fully. From this perspective the researcher has chosen to study learning in this study from both the individual and socio cultural perspectives. The assumption here concerns the

view that individual's on-going functioning (achievement in the case of this study), cognitive behavioral, and environmental factors influence one another in a bidirectional, reciprocal fashion. The study explored those aspects of knowledge to determine their possible roles in the achievement of the students, that is, to test those theories.

PURPOSE, RESEARCH QUESTIONS AND METHODOLOGY OF THE STUDY

The purpose of this study was to assess academic achievement challenges of students in science education in Ethiopian preparatory schools (grades 11 and 12) in three administrative regions (Amhara, Oromia and SNNPR) by assessing students' national examinations and current achievements in science. To meet these objectives, the following basic research questions were formulated:

1. What did Ethiopia preparatory schools students' science education achievements look like?

1.1. To what extent Ethiopian students achieved in science subjects in national examination in the past?

1.2. To what extent do Ethiopian students achieve in science in standard tests?

1.3. To what extent do students' achievements vary across grade levels, regions, schools, sexes, mother tongue and residences?

2. What are the academic achievement challenges in science education of Ethiopian preparatory schools?

2.1 To what extent do academic achievement challenges in science education vary across regions, sex and residences?

2.2   Do Students' achievements in science correlate to academic achievement challenges in science?

2.3   Which of the challenges predict student academic achievement more?

3. What are the possible implications of the developed model for improving student academic achievement in science and quality of education in Ethiopia?

The subjects of the study were science students and science teachers. The data were mainly gathered through questionnaires, observations and interviews. The mixed approach was employed as research method. Document analysis was also made so as to substantiate these instruments. The data obtained were analyzed through the use of percentages, mean values; grand mean values, correlation coefficient, standard deviations, T-test, ANOVA, regression analysis, and path analysis. The analysis of the data has yielded the following major findings.

RESULTS AND DISCUSSIONS

This section provided answers to the research questions raised earlier in the study. The results are presented below.

Students'academic achievement in science education

The grand mean achievements were 49.51% in national examinations and 44.47% in standard tests in science for the study group. This scores were less than the expected average score (50% by the Education and Training Policy) of Ethiopia. They were not only low but also significantly different from this expected value and were deteriorating too. The results of the one-sample T-test showed that the mean differences of the academic achievement test results for

the two tests for both grades were significantly different from the standard value (50%) at 95% confidence interval or at p< 0.05 level of significance (p=0.00). The mean differences were negative (mean difference=-5.53) for both standard tests. This indicated that the students' academic achievement in standard test was below expectation of the policy. These findings are in line with Fensham (12).

Farthermore, their academic achievement in science did vary across their regions, and mother tongues. For instance, the total mean result achievements were 44.78%, 42.84%, 45.36% for Oromia, Amhara and SNNP regions respectively. The ANOVA test calculated for these regional differences revealed that the difference in science achievement among regions (846.96 or .65%) was much less than the differences in science achievement among individual students (129188.20 or 99.35%) in the same region. Therefore, there were significant differences in science achievement within the students of the three regions individually, not as a region which indicated that there were no differences among regions in their science achievement.

However, this finding implies that a participating region in a curriculum implementation study is likely to open up for diversity in visions, alternatives, promoting critical discussions, offering new ideas for experimentation, and above all, learning from others. Curriculum implementation studies thus enable a region to compare the similarities as well as the differences between related activities carried out in various regional contexts. This may offer a better understanding of the lessons learnt or drawn from policy implementation and education sector improvement strategies adopted by other regions.

On the other hand, students' achievements in science do vary across their grade levels, schools, residences and sexes. For instance, the overall science achievement for grade 11 was 40.30% and that of grade 12 was 48.48% which indicated that grade 12 students perform better

in this particular study. The results of the independent sample T-test also showed that the mean difference between grade 11 and 12 students was significant at p< 0.05(t=--9.58, p=0.00). The mean differences was negative (mean difference=-6.51) when test from grade 11 to grade 12.

Similarly, the overall academic achievement in science for male was 47.58% and for female was 39.70%. In all the cases, the mean scores of female were less than the mean scores of males. The mean differences were positive when we compare the results of male students with those of their female counterparts. That means males have scored higher than female students in those tests. This finding clearly supports the established fact that gender differences exist in science achievement (13). The results of the independent sample T-test also showed that the mean difference between male and female students was significant at p< 0.05(p=.00) and t=11.17. Evidently, boys achieved mean scores that were higher by 8.44% than the mean scores achieved by girls.

Moreover, the overall science academic achievement for urban background and rural background students were 45.23% and 44.09% respectively, and the result of T-test showed that these differences in academic achievement of science between urban background and rural background students were significant statistically at p<.05 (p=.024) and at t=799.

Generally, the results of the study showed that the academic achievements of students do vary across regions, residences, across grade levels, sexes and schools. Such differences could be due to proper coverage of courses, better and proper qualification of teachers, better school facilities, proper school administration or differences in the way the students were educated beginning from the lower grades for each particular course. So the regional states can benefits from experience sharing to improve academic achievement of students in science and other courses.

Besides the above explanations, the results of this study beg the question of what could have gone wrong with the students to achieve such low achievement. To this end, in theoretical framework of this study, from constructivist perspective several basic assumptions about academic achievement of students' were explained. One assumption concerns the view that individual's on-going performance, personal factor, and environmental factors influence one another in a bidirectional, reciprocal fashion. That is, a person's on-going performance (academic achievement in the case of this study) is a product of a continuous interaction between cognitive behavior and contextual factors. The results of this study have investigated contextual challenges such as students' related challenges, teachers' related challenges, school related challenges and family related challenges. The study explored those challenges to determine their possible roles in the performance of the students, that is, to test the theory explained in theoretical framework of the study. For these purposes the contextual variables and thier influences on academic achievement were treated in the following subsections.

Challenges on academic achievement in science education

A. Students' attitudes toward science

There were five categories under which attitudes of students were treated. These were: a) development of interest in science and science related activities, b) accepting of scientific enquiry as a way of thought, c) the enjoyment of science learning experience, d) development of interest in pursuing a career in science and science related work, and e) manifestation of favorable attitudes toward science and scientists. Accordingly, the grand mean for the first, second, third, fourth, and fifth categories were 2.36, 2.64, 2.62, 4.00, and 1.85 on a five-point scale.

These results indicated that students were not interested, not accepted scientific thoughts as a way of life, do not enjoy science, but develop interest to pursuing a career in science and did not manifest favorable attitudes toward science. Even though the respondents showed positive responses to one of the categories (develop interest to pursuing career in science) and the total mean for grade 12 was 2.71, that of grade 11 was 2.67 and total grand mean scale of the group on attitude scale was 2.69, the findings of this study showed that the respondents have developed negative attitudes toward science and scientists. The majority of students in preparatory schools feel that science is hard and difficult to them. Hence, they have no positive feeling toward the content of science curriculum, confirming other studies (14).

Furthermore, students' attitudes toward science did vary across their grade levels, residences, regions, sexes, schools and mother tongue. For instance, the grand mean for the first, second, third, fourth, and fifth categories attitudes and the total mean attitudes were 2.70, 3.10, 3.08, 4.44, 2.02, 3.07 and 1.83, 1.90, 1.91, 3.32, 1.58, 2.11 on a five-point scale for males and females respectively. Even though these results indicated that students were not interested, not accept scientific thoughts as a way of life, do not enjoyed science, but develop interest to pursuing a career in science and do not manifested favorable attitudes toward science, males had more positive attitudes toward science. This study showed that boys have more positive attitudes toward science than girls.

B. Students' academic self-concept of Science

This part deals with students' academic self-concepts as science learners in relation to sub-categories of academic self-concept: *Self-efficacy, intrinsic value* and *test anxiety*.

Accordingly, the grand mean for the first, second and third categories were 2.83, 3.12, and 2.39 on a five-point scale.

These results indicated that students were not involved in learning science by their own sake and a belief in their own abilities, but they belief in the value of the task and they have an uncomfortable feeling of nervousness or worry about exams. Even though the respondents showed positive responses to one of the categories (belief in the value of the task)) the total grand mean scale of the group on academic self-concept scale was 2.78 and it showed that the respondents of this study have developed negative academic self-concept of science about their abilities. The majority of students in preparatory schools feel that they are incapable to perform science. Hence, they have negative academic self-concept of science about their abilities.

Moreover, this study showed that there were significant differences in academic self-concept of students in science between the two sexes. There was a mean difference between boys and girls in their academic self-concept of science and science learning in each category of academic self-concept. The overall results for academic self-concept students have about themselves were 2.9 (mean value for boys) and 2.59 (mean value for girls). These results imply that boys were more confident in their academic abilities than girls. Independent sample T- test showed that there was difference in variance for mean scores of males and female students in their academic self-concept. The difference was significant statistically at t=11.54 and p<0.05(p=.00) significant level.

In the same way, the study showed that there were differences between students of different residences in their academic self-concept in science and science learning. The academic self-concept of urban background students (mean value=2.82) was in a better position than rural background students (mean value=2.76). The implication is that urban background area students

perceive themselves as better at science than rural background students. However, the T-test showed this difference was not statistically significant.

C. Students' learning strategies in science education

This study analyzed the self-regulated learning strategies of students in science learning by categorizing the issues in to two categories. These categories were *cognitive learning strategies* and *meta-cognitive learning strategies*. In the first category it is intended to measure the cognitive self-regulated learning strategies students used in learning science by measuring activities that can be measured directly from the responses given by students in the questionnaires and interview responses.

The aggregate mean= 2.44 on a five-point scale for this sub-category showed that students do not make appropriate use of these learning strategies to learn science. Similar to the first category, the grand mean of this category=2.35 showed that the respondents lacked appropriate meta-cognitive self-learning strategies in their science learning. The grand mean for all the categories 2.39 again showed that respondent students lack appropriate learning strategies to learn science which leads to achiving less in science. Supporting this finding different cognitive strategies such as rehearsal, elaboration, and organizational strategies have been found to foster active cognitive engagement in learning and result in higher levels of academic achievement (15).

Even though the majority of students lack appropriate learning strategies to learn science, their degree of usage of different learning strategies varies depending on their regions, sexes, residences and other factors. For instance, there were differences among the two sexes in using self-regulated learning strategies. The mean value for use of cognitive self-regulated learning

strategies for science learning was 2.80 for males and 1.86 for females and the mean for the use of self-regulated meta-cognitive learning strategies in science learning was 2.69 for male and 1.82 for female students. In overall use of self-regulated learning strategies, the mean value was 2.75 for males and 1.85 for females.

This showed that the mean differences were positive when we compare the male results with females' results. This means that males used self-regulated learning strategies in science learning more than girls. The results of the independent sample T-test showed that the mean difference between male and female students was significant at $p < 0.05$. Therefore, in this study, boys were more strategic in their science learning than girls.

SUMMARY AND RECOMMENDATIONS

This study has shown that the Ethiopian schools seem unsuccessful in their efforts to improve the teaching learning of science and students' science achievement. These conclusions are in line with Temechegn (16) that science education in general and chemistry teaching in particular in Ethiopia lack appropriate teaching process and curricular content for the target group of learners. The main factors that were believed to contribute to the poor academic achievement of students in science include: students' attitudes toward science, students learning strategies, academic self-concept of students, teachers' capacity, and ineffective teaching methods, scarcity of human and material resources, and family low income, and large family size.

As findings of this study have indicated, challenges in science education vary, to some extent, from school to school. They also vary from region to region. Moreover, the study indicated that most of our preparatory schools tend to have problems in providing quality

education. Typically, many schools have large class sizes, in some cases as many as eighty students, with few possibilities of meaningful group or individual work and few opportunities for direct contact with teachers; most of the schools experienced high rates of science teacher turnover and consequently lack of continuity in instructional delivery in follow up process; and shortage of science teachers is also a common problem observed in most of the schools. All schools in this study experienced, in one way or another, unsatisfactory teaching conditions. In particular, according to the respondents as cause of teacher's low motivation, the schools seem to be characterized by constraints such as relatively low salaries, whose real value has been eroded over time.

The situation is even critical, for those teachers who teach many classes for many hours within the two shifts of their working hours; the teaching methods tend to widely emphasize on recall and rote learning rather than a journey towards enlightenment and reflective experience, which generate useful knowledge and skills; laboratories for science were widely underutilized or wrongly utilized, that is, they are used for traditional whole class teaching rather than practical work; lack of maintenance of equipments; lack of equipment and resources in general is a major constraint to effective teaching and learning process and there were also striking inequality among schools in terms of resources, resulting in lack of uniformity in science curriculum implementation.

Furthermore, the study indicated a significant sex-based difference in participation in science education. Thus, it has been observed that a far fewer number of female students attend science education than their male counterparts. This disparity in the participation of the two sexes in science education could be attributed mainly to cultural factors and stereotypes which make it difficult for female learners to attend science and related subjects. Even though this

difference can also be ascribed to cognitive styles and learning capacity of individual students, it appears to be negligible as compared to social and cultural factors. Thus, we can conclude from this study that girls' participation in science education is low, inequitable, and inefficient. This implies that talented female workers were missing from science-related careers and that more girls could be attracted to science fields and careers if they were given encouragements and support.

Moreover, the results of this study indicated that there was a considerable level of unfavorable attitude among students toward science, negative academic self-concept of science, less strategic of students and this feeling was often accompanied by hatred of science and science teachers. There was a general feeling among the vast majority of students that science is a difficult subject. Not surprisingly, this unfavorable attitude towards science was more noticeable among female students. Too much theoretical teaching that renders the subjects abstract and boring and the resulting poor academic achievement of students have contributed highly to these feelings. Traditional socio-cultural attitudes, in which harder and more demanding tasks are regarded as masculine, present science as a male domain, reserved only for the specially gifted minority. Such attitudes transmit poor expectations and favor sex discriminations.

Science, especially, is also regarded by many as a tedious experimentation in laboratory, and not as a creative and cultural activity and a source of development. It was evident from the results of this study that boys have higher level of positive attitude towards science than girls and achieve better thatn girls. This means, in this study, one of the significant factors influencing students' academic achievement in science was attitudes of students toward science. The results of this study showed that attitude was one of the significant variables related towards students' academic achievement in science. What becomes clear from the result of study on the subject,

mainly as a result of a serious consideration and investigation of the problem that girls' attitudes to science were significantly less positive than that of boys and their academic achievement too.

More importantly, data from this study showed conclusively that girls science education does not remediate this lack of experience and leads them to lack of experiences in science and leads to a lack of understanding of science and contributes to negative attitudes to science and to less achieve in science. This early established difference in the interests and activities of boys and girls result in parallel differences in their science performances. Sex differences in attitude towards science, in favor of boys, as indicated by the results of this study can be attributed to the socio-cultural roles of boys and girls in Ethiopian society. Boys in Ethiopian society spend most of their time at study because they have less home activities than girls and therefore have plenty of time to study and can complete the assignments given by teachers which could contribute to their relatively higher level of academic achievement in science.

The above discussions and findings of the study lead to the following specific implications of the study for the educational policy makers:

- There should be policy formulation that will ensure adequate provision of standards for instructional materials.

- All science subject teachers should be exposed to and trained on the art of provision of instructional materials on regular basis so as to make teaching-learning more effective.

There are also some important resource-related issues where policy is needed;

a) Class size standard is needed

b) Teachers' work load standard is needed

c) Teachers' qualification standard for particular grade level is needed

d) Strengthen efforts to close the academic achievement gap through high standards, accountability and more information should be given for parents at policy level.

All of these challenges identified may have their own causes and possible solutions. However, the researcher wants to comment only on the following issues.

1. Science teachers' deployment is a critical issue. It represents by far the largest recurrent cost of teaching science. Yet, often teacher posting is not driven clearly by need. Woreda (district) and regional level planning data may not be able to identify the science teacher establishment in particular school and are even less likely to be able to relate this to the number of students actually studying science. Formula-based staffing that relates science teacher posting to indicators of numbers of science students must be used.

2. Although lack of material resources (equipment, laboratory environment) can be a very real challenge on how much science can be taught, there is evidence that this reason is posed even by those teachers, and workers in relatively well-resourced schools. Teachers' poor motivation, lack of skills in planning flexible and creative lessons, and lack of understanding of curriculum objectives are all likely to be contributory factors in determining why so much of the science that is taught appears to diverge from the expectations of the curriculum developers. On occasions, it may also be these expectations which are at fault. Hence, teachers have to get training on how to use the existing materials and how to implement the revised curriculum.

3. Although what students actually experience in science education is largely determined by school-level decisions about who teaches them, under what conditions, and with what resources, not much is known about allocation practices within the school, or between types of schools. It is noted that often grossly disproportionate allocations are made for

the study of science. Class sizes are often excessively large, and taught in the poorest

conditions by limited number of teachers. Hence, allocation at school level must be

similar

REFERENCES

1. Mohanty, J. (2003). *Educational Technology*. New Delhi, Deep & Deep Pvt. Ltd.
2. Watson, R., and Crawford, M. (2003). Strategic approaches to science and technology in development: *World Bank Paper Review Work.*
3. MoE. (2008). Educational statistics annual abstract: *Education Sector Development Program Planning and Policy Analysis Department at Ministry of Education*. Addis Ababa, Ethiopia.
4. Samuel, B. and Welflord, A.G. (2000). Practical activities in Ethiopian secondary physical sciences: Implications for policy and practice of the match between the intended and implemented curriculum. *Research Papers in Education*, *15,185-212.*
5. Applefield, J. M., Huber, R., and Moallem, M. (2000). Constructivism in theory and practice: Toward a better understanding. *High School Journal, 84*(2), 35-53.
6. Von glasersfeld, E. V. (1993). Questions and answers about radical constructivism. The practice of constructivism in science education. Washington, DC: AAAS Press.
7. Ausubel, D.P.(1968). *Educational psychology: A Cognitive view.*New York: Rinehart and Winston.
8. Duit, R., and Treagust, D. (2003). Conceptual change: a powerful framework for improving science teaching and learning. *International Journal of Science Education*, 25, 671-688.
9. Vygotsky, L.S.(1978). *Mind in society*. Cambridge: Harvard University Press.
10. Bandura, A.(1997). *Self-efficacy: The exercise of control*. New York: W.H.Freeman.
11. Bandura, A.((1986). *Social foundations of thought and action: A social-cognitive theory.* Englewood Cliffs, NJ: Prentice Hall.
12. Fensham, P.J. (2000b). Providing suitable content in the "science for all" curriculum. *Improving science education: the contribution of research,* 1(2), 147-164. Buckingham: Open University Press.
13. Sanchez, C.A., & Wiley, J. (2010). Sex difference in science learning: Closing the gap through animations. *Learning and Individual Difference, 20, 271-275.*
14. Bishop, M. (2009). *A case study on facility design: The impact of new high school facilities in Virginia on student achievement and staff attitudes and behaviors.* EdD dissertation, The George Washington University, United States – Washington, DC. Retrieved July 2, 2009, from Dissertations & Theses: Full Text. (Publication No. AAT 3344635).
15. Monk, M. and Osborne, J. (2000). *Good practice in science teaching: What research has to say?* Open University Press: Maidenhead, Philadelphia.
16. Temechegn, E. (2002). Reflection on African science education for the new millennium: The case of the Ethiopian chemistry curriculum for beginners. *International Journal of Science Education, (24), 941-953.*