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Factors hindering conduct of biology laboratory work in classes IX and X schools under Trongsa district in Bhutan

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ABSTRACT

This study aimed to determine the factors hindering the conduct of Biology laboratory work in classes IX and X schools under Trongsa District in Bhutan. The study was administered using convergent parallel mixed methods. A total of 320 sample sizes, comprising 300 class X and XI respondents, six principals, six laboratory assistants, and eight Biology teachers participated in the study. Data were collected through survey questionnaires, interviews, and document analysis. Findings from descriptive statistics showed that teachers have a positive perception on the conduct of laboratory work with a mean value of 4.48. Similarly, descriptive analyses of the study also confirmed that students' motivation and interest are the key factors influenced by laboratory work that improves the learning environment which enhances their academic achievement. Additionally, the study also confirmed that the effective conduct of practical work helps to enhance interest and develop motivation of the learners as shown in Spearman's rho coefficient correlation analysis; motivation (r = .810**, p =.001) and interest (r = .813**, p =.001) indicating significant strong positive relation, which is considered pivotal to enhance students' academic performance in the subject. Although, the conduct of laboratory work in the schools attributed to students' academic success, the finding of the study also showed that numerous impeding factors such as poor laboratory facilities, insufficient teaching periods, bulky curriculum, heavy workloads, crowded classes, and lack of qualified laboratory assistants contributed significantly to low conduct of Biology laboratory work in the classes IX and X schools in Bhutan. The finding of the study further revealed that despite difficulties encountered; teachers, laboratory assistants, and students collaboratively adjusted, managed, and improvised materials to conduct laboratory work. Therefore, the study recommends the Royal Education Council and Ministry of Education as baseline information to study on addressing the gaps revealed in the study.

Keywords: Academic Achievement, Biology, Learning Environment, Laboratory Work, Perception.

1. INTRODUCTION

Science education indeed plays an important role in improving the lives of mankind through medicine, agriculture, communication, transportation, engineering, and economy. Olutola (2016) asserted that science improves the economy of any nation and is instrumental

for progressing the nation's economic growth [1]. The knowledge of science has aided in transforming people's lives into luxury with the emergence of new technologies. Science and technology are keys to the socio-economic development of the nation in an increasingly interconnected world. It is, therefore, imperative that developing countries like Bhutan embrace science education, its knowledge, and its application as vital means to accelerate the country's social-economic development.

Additionally, science has also contributed immensely in the field of transportation, communication, structures development, nuclear weapons, energy generation, pollution reduction, and medicines [2]. Similarly, Wangchuk (2018) stated that the Bhutanese education system must align to prepare our children for a different future that would be greatly shaped by advancements in science and technology, globalization, and information explosion [3]. Thus, science and technology education is central to national development in Bhutan.

Today, in Bhutan, the poor performance of students in science subjects is one of the growing concerns amongst science educators in educational development, despite significant efforts and investments put in place by the government in improving access to quality education over the past years. The low rates of students' performance in both mathematics and science subjects remain high at all levels of the Bhutan Council for School Examination and Assessment (BCSEA), with only a handful of students making it to tertiary level studies in science streams.

The decline of Bhutanese students' performance in science and taking up science subjects in higher grades is attributed to certain factors and science educators must be mindful and know the growing concerns at the earliest to mediate the problem. Further, it is also critical to create an avenue where young Bhutanese would be interested and motivated to pursue their career in the science profession.

To improve these growing concerns, various interventions enhance the learning interest of students and motivate them to learn the subject. There are various strategies implemented and contributed to interactive learning and students' engagement as propounded by some of the studies are Information Communication Technology [ICT], Inquiry-based Learning, Fieldwork, Placed-Based Learning and Project-Based Learning [4-7].

On the other hand, several studies still claim that laboratory activities enhance students' scientific knowledge, skills and widen their understanding of scientific concepts. For instance, Cimer (2012) conducted study in Turkey claims that students recommended using practical work to teach the most difficult topics to enhance their understanding [8]. Similarly, the study of Driver (1995) concluded that laboratory investigation offers important opportunities to connect science concepts and theories learned from the textbook in the classroom with observations of phenomena and systems [9]. Additionally, to enable learners to construct the complex conceptual understandings of the contemporary scientific community, or to transform students' understanding towards accepted science, Driver stated that laboratory inquiry alone is insufficient. There should be consistent assistance and support from teachers and concerned authorities. Further, according to Tobin (1990), 'meaningful learning is possible in the laboratory if students are provided opportunities to manipulate equipment and materials to be able to construct their knowledge of phenomena and related scientific concepts [10].

Laboratory work is defined as any teaching and learning activity that involves the students in observing or manipulating the objects and materials they are studying

[11]. It is also explained as any science teaching and learning activity for students to work individually or in small groups, or in observing or manipulating objects, and conditions to develop biological knowledge and understanding [12]. Furthermore, laboratory work according to SCORE (2009a) is a hands-on learning experience that prompts thinking about the world in which we live [13].

Gee and Clackson (1992) asserted that laboratory work first became a part of science education in the mid-1850s [14]. During the time, it was regarded mainly as means of clarifying scientific concepts and carried out by the teachers. However, as the century revolved and with the approach of Armstrong's heurism in 1986, laboratory work emerged as a means of permitting children to discover by themselves. As a result, the need for incorporation of laboratory work in the science curriculum was felt necessary and implemented accordingly [15].

The science curriculum framework in Bhutanese context has several purposes among which the main emphasis is made on the importance of laboratory activities and activity-based learning experiences [16]. Thus, laboratory work in the schools in Bhutan is guided by its curriculum framework provided by Royal Education Council [REC]. The Bhutanese science curriculum framework is grounded on four strands and five key stages where laboratory work is integrated with strand 1; Working scientifically [17]. However, for classes IV to X, laboratory work is conducted by integrating with the course of teaching and learning processes without separate allocation of periods for laboratory work.

To foster effective teaching and learning of science, especially Biology, integration of laboratory work in the daily lessons are indispensable. Laboratory work in the teaching and learning process not only promotes the learning environment but contributes to developing students' understanding of scientific ideas and skills. Hunde and Tegegne (2010) reported that despite the multiple benefits of laboratory activities such as making learning concrete to lying basis for science education, students were deprived of such opportunities [18]. Additionally, Millar (2004) also claimed that laboratory work helps develop knowledge of abstract ideas through their own practical experiences in the activities [11]. Similarly, laboratory work to greater extent "enable students to build a bridge between what they can see and handle (hands-on) and scientific ideas that account for their observations (brains-on)" [19]. Furthermore, REC (2019) asserted that laboratory work is one of the means to Biology learning [20]. Laboratory work provides learners with opportunities to question, observe, sample, experience, and experiment with scientific phenomena in their search for knowledge. REC further emphasizes that laboratory work is effective means for comprehension, understanding, and application of biological knowledge.

The main aim of this study was to find out students' and teachers' perceptions of the conduct of Biology laboratory work in the classes IX and X schools in Bhutan. Furthermore, the study aimed to determine the contributing factors that hinder the conduct of Biology laboratory work in the classes IX and X schools in the Bhutan. Similarly, the study also attempts to investigate the alternative measures to address the existing gap of limited conduct of laboratory work. Therefore, the findings of this study would be useful to policymakers and curriculum developers in education, particularly the Royal Education Council [REC] as the study would provide information on the existing gap of significantly low conduct of Biology laboratory work in class IX and X level schools in Bhutan.

2. METHOD AND MATERIALS

2.1. Research Paradigm

This study was grounded on the philosophy of Pragmatism. The choice of this research paradigm is that

this paradigm provides a fundamental philosophical framework for mixed methods research [21]. Through the use of pragmatism, the researcher intends to find out the issues of limited conduct of Biology laboratory work in the classes IX and X schools in Bhutan. Furthermore, the study will determine possible solutions to overcome the problem.

2.2. Research Design

Research designs are types of inquiry within qualitative, quantitative, and mixed methods approaches that provides specific direction for procedures in a research design [22]. In addition, the concept of research design is expanded as the "plan and structure of a research" [23]. Similarly, the research design is elaborated as a specific procedure involved in the research process: data collection, data analysis, and report writing [24].

2.3. Location of the Study

This study was carried out in Trongsa District, which consisted of one higher secondary school and two central schools, and one autonomous school. The researcher chose to conduct a study in the particular District as students performed low in Biology with a mean mark of 54.25 according to the Bhutan Certificate of Secondary Education Examination (BCSEA, 2018) compared to other District schools [25].

2.4. Target Population

In this study, the sampling frame includes principals, Biology teachers, laboratory assistants, and students. Principals were chosen owing to the significant role and responsibilities they have in planning and formulating overall school-level academic policy in their respective schools. In addition, principals in the schools enforce, monitor, and evaluate entire academic programs through the decentralisation of power. Similarly, Biology teachers were selected as they are equally important personnel in schools who play a pivotal role in the implementation and operation of the teaching and learning process including laboratory work that is integrated into the textbooks. The laboratory assistants were also included in the study as they serve in the schools as principal supporters and assist in preparing specimens, arranging the equipment, and recording laboratory materials, chemicals and also log records of laboratory work conducted by science teachers. The students were selected as participants in this study as they are the ones who would be benefiting from the study.

2.5. Sampling and Sample Size

All four secondary schools of the District were selected for the study based on the cluster sampling and purposive sampling. These comprised of two central schools, one higher secondary school, and one central cum autonomous school with 320 sample size. For the qualitative study, one Biology teacher from all the schools was purposively interviewed. Likewise, two senior-most principals and two experienced laboratory assistants were also purposively interviewed to obtain the rich data. Similarly, for the quantitative data collection, the sample size in the study was calculated using Yamane's formula (eq. 1),

$$n = \frac{N}{1+Ne2} \quad \text{...eq. 1}$$

Where,
'n' = the sample size
N= the population size
e= the acceptable sampling error at level 0.05

2.6. Data collection instrument

In a quantitative method, a survey questionnaire was employed. This method was used in the study to find out the factors that impeded the conduct of Biology laboratory work in class IX and X level schools in Bhutan. Through administering of the tool (Survey questionnaire), it would assist the researcher to determine alternative interventions to improve and

ensure the effective conduct of the laboratory work in the schools. Similarly, the qualitative method used in this study was interview and document analysis. This method was espoused to further assist to provide valid information and in-depth understanding of the existing gap of significantly low conduct of Biology laboratory work in the classes IX and X secondary schools in Bhutan.

2.6.1. Survey Questionnaires

For the quantitative method, survey questionnaires (five points Likert scale) was used to collect the data from the respondents. Additionally, structured and closed-ended questions were set due to a large number of respondents.

2.6.2. Interview

In the study, semi-structured face-to-face interviews were used to elicit participants' opinions on the existing gap of limited conduct of Biology laboratory work in the classes IX and X in Bhutanese schools. Further, it also assisted researchers to determine and suggest reliable interventions to improve the conduct of Biology laboratory work in the classes IX and X.

2.7. Document Analysis

The quantitative data collected were coded and analysed using Statistical Package for Social Sciences (SPSS) version 22.0. Descriptive statistics including means, standard deviation and Spearman's correlation were used to analyse the data, and interpret the mean scores of quantitative data of respondents. Additionally, to provide explicit information, the mean range was categorized based on four scales, and findings of quantitative data for each theme were interpreted in the form of ranking based on level of opinion (Table 1). The width of the class interval was calculated by equation 2;

Table 1. Mean Ranking on Level of Opinion

S. no.	Mean Range	Level of opinion
1	1.00-2.00	Low
2	2.00-3.00	Moderate
3	3.00-4.00	High
4	4.00-5.00	Very high

$$W_c = \frac{W_h - W_l}{N} \quad \text{...eq. 2}$$

Where:
W_c=Width of class interval
W_h-Highest rating
W_l=Lowest rating
N=Number of levels

The qualitative data collected through semi-structured interviews were analysed based on thematic coding analysis where verbatim are read, transcribed, coded, and deduced themes and then interpreted. Similarly, official document analysis of laboratory log registers and textbooks of classes IX and X were also carried out.

3. RESULTS AND DISCUSSION

3.1. Teachers' and Students' Perceptions on Conduct of Laboratory Work

The findings from the respondents' survey questionnaire analysis revealed that teachers have highest positive perceptions towards the conduct of Biology laboratory work for example, descriptive statistical analysis based quantitative data showed the mean value of 4.48 and SD 0.39, indicating teachers' highest perception towards practical work. The finding is further supported by the teacher interview, whereby, all the teachers expressed positive views on the need for Biology laboratory work. Such opinions were attributed to the positive impacts of laboratory works such as assisting teachers to ensure that students understand the Biology concepts, enabling teachers to create interactive classes, and providing students with hands-on learning. Further, laboratory work helps in the acquisition of scientific knowledge and skills, ultimately, enhancing the overall academic achievement of the students. This finding is consistent with the findings of other studies which revealed teachers have positive perceptions towards laboratory experiments [26-29]. Similarly, Lunnetta *et al.*, (2007) further elaborated that laboratory activities provide

first-hand practical experiences/or information in the laboratory through which students can acquire fundamental scientific skills (observation, classification, and drawing), critical thinking, and techniques that have significant values in their day to day life [27]. In addition, the study by Doosti (2014) supports the present finding where it revealed a high percentage of teachers found the laboratory work as a crucial component of learning activity that assists learners to widen the understanding of the theoretical concept [30].

Similarly, the findings of this study based on two factors (motivation and interest) revealed that students have highest positive perception towards the conduct of laboratory experiments in Biology. Additionally, respondents perceive laboratory work as an indispensable element to improve the learning environment, which helps them in learning abstract concepts of Biology. This finding resonates with the finding of Sharpe (2012) who reported that 78% of students had positive perceptions towards incorporating laboratory activities in the teaching-learning process [31]. In addition, students claimed that laboratory work

Table 2. Level of Biology Teachers' Perception toward Laboratory Work

Statement	Mean	SD	Level of Opinion
Laboratory work enables students to understand Biology concepts better.	5.00	0.00	Very high
Laboratory work infused in a lesson helps in teaching effectively and engages students.	4.75	0.50	Very high
Laboratory work stimulates the interest of students in learning Biology.	5.00	0.00	Very high
Conduct of laboratory work affects syllabus coverage in Biology.	3.25	0.50	High
Students learn better and understand the most through the conduct of laboratory work than lecturing.	5.00	0.00	Very high
Teaching and conducting laboratory work is time-consuming for the teacher.	3.75	1.89	High
Laboratory work is just confirmation of theory learned in class.	4.50	0.58	Very high
Laboratory work helps students to develop scientific concepts and skills.	5.00	0.00	Very high
Conduct of laboratory work enhances learning environment of students.	3.50	0.50	High
Laboratory work help students to improve academic achievement.	5.00	0.00	Very high
Mean	4.48	0.39	Very high

Table 3. Students' Motivation towards Conduct of Laboratory Work

Statement	Mean	SD	Level of Opinion
Laboratory work conducted in Biology improves better understanding of concepts.	4.47	0.66	Very high
Learning is Biology is better through the conduct of laboratory work.	4.38	0.80	Very high
Learning through laboratory work makes easier to remember theoretical concepts.	4.42	0.70	Very high
Biology teachers must teach Biology through the conduct of laboratory work in the school.	4.20	0.86	Very high
Mean	4.37	0.76	Very high

Table 4. Students' Interest towards Conduct of Practical Work

Statement	Mean	SD	Level of Opinion
Learning Biology is fun, interesting and useful through laboratory work.	4.40	0.70	Very high
My interest to learn Biology is improved through conduct of laboratory work.	4.40	0.76	Very high
Laboratory work provides opportunity to acquire scientific skills.	3.99	0.86	High
Laboratory work are useful in learning Biology even though it consume time.	4.23	0.76	Very high
Mean	4.26	0.77	Very high

is one influencing factor that motivates and stimulates their interest which helped them to learn, understand and recall scientific concepts. Further, the student participants in the studies by Osborne and Collins (2001); Abraham and Miller (2008) expressed great interest in laboratory work and asserted that it is fun, useful, and more accessible which helped in retaining the scientific concepts [32-33]. The finding of this study is also in an agreement with Dohn *et al*., (2016) study where the finding revealed that students in the study found laboratory work as highly motivating that assists in academic learning [34]. Moreover, the study also showed that students found laboratory work highly interesting that support them to enhance academic achievement.

Furthermore, a statistical test of Spearman's correlation performed in this study also revealed a significant strong positive relationship with the correlation coefficient values of r = .810**, p =.001 for motivation and interest with r = 813**, p =.001 confirming that laboratory work assisted to motivate and stimulate interest thus, enhancing their academic performance.

This finding is incongruent with the study of Aladejana and Aderibigbe (2007) whose findings showed a significant correlation between science laboratory environment and students' academic performance [35].

3.2. Challenges Encountered by Biology Teachers to Conduct Laboratory Work

The analysis of both the survey data and interview data of Biology teachers found that respondents and participants face numerous challenges to have effective conduct of laboratory experiments. The impeding factors include poor laboratory facilities, limited resources, less teaching period, bulky curriculum, heavy workloads, crowded classes, and lack of qualified laboratory assistants.

Principals assured that the lack of adequate resources

Table 5. Correlation of students' motivation towards laboratory work and scores

Correlations				
			Motivation	Scores
Spearman's rho	Motivation	Correlation Coefficient	1.000	.810**
		Sig. (2-tailed)		.001
		N	300	300
	Scores	Correlation Coefficient	.810**	1.000
		Sig. (2-tailed)	.001	
		N	300	300
**. Correlation is significant at the 0.01 level (2-tailed).				

Table 6. Correlation of students' interest towards laboratory work and scores

Correlations				
			Interest	Scores
Spearman's rho	Interest	Correlation Coefficient	1.000	.813**
		Sig. (2-tailed)		.001
		N	300	300
	Scores	Correlation Coefficient	.813**	1.000
		Sig. (2-tailed)	.001	
		N	300	300
**. Correlation is significant at the 0.01 level (2-tailed).				

and a common laboratory for three science subjects hindered teachers from conducting laboratory activities on a regular basis. Similarly, the document analysis of laboratory log registers and textbooks of classes IX and X also showed significantly low records of laboratory work conducted in the schools which indicated that numerous factors hindered the conduct of laboratory work. For example, in school 1, only single laboratory work for class IX in 2018 was conducted on the topic 'Investigating a pathway of water in a cut', and also one laboratory work in 2019 without mentioning the class label was recorded. Similarly, in school 2, no laboratory work is conducted in 2018, however, single laboratory work conducted for class X on 'Water potential' in 2019 was recorded from an average of 11 laboratory work for class X and 15 laboratory work for class IX that were required to carry out in the laboratory.

The finding of this study corresponds to several findings who found that teaching Biology through practical class was impeded by lack of resources, facilities, lesson time, and large class size [36-38]. Further, their study also showed that lack of apparatus, chemicals, and equipment are the most common problems, experienced by the teachers. Additionally, their study also revealed that other indispensable problems constraining the teaching of the practical lessons were laboratory space and crowded classrooms. The present study finding is also consistent with the finding of Nasri *et al*., (2010) study carried out in Malaysia, which revealed that limited time and bulky curriculum inhibited teachers to conduct practical activities [39]. Additionally, the studies also reported that teachers' heavy workload had negatively affected the teaching of Biology through practical lessons [40-41]. Further, the study findings of Chedup (2019) revealed that a crowded classroom is one factor that hinders the conduct of laboratory work [42]. This is mainly because of the difficulty faced in managing and

Table 7. Biology teachers' rating on difficulties encountered to conduct laboratory work

Statement	Mean	SD	Level of Opinion
All equipment needed are insufficient to conduct laboratory work effectively.	4.25	0.50	Very high
Some of the specimens, chemicals, and reagents required by the practical topics are unavailable.	4.00	0.00	Very high
Lack of separate Biology laboratory hampers the effective conduct of laboratory work.	3.75	0.50	High
The laboratory in the school is not spacious to conduct laboratory work.	4.75	0.50	Very high
Conduct of laboratory work is difficult in large class sizes.	4.25	0.96	Very high
Lack of qualified lab assistant hinders effective conduct of practical work.	4.25	0.96	Very high
Some practical work has to escape due to lack of time.	4.00	0.82	High
Heavy teaching workload hampers effective conduct of laboratory work.	4.25	0.96	Very high
Bulky Biology textbooks hinder effective conduct of laboratory work.	4.25	0.50	Very high
Insufficient teaching period in Biology hampers effective conduct of laboratory work.	4.25	0.96	Very high
Lack of proper support and services from lab assistants hinders effective conduct of laboratory work.	4.00	0.82	High
Lack of Principals and HoD's support to manage unavailable materials and equipment affect effective conduct of laboratory work.	3.50	0.58	High
Other leadership roles and responsibilities hinders effective conduct laboratory work.	4.00	0.00	High
Mean	4.11	0.62	Very high

controlling a large number of students in the laboratory.

The finding of this study on the lack of qualified lab assistants as the hindrance to having effective conduct of laboratory work is also in line with the study of Wangdi (2019) who found that lab assistants lack the required knowledge and skills to assist teachers in conducting experiments [41]. Similarly, findings of this study found that the lack of adequate training, knowledge, and skills in lab assistants, contributes to their failure to provide necessary and timely support to the teachers.

3.3. Strategies Intervened by Biology Teachers to Overcome Associated Challenges during Laboratory Work in the school

The aforementioned findings indicate that teachers face numerous challenges to conduct laboratory experiments. However, the other findings of this study revealed that teachers come up with innovative strategies to overcome those challenges and correspondingly, carry out the experiments. It is found that teachers try to manage the laboratory equipment which is not available in their schools, from the nearby schools. Further, teachers shared that they use videos and simulations in place of laboratory experiments. Additionally, teachers reported that they try to improvise some material, using locally available resources. This finding is comparable to the finding of Liswaniso (2019) who asserted that teachers go for improvised laboratory equipment, rather than waiting for the school to procure that equipment [37]. The finding of this study is also in agreement with the study of Dorji (2019), where it revealed that some teachers have managed the resources, improvised the materials that are not present in the laboratory, so that the experiments can be carried out without negligence [43].

CONCLUSION

The finding of this study confirmed that teachers have positive perceptions towards the conduct of laboratory work. Similarly, this study finding also confirmed that students' showed a strong positive perception towards the conduct of laboratory work where it significantly influenced students' motivation and interest which assisted them to enhance their academic performance in the school. Although the conduct of laboratory work helped students to improve the learning environment and academic achievement, however, the conduct of laboratory work in the classes IX and X schools in Bhutan is hindered by the factors such as poor laboratory facilities, less number of teaching periods, heavy teachers' workloads, bulky curriculum, crowded class and lack of qualified laboratory assistants.

Despite several factors hindering the conduct of Biology laboratory work in the schools, the present study also found that Biology teachers were not complacent and did not ignore the laboratory activities in class IX and X in Bhutanese schools. It is found that teachers, with the help of laboratory assistants and students, used other strategies such as improvisation of materials, locally available resources, and managing the equipment from the nearby schools. Additionally, teachers used video clips and lecturing methods to explain the practical concepts. Hence, the study concludes that laboratory activities are carried out to some extent for classes IX and X Biology.

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5. CONFLICT OF INTEREST

The authors have declared that there is no conflict of interest.

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NA

7. REFERENCES

1. Olutola, A.T. (2016). Comparative effects of practical and alternative to practical methods on students' academic performance in Biology. *International Journal of Educational Benchmark*, **3*(1)***: 67-80.
2. Wangchuk, D. (2019). Factors contributing to effective learning of Particle theory in class XII. [Unpublished Master's Thesis]. Samtse College of Education.
3. Wangchuk, N. (2018). Sherig Page.
4. Metz, A.M. (2008). Teaching statistics in Biology: Using inquiry-based learning to strengthen understanding of statistical analysis in Biology laboratory courses. *Life Science Education*, **7**: 317–326.
5. Fleischner, T.L., Espinoza, R.E., Gerrish, G.A., Greene, H.W., Kimmerer, R.W., Lacey, E.A., Pace, S., Parrish, J.K., Swain, H.M., Trombulak, S.C., Weisberg, S., Winkler, D.W., & Zander, L. (2017). Teaching Biology in the field: importance, challenges, and solutions. *Bioscience*, **67*(6)***: 558–567.
6. Fisher, G.R., Esparza, D. & Olimpo, J.T. (2019). Place-based case studies: A new approach to an effective teaching practice. *Journal of Microbiology & Biology Education*, **20*(1)***: 1-9.
7. Bell, S. (2010). Project-based learning for the 21st Century: Skills for the future. *The Clearing House*, **83*(2)***: 39-43.
8. Cimer, A. (2012). What makes biology learning difficult and effective: Students' views. *Education Research and Reviews*, **7*(3)***: 61-71.
9. Driver, R. (1995). Constructivist approaches to science teaching. *Constructivism in education*, 385-400.
10. Hofstein, A. & Naaman, R.M. (2007). The laboratory in science education: the state of the art. *Chemistry Education Research and Practice*, **8 *(2)***: 105-107.
11. Millar, R. (2004).The role of practical work in teaching and learning science. National Academy of Science: Washington.
12. Millar,R. & Abrahams, I. (2009). Practical work: making it more effective. *Getting Practical*, **91*(334)***: 59-64.
13. SCORE (2009a) Getting practical: a framework for practical science in schools. DCSF.
14. GEE, B. & Clackson, S. G. (1992). The origin of practical work in the English school science curriculum, *School Science Review*, **73*(265)***: 79—83.
15. Gott, R. & Duggan, S. (1996). Practical work: its role in the understanding of evidence in science. *International Journal of Science Education*, **18*(7)***: 791-806.
16. Ministry of Education (2014). Isherig. Education ICT Master Plan 2014-2018. Retrieved from http://www.education.gov.bt/Documents/10180/12859/ICT+Book+final+2015.pdf/f2791964-b5b7-4f78-9557a15213bd6446? Version=1.0. 33.
17. REC. (2012). Science Curriculum Framework. REC.
18. Hunde, A. B., Tegegne, K. M. (2010). Qualitative exploration on the application of student centered learning in Mathematics and natural sciences: The case of selected general secondary schools in Jimma, Ethiopia. *Ethiop. J. Educ. & Sc.,* **6 *(1)***.
19. Woodley, E. (2009). Practical work in school science – why is it important? Getting Practical, **91*(335)***: 49-51.
20. REC. (2019). Biology. Practical Works Manual. Class XI & XII. REC.
21. Mertens, D. M. (2010). Research and evaluation in education and psychology (3rd Ed). California: SAGE Publication.

22. Creswell, J. W. (2014). Educational Research: Planning, Conducting and Evaluating Quantitative and Qualitative Research (5th ed). APH Publishing.
23. Norbu, D. (2019). Investigating the relationship between self-efficacy beliefs and performance of 10th grade students in chemistry. [Unpublished Master's Thesis]. Samtse College of Education.
24. Creswell, J. W. (2011). Educational Research: Planning, Conducting and Evaluating Quantitative and Qualitative Research (4th ed). APH Publishing.
25. BCSEA. (2018). Pupil Performance Report 2018. School Examination Division. BCSEA.
26. Danmole, B. (2012). Biology teachers' views on practical work in senior secondary schools of south western Nigeria. *Pakistan Journal of Social Sciences*, **9*(2)***: 69-75.
27. Lunetta, V. N., Hofstein, A., & Clough, M. P. (2007). Learning and teaching in the School Science laboratory: An analysis of research, theory, and practice. Handbook of Research on Science Education (pp. 393–441). Routledge.
28. Omiko, A. (2015). Chemistry teachers' attitude and knowledge of the use of Information Communication Technology (ICT) in chemistry instruction delivery at the secondary school level in Ebonyistate of Nigeria. *Journal of curriculum Organization of Nigeria*, 86-94.
29. Woolnough, B., and Allssop, T. (1985). Practical work in science. Cambridge University Press.
30. Doosti, F. (2014). Biology Teachers' Perception of Laboratory Work in Afghanistan. A Survey Study of Secondary Schools in Kabul City. [Thesis. Karlstads University].
31. Sharpe, R.M. (2012). Secondary school students' attitudes to practical work in school science. [Doctoral Thesis. University of New York Education].
32. Osborne, J., & Collins, S. (2001). Pupils' views of the role and value of the science curriculum: a focus group study. *International Journal of Science Education*, **23*(5)***: 441–467.
33. Abrahams, I. & Millar, R. (2008). Does practical work really work? A study of the effectiveness of practical work as a teaching and learning method in school science. *International Journal of Science Education*, **30*(14)***: 1945–1969.
34. Dohn, N.B., Fago, A., Overgaard, J., Madsen, P.T., & Malte, H. (2016). Students' motivation towards laboratory work in physiology teaching. *Advances in Physiology Education*, **40**:313-318.
35. Aladejana, F. & Aderibigbe, O. (2007). Science laboratory environment and academic performance. *Journal of Science Education and Technology*, **16**: 500-506.
36. Mwangu, E.C., & Sibanda, L. (2017). Teaching Biology practical lessons in secondary schools: A case study of five Mzilikazi District secondary schools in Bulawayo metropolitan province, Zimbabwe. *Academic Journal of Interdisciplinary Studies*, **6*(3):*** 47-55.
37. Liswaniso, L. J. (2019). An investigation into the teaching of biology and physical science practical works in senior secondary schools in the Zambezi region, Namibia. [Master's Thesis. The University of Namibia].
38. Cossa, E., F. R., & Uamusse, A. A. (2015). Effects of an in-service program on biology and chemistry teachers' perception of the role of laboratory work. *Procedia-Social and Behavioral Sciences*, **167**: 152-160.
39. Nasri, N.M., Yusof, Z.M., Ramasamy, S. and Halim, L. (2010). Uncovering problems faced by science teacher. *Procedia- Social and Behavioral Sciences*, **9*(3)***: 670–673.

40. Banu, M. S. (2011). The Role of Practical Work in Teaching and Learning Physics at Secondary level in Bangladesh. University of Canterbury.
41. Wangdi, R. (2019). The effectiveness of practical work in Teaching Physics: Its challenges and impact on students' learning in secondary schools. [Unpublished Master's Thesis]. Samtse College of Education.
42. Chedup, K. (2019). The effects of large class size on teaching and learning physics in classes nine and ten. [Unpublished Master's Thesis].Samtse College of Education.
43. Dorji, K. Effectiveness of Laboratory Practical in Understanding Theoretical Concept in Biology: A case Study. [Unpublished Master's Thesis].Samtse College of Education.