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EMPLOYING POE STRATEGY-BASED HANDS-ON-MODEL TO TEACH BREATHING MECHANISM IN GRADE 9 BIOLOGY STUDENTS IN BHUTAN

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Abstract: According to numerous studies meaningful learning by students occurs when they are engaged in a lesson that requires observation and investigation. Further, students' curiosity and level of interests in lesson increase when they are involved in handling physical model. Therefore this study attempts to investigate students' conceptual achievement and their attitudes towards the developed learning lesson: Predict-Observe-Explain based Hands on Model in breathing mechanism in grade 9 students. A group consisting of 30 grade nine biology students was involved in experimental group and a group of 30 students as control group. The data were gathered via pre-test and post-test, students' worksheets (structured concept map and POE task) and attitude by the 5-point Likert scale questionnaire. Interview questions were used to corroborate the data gathered by other tools. The findings show significant conceptual achievement in the experimental group with t-test value of 16.9 with pre-test mean (3.7 ± 0.48) and post-test mean (7.83 ± 0.41), and also show positive learning experience and attitude towards the developed learning lesson and the topic.

Key words: Breathing Mechanism; Hands-on-Model; Predict-Observe-Explain.

Introduction: In biology education, many students find it difficulty in understanding the concepts of breathing mechanisms [1] Previous studies revealed students' lack of understanding on the basic structures of breathing system [2, 3]. For example, students state diaphragm as the only muscles that contribute to breathing. Also, students have incorrect conceptions about the movement of ribcage and intercostals during breathing cycle. There are numerous misconceptions related to basic breathing mechanics [4, 5].

According to [1], lack of appropriate educational materials are the contributing factors that cause difficulty in understanding breathing mechanics in high school students [6]. The structured curriculum, traditional teaching methods and conventional lung model could be limiting effective ways of teaching-learning in breathing mechanisms.

Especially in science, students build immature understanding or erroneous concepts from scientifically accepted ones. So there is a need for effective pedagogical instructional methods and tactile physical model to make abstract concepts concrete to achieve correct concepts [6, 2, 7]. Many researchers have constructed numerous models to teach breathing mechanics at various grade levels. Different models served to provide hands-on experience and simple to use, however, it omits some of the basic physiological concepts. For instance, none of the models represent ribcage and intercostals which are basic structures of breathing process.

The developed model is an improved version of the traditional bell-jar model. The developed physical model presents the basic structures of breathing like ribcage and intercostals portraying correct movements while missing in the former models. The developed physical model has an additional

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advantage of providing the concept of function and positions of ribcage during breathing process.

Scientifically, breathing action is brought by contraction and expansion of intercostals muscles of ribs and diaphragm, and thence lungs and the alveoli are expanded or collapsed. Many basic physiology textbooks have drawings of respiratory organs including parts like diaphragm, ribcage (ribs) and lungs. Their movements and functions during inhalation and exhalation are explained verbally or shown diagrammatically.

From our experience of teaching these concepts, many students had a notion that only diaphragm causes breathing (inspiration and expiration) due to non-inclusion of ribcage in the bell-jar model or any other models. Transmission of such misconceptions may persist with students if not clarified with innovated physical model with POE instructional strategy.

None has attempted Hands-on-model with POE-based instructional approach before, and will be implemented and investigated for the effectiveness and development of positive attitude towards the developed learning lesson as a pedagogical innovation. Likewise, in Bhutan, grade 9 Biology students are taught breathing mechanism by using textbook diagram or a traditional bell-jar model without conceptual change instructional strategy. Therefore, there is a need to study on the effectiveness of POE instructional strategy-based with improved existing physical bell-jar model.

Literature Review: Students find difficulty in understanding mechanism of breathing and basic structures of breathing system thereby leading to weak foundations for higher level studies According to [1], some of the reasons for overlooking physiology concepts in high school curricula are due to the lack of appropriate educational materials, need of expensive laboratory materials and experiments. The importance of foundations of physiological concepts is felt at graduate and postgraduate level, and is imperative to focus on instructions at high school level to engage students meaningfully in the learning. [5] claims that many medical and graduate students face difficulty in the topic of mechanics of breathing. According to him, children grew up with electronic devices and with little idea of its function, engage students mostly and less emphasis is given to physiology concepts in lower grades. Most often students of physiology have been introduced by a drawing in a textbook or on lantern slide without actual model for demonstration in the laboratory [4, 7]. Similarly, in Bhutan, Biology teachers use traditional lung model or textbook diagrams to deliver concepts of breathing mechanism [7]. Students need to be provided with possibilities to engage and explore them in fruitful learning situations within or outside classroom. Several studies have found out POE instructional strategy as effective approach in content achievement [8, 9, 10]. In addition, physical model have enabled to simplify concepts and provided students tactile means to learn. Therefore, the learning lesson-POE based Hands-On-Model was developed.

Physical hands-on-model learning: The use of models to present complex materials has been shown to be an effective medium for science learning [1, 11]. Models have been shown to change the focus and organization of scientific thinking [12, 13]. Use of physical hands-on-models encourage learning and help students understand complex ideas [11, 14]. According to [15], physical models are effective teaching tools because they provide the student with a familiar frame of reference that is similar to the new concept being taught.

The Predict-Observe-Explain (POE) Instructional Strategy [16] proposed effective instructional strategy predict-observe-explain (POE) procedure and often use to promote students' science conception. The instructional approach requires students' prediction of the result of a problem or experiment, next observation of the situation of the problem or experiment, and then finally analyze and clarify any discrepancies between their prediction and observation. POE strategy can help students clarify their own individual ideas and effective in promoting a durable conceptual change [17].

Methodology: In order to evaluate the effectiveness of the developed learning lesson, pre-test post-test control group research design was employed. The learning lesson of 120 minutes was implemented. Pre-test was administered just before intervention and post-test right after the intervention. Experimental group was administered to 5-point Likert-scale questionnaire (LEPQ) to gather attitude towards the learning lesson and responded to semi-structured interview. Additionally, students' worksheet (structured concept map) was collected to investigate students' conceptual achievement on breathing mechanism. The scheme of research design used in this study is shown below.

2 Sections of Grade 9 biology students					
	A class of students (Section A)	Pre-test	Usual teaching format	Post-test	✓Structured concept maps
	A class of students (Section B)	Pre-test	Intervention Developed Learning Unit (A POE-based strategy hands-on-model)	Post-test	✓Structured concept maps ✓LEPQ ✓Semi-structured interview (6 stds. random selection)

Fig.1. Research process

The study employed mixed method to collect data. Both qualitative and quantitative data collection tools were used to gather information. Gathered data were analyzed descriptively.

Results and Analysis: The results in Table 1 present the experimental and control group mean scores of pretest and posttest on breathing mechanism. The independent sample t-test score of 16.9 demonstrating highly significant in the use of the learning lesson. The mean gain percent of experimental group (40.3%) was also significantly higher than those of control group (22%).

Before learning breathing mechanism, the students had some knowledge as detected by pretest scores in both the groups. In experimental group, after participating in the developed learning lesson, the students' knowledge improved significantly from 37 % to 77.3 %. On the other hand, in control group students' knowledge improved from 35% to 57% comparatively less than the experimental group.

Table **1** Pre-test and post-test mean scores of experimental group and control group of grade 9 students on breathing mechanism.

Group	**N**	**Pretest Mean ± SD**	**%**	**Post-test Mean ± SD**	**%**	**% Mean Gain**	**Independent t-test**
Expt. Group	30	3.70 ± 0.48	37	7.73 ± 0.41	77.3	40.3	**16.9**
Control Group	30	3.5 ± 0.48	35	5.70 ± 0.51	57	22	

The Table 2 below presents the structured concept map worksheet on breathing mechanism to investigate their understanding and to support the pre-test and post-test data. Both the experimental group and control group were divided into 7 groups and administered structured concept map to complete individually in their groups. The result indicated significant difference scores in experimental group and control group with mean (5.22 ± 0.71) and (3.65 ± 1.08) respectively.

Table 2 Structured concept map scores with mean (N=7 groups)

Groups	Experimental Group Mean ± SD	Control Group Mean ± SD
1	5.4 ± 0.89	3.2 ± 0.84
2	5.4 ± 0.55	3.6 ± 0.55
3	5.5 ± 0.58	4.0 ± 0.82
4	4.5 ± 0.58	4.0 ± 1.41
5	5.5 ± 0.58	3.75 ± 0.96
6	5.2 ± 0.96	3.25 ± 1.26
7	5.0 ± 0.82	3.75 ± 1.71
Max Score (6 points)	5.22 ± 0.71	3.65 ± 1.08

**Significant different at P<0.05*

Students' worksheet (POE Task): The main activity was to perform POE task. The students performed this task with physical model. For all the activities, students predicted what would happen and explain reasons for prediction before observation. Then observed the activity and explained whether predictions and observations are in agreement or disagreement. The analysis of POE worksheet indicates students' understanding of concepts of breathing mechanism. The following are the excerpts to support.

"Volume of lungs will decrease when the diaphragm relaxes or thoracic cavity decreases because lung air pressure increases forcing air to move out"

"Air moves in when ribcage raised because lung volume increases making low pressure"

"When intercostal muscles contract, it creates low air pressure inside the lungs making outside air to move in"

"When diaphragm contracts/flattened, lung volume increases decreasing air pressure inside the lungs, it forces outside air to move in"

Analysis of Interview questions: To triangulate other data, semi-structured interview questions were used to gather more data. Six students volunteered to take part from experimental group (3 boys and 3 girls). They responded to interview questions right after the learning lesson for 15-20 minutes. The interview respondents liked that way the lesson was presented. They expressed that the lesson style was new, interesting and full of activities to keep them engaged. The following are some of the responses from the students.

"I liked the lesson style; it was full of activities- my thoughts are stimulated through prediction and explanation in the task"

"*Use of physical model together with POE strategy was interesting tasks"*

Interview respondents had also shown understanding on some concepts of breathing mechanism. The following responses support the earlier data on conceptual understanding.

"Diaphragm, ribcage and intercostal muscles are the main respiratory structures that contribute to breathing"

"*Inhalation occurs when diaphragm is lowered; ribcage elevated contracting intercostals and opposite happens when conditions reverse"*

Students' Perceptions towards the learning lesson: Students in experimental group were administered to assess their perceptions towards the developed learning lesson as detected by LEPQ. The mean of the 5-point Likert scales score ranging from 1 (strongly disagree) to 5 (strongly agree) is shown in Table 3 ranging from 3.14 to 4.18 indicating generally students were positive towards the learning lesson.

Table 3 Construct wise mean scores of experimental group grade 9 students' response on LEPQ

Scale on LEPQ	Mean ± SD
1. Perceptions towards topic	3.57 ± 0.87
2. Involvement in activities	3.14 ± 0.81
3. Perceptions towards learning activities	3.39 ± 0.72
4. Teacher support	4.18 ± 0.80
Overall	3.57 ± 0.79

In details, the students' perceptions on each scale are presented below.

Table 4 shows the results of students' responses on LEPQ in the perceptions towards the topic, which consisted of 5 items. The mean scores for all items in this construct range from 3.43 to 4.70, indicating that the students perceived science as important and can be part of their life. More importantly, students liked the topic of breathing mechanism, felt importance and learnt better via such learning format. More than 50 % of students indicated that the lesson was not difficult to understand.

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Table 4: The frequency of respondents and mean scores of students' responses on perceptions towards the topic.

	Frequency of respondents					
Items	SD (1)	D (2)	N (3)	A (4)	SA (5)	Mean ± SD
1. Now I like to learn the topic of breathing mechanism.	2	0	1	11	16	4.30 ± 1.06
2. This class made me learn how science can be part of my life	0	0	1	7	22	4.70 ± 0.53
3. I understood well about breathing mechanism from this model-based learning unit.	0	0	4	15	11	4.23 ± 0.68
4. The topic is important for us to learn	1	0	1	5	23	4.63 ± 0.85
5. The lesson was difficult to understand*	8	5	11	4	2	3.43 ± 1.22
Overall						.57 ± 0.87

*Negative item with reverse coding

Table 5 shows the students' involvement in developed learning unit. The result depicted that students participated in the activities and kept them engaged in the lesson. Maximum students felt that they got chance to discuss and participate in the lesson. However, minimum score was observed in students' free expression in the lesson. Overall, students had positive towards the learning activities.

Table 5 The frequency of respondents and mean scores on involvement in activities

	Frequency of respondents					
Items	SD (1)	D (2)	N(3)	A (4)	SA (5)	Mean ±SD
1. I felt free to express my opinion in this lesson.	0	0	12	11	7	3.83± 0.79
2. I participated in this class more than I do in other science lessons.	0	3	16	5	6	3.47± 0.94
3. I got more chance to discuss with mates in this lesson.	0	0	5	9	16	4.37± 0.76
4. I did not get chance to participate in the activities*	19	8	2	1	0	4.50 ± 0.78
5. I actively participated and contributed in the group activities	0	0	8	13	9	4.05± 0.76
Overall						3.14 ± 0.81

*Negative item with reverse coding

The Table 6 below presents results of students' perceptions towards the developed learning lesson. Students expressed their positive perceptions towards the learning activities. Majority of the students felt motivated working in groups and look forward to similar kind of session with mean scores 4.33 and 4.27. The result also shows students felt interested by the learning activities.

Table 6 The frequency of respondents and mean scores in perceptions towards learning activities

Items	SD (1)	D (2)	N (3)	A (4)	SA (5)	Mean ± SD
	Frequency of respondents					
1. I look forward to similar type of learning activities in science lessons.	0	1	3	13	13	4.27± 0.78
2. The learning activities in this class were interesting.	0	0	2	13	15	4.43±0.63
3. The learning activities in this class is a waste of time*	21	7	2	0	0	4.63±0.61
4. The learning activities challenged my thoughts	0	2	5	17	6	3.90±0.80
5. Working in the group motivated me to learn in this class	0	0	5	10	15	4.33± 0.76
Overall						3.39 ±0.72

*Negative item with reverse

Table 7 shows the students' responses on teacher support during the lesson activities. Majority of students (24 students) liked the way teacher deliver the lesson. 24 students felt that the teacher was approachable and supportive to ask questions. Maximum mean score (4.50±0.63) was in the item *"I liked the lesson the way teacher directs and control"* and minimum mean score (3.97±0.72) in the item *"I look forward to the way teacher teach the lesson"*. The overall mean score depicts students had positive experiences in terms of teacher support.

Table 7 The frequency of respondents and mean scores on teacher support

Items	SD (1)	D (2)	N (3)	A (4)	SA (5)	Mean ±SD
	Frequency of respondents					
1. I look forward to the way teacher teach the lesson	0	1	5	18	6	3.97±0.72
2. The teacher was approachable and encouraging me to ask questions	1	2	3	12	12	4.07±1.05
3. I liked the lesson the way teacher directs and controls	0	0	2	11	17	4.50±0.63
Overall						4.18±0.80

Students' reflections: At the end of the questionnaire, students were given to reflect on their perceptions towards the learning lesson as a whole. The analysis of their reflections reveals students' satisfaction and development of positive attitude by the lesson. The following are the excerpts from the students.

"I liked the model learning unit. It is less confusing".

"It challenged my thoughts and knowledge".

"I look forward to such learning activities in future".

"Model was simple and understandable".

"no change needed"

"Simple model based learning activity"

"Model based POE activity was challenging and stimulating"

"Learnt about respiration with models"

"All activities were new and interesting"

"Group activities because we discuss and share views"

"Ribcage movement can be developed further"

"Adequate models could have developed"

Discussion and Conclusions: The findings from the study demonstrated that participants had acquired body of knowledge on breathing mechanism. The findings reveal that grade 9 students in experimental group had significant mean gain percentage compared to the control group as indicated in pre-test and post-test results.

From the pre-test and post-test result, the experimental group had significant content achievement of mean gain (40.3%) than the counter group of mean gain (22 %). Similarly, the result from structured concept map shows experimental group (POE strategy model based learning) had performed better than control group with mean scores of 5.43 and 4.0 respectively. This finding is in congruence to the findings of [17] that POE strategy, and physical model promote better understanding of concepts [6].

The POE task in experimental group provided main activities to students. Student's excerpts indicated understanding of concepts while working with models in the step by step process. This worksheet data was to investigate and support the earlier data. Interview questions were posed to further delve into the students' concept understanding and their perceptions toward the topic and developed learning unit. Participants responded that physical model and POE strategy was interesting to them. POE strategy based physical model enabled them to touch, investigate and observe building curiosity. Such findings were similar to the findings of [8, 9, 10].

Findings from the students' perception questionnaires revealed they were generally satisfied with the developed learning unit. In all the four scale, they expressed positive perceptions from the POE strategy based physical model learning. The findings were in accordance to the findings of [18, 19, 20].

Besides, students' reflections indicated used of physical model in learning were simple, concrete and less confusing. However, some stated that further development of model could be looked into, as ribcage could be assumed it moves. Also some felt that the number of models was inadequate. The study is also limited to one school setting with small sample size. Future studies can be done by improving limitations of the model described, and increasing the sample size and adopting better research design.

In summary, the POE strategy based hand-on physical model has significantly helped improve conceptual achievement as indicated by pre-test and post-test results. Additionally, results of students' reflections and worksheets (concept map and POE task) imply the developed learning lesson had enhanced content achievement in the topic of breathing mechanism.

Further, the developed learning lesson has also developed positive perceptions toward the lesson topic. The results revealed majority of students are satisfied with the developed learning lesson.

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