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RESEARCH PAPER

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Learning Station Approach for Teaching Genetics in Grade ten in Tendu Central School, Bhutan

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ABSTRACT

The Learning Station Approach (LSA) is one of the strategies of Differentiated Instruction (DI) that refers to a physical location in the classroom where the teacher plans and designs activities based on the need of the students. Learning Station Approach is a new teaching pedagogy in the Bhutanese classroom context; thus, this study investigated the effectiveness of the Learning Station Approach on students' academic achievement in genetics concept at grade ten level (Bhutanese curriculum) with a sample size of 68 students. The study employed a non-equivalent quasi-experimental design based on pre-test and post-test scores of experimental and control groups as a means of gathering data. The findings revealed that Learning Station Approach is a practical instructional approach ($p<0.001$) that can improve students' academic achievement in genetics at the grade ten level. Therefore, the finding recommends teachers use Learning Station Approach to enhance students' learning achievement.

Keywords: Learning Station Approach, Quasi-experimental, Traditional teaching method, Test scores

1. INTRODUCTION

The universal goal of effective teaching is to enable every student to achieve success and to make them self-directed, reflective, productive problem-solvers, and creative thinkers. Such attributes bring success not just in the school but also in their life. Likewise, schools are the institutions that provide opportunities for developing and inculcating those good elements of effective teaching [1]. However, fulfilling the inclusiveness of curriculum within the classroom environment is a challenge, particularly when the class comprises diverse groups of students with different learning abilities, interests, and learning styles. Learners learn the same thing in different ways. Therefore, considering the learner's needs, readiness, preferences, and interests, teachers must come up with effective strategies with multiple options to enable the students to learn effectively.

Bhutan, in its attempt to shift the method of instruction from conventional to 21st-century skills and strategies, the Ministry of Education (MoE) has provided the professional development programme on the 21st

century transformation pedagogies to all teachers in the country to equip teachers with the latest teaching-learning tools or approaches [2]. One way to accomplish the 21st-century educational goals is by using a widely used science and mathematics teaching strategy known as Learning Station Approach (LSA). Learning station is an approach within the differentiated instruction that caters to students' readiness, interest, and learning profile. It is the physical location in the classroom where students are asked to solve a problem and answer some questions using the materials provided based on their readiness, interest, and learning profile.

Several studies have claimed that LSA is the most successful teaching strategy that promotes active learning during all stages of the educational process [3-4]. Further, Azaman *et al.* (2020) claimed that LSA helps in keeping students actively engaged in their learning and to build concepts based on their own experiences [3]. Similarly, Aqel and Haboush (2017) affirmed that the learning station strategy contributes to facilitating better conceptual understanding of the subject matter as students share ideas and their points of views, give and receive support from each member who helps to dig below the superficial level of understanding of the material they learn. They further stated that the station technique provides an opportunity for interactive thinking and information organization so that the students know what they learn and how they learn? [5]. In addition, Humphrey *et al.* (1982) stated that the improved academic achievement in station technique is attributed to the support that individual students receive from the group members that keep them going, providing more chances to be successful academically [6].

However, there is no literature-based evidence on the use of LSA in Bhutanese classrooms to date. Hence, the question of whether LSA can be effectively implemented in Bhutanese classrooms and how effective it would be on students' learning, specifically in Biology remains unanswered [7-9]. Therefore, by employing LSA using a quasi-experimental design, this study investigated the effectiveness of LSA in teaching and learning of genetics concept from grade ten Biology in the Bhutanese school context to have authentic information as well as to establish the baseline data.

2. MATERIALS AND METHODS

2.1. Research design

This study is based on a pragmatist paradigm to explore the impact of LSA in teaching genetics in grade ten Biology subject. The study employed a quasi-experimental design to test the effectiveness of the intervention strategy 'LSA'.

Out of the three types of quazi-experimental designs, the study adopted a non-equivalent group design as the non-equivalent group's design. This is because of its significance such as the use of pre-test and post-test allows the establishment of "temporal precedence" of the independent variable to the dependent variable.

2.2. Sample

The convenience sampling method was used to choose one of the Middle Secondary schools in Samtse Dzongkhag. Following the cluster sampling procedure, the experimental group (EG) and control group (CG) were chosen. 68 students out of 136 students, two sections out of four were chosen as EG and CG consisting of an equal number of students (34) in each group with the same level of academic achievement (table 1).

2.3. Data collecting instruments

This study has used the Biology Achievement Test (BAT) to find out the student's pre-existing knowledge on 'genetics' from the chapter Genetics and Evolution, from the grade ten Biology textbook (Bhutanese curriculum). BAT questions were framed based on the Bhutanese Secondary School Biology curriculum 2016. In addition,

Table 1. Sampling Size for Quasi-experiment

Group	Male	Female	Total
CG	15	19	34
EG	17	17	34
Total	32	36	68

some of the questions were adapted from Bhutan Certificate Secondary Examination (BCSE). The questions contain a good number of Competency-Based Questions (CQB) to validate the learning outcome. BAT is administered to both EG and CG at the beginning of the intervention and the end of the intervention.

2.4. Procedures of an intervention strategy

2.4.1. For experimental group

Learning Stations (LS), developed using the ADDIE (Analysis, Design, Development, Implementation, Evaluation) instructional design model was implemented for teaching genetics to EG students. This instructional design was found to be effective in providing developers with a generic, systematic framework that was easy to use and applicable to a variety of settings. This study incorporated the ADDIE model in two ways; firstly, in developing the framework to determine the learning experiences of the students based on the topic of genetics, and secondly, in designing the instructional strategy, LS incorporating the diverse abilities of the students as follows:

2.4.2. Analysis

In this phase, the goals and objectives of the lesson are established, and the learning environment and learner characteristics are identified to design appropriate learning experiences for diverse learners.

2.4.3. Design

In this phase, the instructional strategies were designed incorporating the differentiated instructional strategy where different station activities can cater to varied learning profiles of the students. It has used the following learning stations in teaching the genetic concept to the students.

i. Waiting station
ii. Reading station
iii. E-Station
iv. Visual station and
v. Exploratory station

2.4.4. Development

In this phase, the five learning stations were developed encompassing varied learning activities that can cater to different learning profiles of the students. This includes the required educational objectives, the roles of students, and executing steps in the light of the learning station approach. In addition to the four learning stations, the researcher added a 'Waiting Station' at the beginning of the lesson, where students attend in the whole group before going to the stations. Video and PowerPoint presentations were used as an alternative to introducing the topic in the waiting station, followed by smaller group activities in respective learning stations within the allocated time frame.

2.4.5. Implementation

In this stage, students were divided into groups of five using a flexible grouping strategy to include students' readiness level, interest, and choice so that they get to learn as per their competency and compatibility. Each group was assigned with group numbers. Each student within the group was assigned the respective role, as shown in table 2.

2.4.6. Evaluation

The evaluation was carried out in each level of the model, i.e from analysis till the implementation phase to fine-tune the lesson activity all along the way. Formative evaluations were carried out in the process of activity in respective stations. A summative evaluation was also

Table 2. Role of Each Student in the Group

S.No	Rank	Task
1	Leader	Lead the group in each station
2	Observer	Making sure everyone is on his/her job, watching the time and sound of the group members, overseeing the cleaning stations before going to the next, and acting as the group's leader in the absence of the commander.
3	Information bank	Get a sheet, and ask the teacher for more explanations.
4	Blogger	Make sure that works sheets are done, summarizing the decisions and conclusions they have reached.
5	Supplier	Getting the needed tools, and asking the teacher for unavailable materials.

Note: Adapted from *Aqel and Haboush (2017), p. 71*

conducted after implementation to determine the impact of the learning station approach as an instructional strategy.

2.5. Preparing LS and execution of LS activities

This study used four stations: Reading station, E-station, Visual station, and Exploratory station to see its impact in enhancing the learning of genetic concepts by grade ten students in Biology. Following the ADDIE model, lesson activities on genetics were designed and implemented as given below:

Reading station: In groups, students read an article that helps in explaining the concept. After that, the group answers the worksheet for the station. Students jot down the takeaway points.

E-Station: Groups attend to interactive PowerPoint presentations displayed in the station on the computer. After that, the group answers the worksheet for the station. Students jot down the takeaway points.

Visual station: Groups attend the interactive video lesson on the topic under study. After that, the group answers the worksheet for the station. Students jot down the takeaway points.

Exploratory station: The researcher prepared necessary materials like text, solved problems, or jumbled up tasks where the groups explore through that. After that, the group answers the worksheet for the station. Students jot down the takeaway points.

Finally, having completed a round of station activities, the groups take turns in presenting their work to the whole class and generate further discussions to authenticate their effective learning.

The range of activities was designed in different learning stations to cater to different learning profiles of the students to boost their confidence and serve as a foundation for further learning. Similarly, students were given the choice of the way that they present their work/activity to enable them to adhere to and build their innate potential. Further, every student was made to think, analyze and part-take in the task and necessary scaffolding was given by the abled peers and the teacher to maximize their learning ability. LSA lesson was carried out for a week providing every learner with an opportunity to explore within the scope of one's capability in collaboration with the abled peers and teacher to construct the knowledge and values.

2.6. For Control Group

A control group is an essential part of many research designs, allowing researchers to minimize the effect of all variables except the independent variable. The control group, receiving no intervention, was used as a baseline to compare groups and assess the effect of the intervention method used. The control group was taught in a traditional lecture method (TLM).

2.7. Data Analysis

The data collected through BAT were coded and entered into Statistical Packages for Social Science (SPSS, 22.0 version). The Shapiro-Wilk test was performed to check the data normality in SPSS. This test was important to choose the right inferential test for the variables of interest. It was observed that the spread of data was normally distributed with the p-values > 0.05 (Table 3).

3. RESULTS AND DISCUSSIO

3.1. Analysis of Pre-test Data between Control Group and Experimental Group before Intervention

An independent sample t-test was performed at a 95% confidence interval to address the research sub-question 1 to examine the level of prior knowledge on genetic concepts possessed by the students of the experimental group (EG) and control group (CG). Data indicated that there was no statistically significant difference (p=0.841) with an average mean value of 5.85 for CG and 5.75 for EG during the pre-test. This indicated that the student's prior knowledge of genetics was low. Further, this also shows that the distribution of students between CG and EG was equally considered in terms of learning abilities before the intervention was made (Table 4).

Furthermore, to examine the effect size of the two groups, Cohen's d was calculated. As per Cohen (1988), Cohen's d is calculated by dividing the difference of two means (M1 and M2) by the average standard deviation of the groups [11]. Cohen considered d = 0.2, 0.5 and 0.8 corresponding to small, medium and large effect size respectively. Similarly, the effect size is an estimated measure of the strength of two or more variables in an inferential test. This enables the researchers to see the magnitude of effect size to determine its practical significance. Therefore, the Cohen's d value for the pre-test between the groups was 0.05 which implies that the mean difference between the group was small and practically negligible (Table 4).

Table 3. Normality of Test Scores of Control Group and Experimental Group

Test	Group	N	p-value
Pre-test	CG	34	0.425
	EG	34	1.298
Post-test	CG	34	1.251
	EG	34	1.107

* Significant (p<0.05) CG: control group EG: experimental group

Table 4. Independent Sample T-Test of Pre-test between Groups

	Groups	N	Mean	Mean difference	SD	Sig (2 tailed)
Pre-test	CG	34	5.85	0.09	2.02	0.841
	EG	34	5.76		1.56	
	Cohen's d	0.05				

*A significant level of P<0.05 EG: experimental group
Cohen's d value: d=0.2-small effect, d=0.5-medium effect, d=0.8-large effect

Table 5. Independent Sample T-Test Based on Post-test Scores Between CG and EG

	Groups	N	Mean	Mean difference	SD	Sig (2 tailed)
Post-test	CG	34	10.18	6.35	1.77	0.000
	EG	34	16.53		1.56	
	Cohen's d	3.8				

*A significant level of P<0.05 EG: experimental group
Cohen's d value: d=0.2-small effect, d=0.5-medium effect, d=0.8-large effect

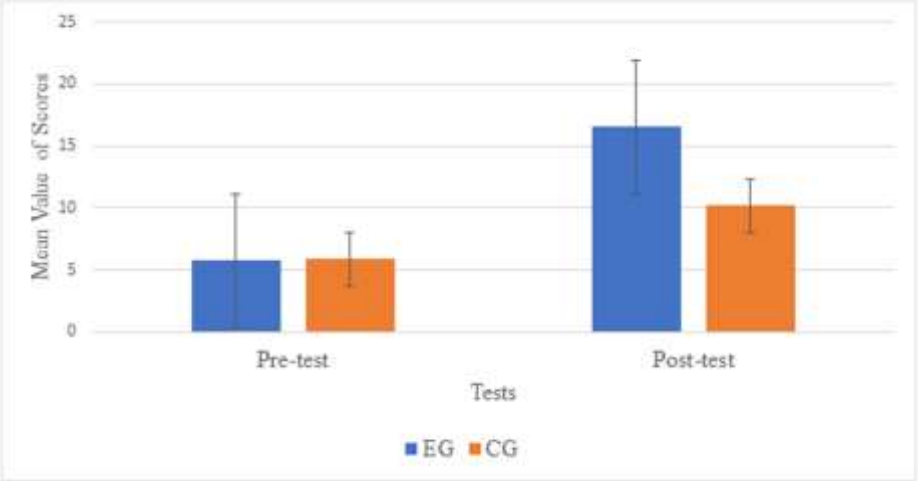

Fig 1. A comparison of Pre-test and Post-test Between the Groups (CG and EG)

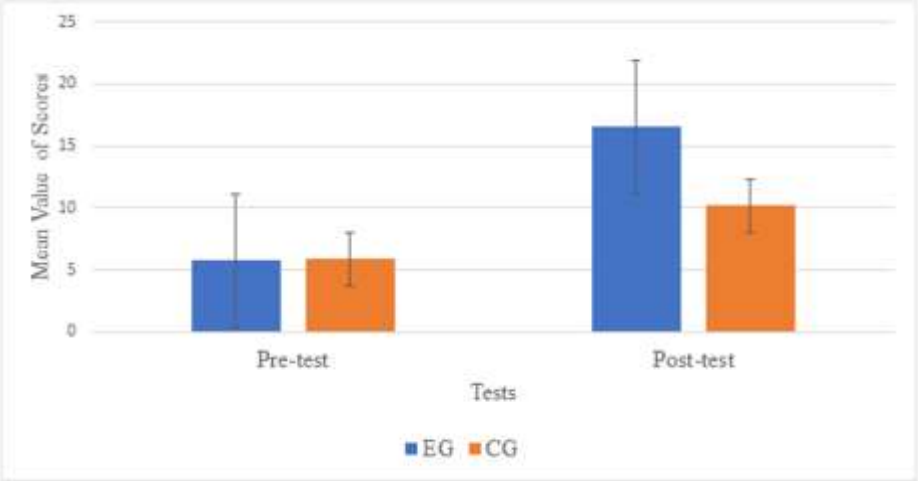

Fig 2. Mean Difference Comparison of Pre-test and Post-test Within the Groups

3.2. Analysis of Post-test Data between the Control Group and Experimental Group after the Intervention

To address research sub-question 2 (see Chapter 1), an independent sample t-test was performed at a 95% confidence interval to examine the prevalence of any statistically significant difference between the post-test scores of EG and CG. Data indicated that there was a statistically significant difference ($p<0.001$) between CG and EG with the mean difference value of 6.35 and the Cohen's d value 3.8 inferring the significant difference in means between the two groups (Table 5; Figure 1).

3.3. Findings on Learning Station Approach vs Traditional Lecture Method

In an attempt to analyze the level of student's performance based on two selected teaching methods (i.e. LSA and traditional lecture method), a paired sample t-test was performed within groups using pre-test and post-test scores of the respective groups (To address research sub-question 3). Data indicated a statistically significant difference between pre-test and post-test scores of EG with a p-value less than 0.001, a mean difference of 10.76, and Cohen's d value 4.45(Table 6; Figure 2). Similarly, a statistically significant difference was observed with a p-value <0.001, a mean difference of 4.32, and Cohen's d value 1.66 for CG (Table 7; Figure 3). These findings indicate that both the instructional approaches i.e. LSA and traditional lecture method were

Table 6. Paired Sample T-Test of Pre-test and Post-test of EG

	Groups	N	Mean	Mean difference	SD	Sig (2 tailed)
EG	Pre-test	34	5.76	10.76	2.42	0.000
	Post-test	34	16.53			
	Cohen's d	4.45				

*A significant level of P<0.05 EG: experimental group
Cohen's d value: d=0.2-small effect, d=0.5-medium effect, d=0.8-large effect

Table 7. Paired Sample T-Test of Pre-test and Post-test of CG

	Groups	N	Mean	Mean difference	SD	Sig (2 tailed)
CG	Pre-test	34	5.85	4.32	2.61	0.000
	Post-test	34	10.17			
	Cohen's d	1.66				

*A significant level of P<0.05 EG: experimental group
Cohen's d value: d=0.2-small effect, d=0.5-medium effect, d=0.8-large effect

observed to be effective in this study. However, the effect of LSA was found to be greater than the traditional lecture method.

Furthermore, to compare the effectiveness of the traditional lecture method vs. LSA, pre-test and post-test data were analysed based on score ranges within and between groups (Table 8a & 8b). Students' improvements were observed in both groups. However, higher performance of the students was noted within the EG, indicating that LSA as a teaching-learning tool was better than the traditional lecture method.

The key findings of the study are discussed and sequentially presented within the concepts of the following three key research sub-questions:

- What level of prior knowledge on genetic concepts possess by the students?
- Is there a significant difference in scores between the experimental group and the control group during the post-test?
- To what extent does the traditional lecture method show its credibility in students' learning?

3.4. Findings Based on the Students' Pre-test Exercise

To determine students' prior knowledge on the concepts of 'genetics', and to address research sub-question 1, the scores of the pre-test exercise were statistically analyzed using an independent pair sample t-test between the groups (control and experimental). Data indicated mean marks of 5.85 for the control group and 5.76 for the experimental group, and the test was conducted based on 20 marks. The Cohen's d value for the pre-test analysis was 0.05, indicating a negligible or statistically not significant mean difference between the groups. This result indicated that the students possess some prior knowledge on the concepts of genetics for both groups before the commencement of the intervention. Studies have reported that students' prior knowledge is essential for the construction of new knowledge during the learning process. For example, Ausubel *et al.* (1968) claimed that the prior knowledge of students plays a significant role in knowledge construction in learning settings and that the execution of the study in the groups with similar prior knowledge would be better for any experimental studies [12]. More specifically, Blurton (1985) reported that students' prior genetics knowledge had significantly foreseen the performance of the students during the post-test events [13]. In addition, a study carried out by Hegarty-Hazel and Prosser (1991) indicated that prior knowledge helped students internalize more effective study strategies to achieve in college Biology and physics classes [14].

Table 8a. Effectiveness of Lecture Method and LSA Based on Scores of CG and EG

Standard	Score range	CG Pre-test		CG Post-test	
		No of stds	Percent	No of stds	Percent
Very good	90-100	-	-	-	-
	80-89	-	-	-	-
Credit	71-79	-	-	-	-
	61-70	-	-	4	11.80%
	51-60	-	-	9	26.50%
Pass	44-50	2	5.90%	15	44.10%
	35-43	9	26.50%	5	14.70%
Fail	< 34	24	70.90%	1	2.90%

Table 8b. Effectiveness of Lecture Method and LSA Based on Scores of CG and EG

Standard	Score range	EG Pre-test		EG Post-test	
		No of stds	Percent	No of stds	Percent
Very good	90-100	-	-	10	29.40%
	80-89	-	-	16	47.10%
Credit	71-79	-	-	5	14.70%
	61-70	-	-	3	8.80%
	51-60	-	-	-	-
Pass	44-50	2	5.90%	-	-
	35-43	3	8.80%	-	-
Fail	< 34	29	85.30%	-	-

Moreover, in this study, a statistically significant difference was not observed between the groups in the pre-test event, hereby supporting the idea that the group formation was confirmed to be equal in terms of students' prior knowledge on genetics and their learning abilities, so that reliability of the data collection during post-test exercise be enhanced. Since there was no significant difference found between the control group and experimental group students before the treatment, the effectiveness of the LSA on students' conceptual understanding and achievement cannot be attributed to the students' prior knowledge differences between the groups.

3.5. Findings Based on the Students' Post-test Exercise

To address the research sub-question 2, the independent sample t-test was performed to examine any statistically significant differences between the control and experimental groups. The results of the study revealed that the experimental group outperformed the control group during the post-test indicating the effectiveness of LSA as an innovative teaching-learning strategy in teaching genetic concepts. For example, in this study, the statistical result analysis showed that there was a significant difference ($p < 0.001$) between the performances of the experimental group (M=16.53) and the control group (M=10.18) with a mean difference of 6.35 in the post-test scores. When the gained means scores were compared, it was 10.77 for the experimental group and 4.20 for the control group respectively. The Cohen's d value for the post-test between the group was 3.8 that shows a large practical significant effect on students' learning achievement when taught through LSA. The effectiveness of LSA in this study may be attributed to associated features of the tool such as flexibility, self-paced learning, interactive video, and activity-based learning with close interaction among peers and the subject teacher. For example, Koseoglu *et al.* (2009), observed that the students were able to learn more easily and had more fun when they worked at

stations [15]. This is also supported by the study of Benek and Kocakaya (2019) that students learning at stations are found to be more responsible for their learning by working in collaborative groups and taking an active role in activities that address all intelligence [16]. Further, they also stated that students get more opportunities to socialize by taking roles and responsibilities in heterogeneous teams where even the shy students can work in a team through sharing their views and concerns in the process of learning [16].

The other possible reasons for such a significant increase in the test scores in the experimental group were due to students' likeness to learn Biology, their interest, and motivation generated towards LSA lessons. Various studies reported that LSA serves as a motivating and interesting factor that contributes to students' own pace of learning and enhance their academic performance [3, 17-19]. Similarly, in LSA lessons students were given multiple entry points to access the same classroom curriculum, learning tasks, and outcomes that are tailored to pupils' needs and interests, where these kinds of platforms are not available in the textbook in traditional classrooms. Moreover, students can rewind, pause, and watch the video lessons and re-attempt the progress check questions as many as they want until the concept is clear for them. In addition, LSA lesson provides the freedom to either work alone or in groups with their choice of member friends, and this has helped boost students' interest and motivation towards learning the subject thereby enhancing their academic performance.

Therefore, the present finding is consistent with that of the finding of Azaman *et al.* (2020) who claimed about 88.3% of the students accomplished higher performance grades in the post-test assessment when they were taught via the learning station technique [3]. Other studies have confirmed that the learning station technique is more effective in increasing the achievement of students compared to other methods applied in control groups [16, 20]. This finding is also in parallel to a meta-analysis study carried out by Aydogmus and Senturk (2019) between 2000 and 2018 in Turkey who reported the effect size of the learning stations technique on academic achievement was 0.84 [21] which in accordance to Cohen (1998), is large effect size [11]. Further, this finding is also in line with the study done by Rogayan Jr. (2019) on the effects of Biology Learning Station Strategy (BLISS) on the academic achievement and attitude of junior high school science students, where he reported that the BLISS intervention enhanced the student's academic achievement and their attitude towards Biology [19].

3.6. Credibility of Lecture Method in This Study

To determine the credibility of the lecture method and to address research sub-question 3, the scores of pre-test and post-test exercise were statistically analyzed using paired sample t-test for both the groups (control and experimental). The results of the study revealed that the traditional lecture method has also helped in enhancing students' test performance through its impact on students' learning was less as compared to LSA. For example, the inferential result analysis showed that there was a statistically significant difference with a p-value <0.001 for both the groups with a mean difference of 4.32 for the control group and 10.76 for the experimental group. This indicates that the students in both groups have considerably performed better in the post-test. Even though the increase in the understanding level of experimental group students were higher than the control group students when the mean scores on pre-post Biology achievement test (BAT) were compared, however, control group students have also significantly exhibited a higher level of conceptual understanding in the post-test with the confident interval ≥ 95%. This finding suggests that the traditional

lecture method is also a useful teaching strategy that can enhance students' learning if used optimally.

The effectiveness of the traditional lecture method in this study may be attributed to the fact that the teachers make the lesson logically sequenced with clarity of ideas presented for better conceptual understanding of the lesson. For example, Solomon (2020) reported that students prefer the lecture method because of the reasons: instructors making the lesson simpler, well-organized lesson, absence of alteration, instructor's short note useful during exams, and lesson plans well – organized [21]. Similarly, another study revealed that most of the students liked the lesson delivered though the traditional lecture method because the teacher gives all the information related to the subject, it is time-saving, students listen thoughtfully to lectures and take short notes that help them learn and retain the concept better [22].

4. CONCLUSION

The findings of study confirmed that the LSA has been effective teaching-learning approach in teaching biological abstract concepts, particularly genetics in grade ten level in Bhutanese schools. The better performance of students in LSA is evident in this study whereby, the EG performed significantly higher ($p<0.001$) in terms of test scores as compared to CG during the post-test results. It was also noted that the mean and average test scores of the EG were considerably better than the CG in the post-test result as discussed in the result section. Therefore, the result of the study manifested a significant improvement in the academic performance of the students. The significant improvement in academic performance may be attributed to the fact that the LSA provides preferential learning opportunities for the students capturing their learning interest and motivation to learn better. Furthermore, LSA provides more opportunities to interact with the teachers and peers than the traditional lecture method. This scaffolding opportunity enhances students' academic learning. As a result, LSA is found as one of the effective strategies in teaching and learning genetics concepts in Secondary Schools of Bhutan.

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6. CONFLICT OF INTEREST

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

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