INEXPERIENCE STUDENTS’ PERCEPTION, DIFFICULTIES AND CHALLENGES TOWARDS IMPLEMENTATION OF LAB-BASED INQUIRY APPROACH: A CASE STUDY IN BHUTAN

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ABSTRACT

An Inquiry approach has been widely recognized as effective instructional method in science education and, lab-based inquiry is well acknowledged in chemistry education. Many researchers in this field raised some issues like identifying aspects of inquiries that results in more fruitful outcome; need of more research on students’ performance towards teacher-designed inquiry – based instruction; opinions of students on lab based inquiry, and relationship between students’ lab experience and learning. Implementation of lab-based inquiry has resulted in wide range of students’ experience in laboratory activity in secondary schools. However the experience of students in laboratory work is restricted to ones’ learning environment like curriculum, syllabus, school culture, resources, skills, and time beside other issues. Therefore, the current study looks into the perception, challenges and difficulties faced by students who have no experience or little experience of inquiry based laboratory activities. A case study included 43 students from one of the secondary schools in Bhutan. The teacher designed lab-based inquiry of two lessons on the concept of colloids to understand the effect of size of particles in solution was implemented. The data collected from questionnaires, semi-structured interview and student reflections indicated positive perception towards the approach; satisfaction and confidence, enjoy working in groups, active participation, and positive look towards probing questions and in building teacher-student relationship. However factors like management of time, slow process, handling of laboratory apparatus and its uses (test tubes, measuring cylinder, burette, conical flask, etc..,) observation skills, fear of chemical and fragility of glass apparatus were some of many difficulties and challenges faced by the students. The study suggest the need of students’ knowledge and experience in use and handling of laboratory apparatus and, observation skills are important for implementation of such approach to remedy the shortcoming of time and efficiency. Issues to overcome problems are discussed.

Keywords: Inquiry, Inquiry Lab, Lab-Based Inquiry, Laboratory Apparatus, Colloids, Particle Size

1. Introduction

The science curriculum in Bhutan is now guided by constructivist approach on the ground where learning is active; learning is both individual and group process where children learn and make meaning of their experiences; and that learning is interrelated and is an ongoing process (Royal Education Council, 2012). The shift in paradigm from traditional approach towards constructivist is realized due to science curriculum being too much content laden as it was borrowed from India (Childs, Tenzin, Johnson, & Ramachandran, 2012). Few of many goals of science curriculum in Bhutan includes to develop and apply skills of inquiry, investigation, problem solving and logical reasoning and to prepare learners for higher studies in science and technology (DCRD, 2013). So the
use of active hands-on learning as effective pedagogy involving more of inquiry approach is highly recommended.

Hands-on activities is a teaching strategies where student usually work in groups, interact with peers, ask questions, collect data and attempt to explain natural phenomenon (Satterthwait, 2010). It permits wide arena of application in terms of role of the experiment and teaching methods (Wen-jin, Chia-ju, & Shi-an, 2012). Studies indicate that lab-based inquiry approach has shown positive impact on the students’ perception and attitude towards learning. Laboratory work beside inquiry allows students to learn by doing experiments and school laboratory provides special potential for learning.

Though the implementation of lab-based inquiry in schools showed positive impact on their understanding as well as in their attitudes, there have been some confining issues and challenges in its implementation especially the laboratory works. Kim and Tan (2011) discussed and mentioned limited time, large number of students, availability of resources, low proficiency of teachers and the absence of trained laboratory assistance as some issues, while (Kilinc, 2007) outlined lack of materials and longer time duration. Lack of time and content overload (practical classes sometimes take place after school); lack of expert technical support; and lack of teacher expertise and withdrawal of the practical exam in class 10 are some of the issues raised in Bhutan (Childs et al., 2012). Such challenges have resulted in wide range of students’ experience in laboratory activity.

Wallace and Kang (2004) revealed that the experience of students, whether they do laboratory work in the secondary schools is restricted to ones’ learning environment like curriculum, syllabus and school culture. On this ground, the experience of students on laboratory work differs from school to school, culture to culture, curriculum to curriculum and as a whole from the educational framework of country itself. Hofstein and Lunetta (2004) highlighted the need to examine the effect of specific school laboratory experiences and associated context on students learning. Childs et al., (2012) clearly identified a capacity issue in terms of both professional developments of teachers and of the technical staff who support them. They also mention that higher studies lecturers were particularly concerned about practical work and felt there was an urgent need to redefine the nature and role of practical.

Such challenges produce varied experience of students especially in lab-based inquiry instruction. Despite the lack of opportunities or challenges the researchers stressed, yet attempt have not been focused on students’ perception, opinion and feeling about such learning approach based on their limited experience. Therefore the current study looks into the perception, challenges and difficulties faced by inexperience students who have no experience or little experience of lab-based inquiry activities.

2. Methodology

The research is a case study. A learning unit of lab-based inquiry was developed based on the topic colloids under the surface chemistry syllabus of grade XI-XII of Bhutan. The learning unit was developed to enhance students’ understanding of effect of size of the particles in solution. It contains two lessons on hands-on activities of three hour each. The students worked in small groups of 4-5 throughout the activities. The first lab activity is a guided inquiry. The students are provided with sand, sugar and milk powder and all the necessary materials. They have to make solution of these three substances and find out the differences. The experiment intent students to find out the differences between solution, suspension and colloids using the materials like laser pointer (green and red light) to see scattering of light, cellophane paper and filter paper for filterability property; gravitational property etc.., The students design, collect data, interpret and conclude their
understanding with evidence that size of the particle is the main difference which effects the properties of the solution.

With the prior concept of relationship between size of the particles and scattering of light from first activity, students proceed to second inquiry experiment. The students follow structured inquiry lab where procedures are provided. They collect data, observe, interpret, discuss and present their findings. The students use sol-gel process to prepare silica sol and gel from water glass (sodium silicate), vinegar (acetic acid) and sodium hydroxide. They learn to prepare colloids through both condensation and dispersion method using relationship of scattering of light and size of the particles.

2.1 Sample and data collection method

43 grade XI students from one of the schools in south eastern part of Bhutan participated in the study. The study was carried out based on their prior information that the students were not taught the concept that was under study. Every school in Bhutan is guided by same educational framework; schools all over the country follow the same curriculum and syllabus, and are co-education institute.

The data was collected through semi-structured interview, students’ reflection and 5-point Likert scale questionnaire with 3 open ended questions. At the end of each activity, each student was asked to write reflection about their understanding and feeling about the lesson. After the implementation, questionnaires were distributed to each student and 8 students were interviewed.

2.2 Instrumentation

2.2.1: Questionnaire

The following Table 1 indicates the instrumentation of questionnaires. The instrument items were adapted and developed based on 3 dimensions and contains three open-ended questions: 1) what did you learn in overall from the activities in the learning unit? 2) What did you think you want to learn more from the activities in the learning unit? And 3) any Comments or Suggestions. The open-ended questions were coded for descriptive analysis.

Table 1: Instrumentation of questionnaires

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Description</th>
<th>No of items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perception towards Interest in</td>
<td>To check the pupils perception towards the activities in the class</td>
<td>8</td>
</tr>
<tr>
<td>science class activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perception towards Learning environment</td>
<td>To see students’ preference of cooperative work while doing activities.</td>
<td>4</td>
</tr>
<tr>
<td>in the class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perception towards Instructor</td>
<td>To see students’ view of instructors’ role in activities</td>
<td>4</td>
</tr>
</tbody>
</table>

2.2.2: Reflective journal

The reflective journal here uses the students’ reflection format of Lingua Folio training modules which contain guiding phrases to help student reflect and contain reflection on topic and lesson. Descriptive analysis was carried out.
2.2.3: Semi-structured interview

The table 3 indicates the instrumentation of 10 interview questions which are grouped under 5 pre-determined categories. The data were collected and analyzed using thematic coding.

Table 3: Instrumentation of semi-structured interview

<table>
<thead>
<tr>
<th>Categories</th>
<th>Description</th>
<th>No of items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparative differences</td>
<td>Compare the class under study with other normal classes. To evaluate the differences and similarity.</td>
<td>2</td>
</tr>
<tr>
<td>Challenges and difficulties</td>
<td>To find some of the challenges and difficulties faced by students during the implementation of lab-based inquiry lesson</td>
<td>1</td>
</tr>
<tr>
<td>Perception about activities</td>
<td>To find out students perception towards the lab-based inquiry activities.</td>
<td>3</td>
</tr>
<tr>
<td>Instructor role</td>
<td>To assess the impact of role played by instructor during the implementation</td>
<td>1</td>
</tr>
<tr>
<td>Improvement and Overall feeling</td>
<td>To find out the overall reaction or feeling about the student for the whole lesson; Ask for students’ opinion and suggestion in order to improve the implementation of such activities</td>
<td>3</td>
</tr>
</tbody>
</table>

3. Finding & Result

3.1 From the questionnaire

The Diagram 1 shows first dimension, the students’ perception towards interest in science class. Total students (N= 43) response is plotted with 8 items. All the students found the activity very interesting and the response from second item indicate that student were comfortable except for 3 students and 1 being neutral. All the students responded that activities motivated them to learn and made them curious beside 3 students remaining neutral. Majority of the students found that activity took very long time. However all students seem to be satisfied and responded they wanted to learn through such kind of activities in future.

In the 2nd dimension, students’ response shows positive attribute toward group work and probing questions asked by the teacher. However, 3 students don’t like to work in group while 2 are neutral.
In the 3rd dimension, students’ response indicates satisfactory role played by instructor. However, some students are neutral about the last item and 1 student don’t feel free to tell teacher about anything that stop them from learning.

### Table 4: Student’s reflection on topics

<table>
<thead>
<tr>
<th>Topic (phrases)</th>
<th>Exemplar quote</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have learned. . . . .</td>
<td>“learned about setting up of apparatus and procedures”; “how to prepare sol., and use apparatus”</td>
</tr>
<tr>
<td>I can. . . . .</td>
<td>“doing practical work”; “ redo the experiment perfectly”; “confidently characterize the 3 different sol”; “do practical myself”</td>
</tr>
<tr>
<td>I am good at. . . . . .</td>
<td>“helping my practical partner and doing work together”; “cooperating to friends”; “setting up experiment”</td>
</tr>
<tr>
<td>I haven’t managed to. . . .</td>
<td>“complete the work on time”; “use glass materials freely”; “understanding which is measuring cylinder and which we are going to use beaker or test tube for experiment”; “clearly observe”; “look into solution so see”.</td>
</tr>
<tr>
<td>I don’t understand. . . .</td>
<td>“why it is taking long time to give result”; “handling the things”;</td>
</tr>
<tr>
<td>I have difficulty in. . . .</td>
<td>“observing result”; “setting up of procedures since it was first time and not able to understand the function of apparatus”; “set the procedure since experiment was done for first time, the function of apparatus and materials was strange”; “ handling the instruments and uses of materials”.</td>
</tr>
</tbody>
</table>

The students express their skills development in setting up of experiment and designing procedure. They show confidence in replicating and redoing the experiment with ease and shows cooperation in group. However students say they are unable to complete their work on time; show hesitation and
difficulty in handling laboratory materials; lacks observation skills. They say since it was first time, it was difficult for them.

Table 5: Summary of response collected from the reflection on lesson section.

<table>
<thead>
<tr>
<th>Lesson (phrases)</th>
<th>Exemplar quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I like best....</td>
<td>“doing the experiment and observing the result”; “designing practical because we are able to learn more”; “going about of the experiment by ourselves and exploring things though it was challenging”; “doing practical with procedure”</td>
</tr>
<tr>
<td>The most interesting thing</td>
<td>“trying out new thing was interesting”; “work with group”; “setting up for experiment”; “having discussion among groups and presentations”; “preparing procedures ourselves”; “question answer session between friends and teachers”</td>
</tr>
<tr>
<td>I don’t like.....</td>
<td>“waiting for result”; “use of glass materials inside lab”; “slow process”; “touch of chemical thing”; “when experiment fail and do again”;</td>
</tr>
<tr>
<td>Any suggestion....</td>
<td>“…carry out experiment individually rather than in group”; “experiment would be effective if we get more time”; “tell us the uses of materials”; “experiment need to be done faster because in exam we get only three hours”</td>
</tr>
</tbody>
</table>

The students like doing experiment, observing, designing and exploring things. They like working in group and trying out new things. They don’t like waiting for result; redo the experiment; and using fragile materials and chemicals. Some suggest individual work rather than group work for effectiveness and also from examination point of view. They demand more time and expect help from teacher directly.

3.3: Semi-structured interview

**Category 1 Comparative differences**: In this category to find the differences from other classes, students find it interesting and easy to work in group. They show team work, cooperation and group management. One of the pupil said “everything is new. It is interesting to work in group because we got more interactive, we get to know more about them”. They say it was a new experience and found it very engaging, satisfying and got opportunity to work with lab equipment. One of them said “by doing practical, we know how it takes place and can see with our eyes”.

**Category 2 Challenges and difficulties**: Students find difficult in use and handling of simple lab materials. They say that they are inexperience due to lack of opportunity and are unfamiliar with materials and how to use it. One of them said “not that much difficulty as such but with handling of materials and apparatus because it is first time and bit nervous. No experience learning like this. We visit lab but didn’t get chance to experiment by our own”. Time constraint is one challenge that almost all students mentioned. It made them feel hesitant about their work and make them impatient and doubtful. One of them says “it takes longer time and I feel hesitant because I thought this might be wrong result”.

**Category 3 Perception about activities**: Students realize it is always better to learn by doing. They found it interesting, fun, useful, interactive, confident and comfortable. They pointed out it was hands-on experience and can able to do and experience themselves. They show positive relationship with friends by working in group. One of them said “we did practical in group so more interaction and we had fun. We helped each other and it was interesting”. Another says “I like it because we are able to do and experience ourselves. Doing practical is interesting and we like to have another opportunity”. However, their lack of experience and time constraint was some negative aspects.
Category 4 Instructor role: Student found the instructor role as facilitator and is organized and prepared. One student said “when we were not able to do, sir ask question and we came to know. It helped us by asking us question as question was related to experiment and we thought, and it helped us think and find answer”.

Category 5 Improvement and Overall feeling: For the improvement, student pointed out individual work rather than group work for better performance. They express it from examination viewpoint. The need of job distribution, individual responsibility to work within group was raised by student as it gives confusion over who is going to do what. Student said “instructor could have given chance to do individual as exam are done on individual basis” and another one said “doing individual is quite better. When we do in group it is confusing because like who will say some question and who will do the work”. Overall the students found it better learning experience, satisfaction and confidence, active, enjoyable and better understanding. “I feel satisfied, interesting and enjoyable. When we work in group, we are known to each other so, it is interesting doing all new things”.

4. Discussion

Kilinc (2007) states that to make inquiry-based learning a powerful learning experience for students and teachers, one should understand and deal with thoughts and feelings. Such experience requires the consideration of beliefs about necessity of covering the curriculum, preparing students for examinations, and keeping science classroom efficient (Wallace & Kang, 2004). Implementing the lab-based inquiry in the current study is constraint to present school culture, and the study is limited to a sample of school and students, though every school in the country is guided by the same curriculum. So to discuss and judge the prevalence in different culture is restricted by the nature of study. Further works in the future will be conducted to generalize and to evaluate the scenario all over the country. The study however reflects some insight into students’ opinion and perception about lab-based inquiry approach. The little experience or lack of experience of students perhaps stem out due to consideration of such beliefs in varied cultures. But the inquiry-based laboratory instruction has the outcome of making the laboratory experience more valuable for students, and therefore improved their persistence in the course.

Result from studies on students’ attitude towards lab-based inquiry approach showed that students enjoyed working in group and provided opportunities for cooperative learning. Students enjoyed working in group. They found it interesting, fun, and interactive. Though the students showed strong and positive point towards working in group, a few students suggested working individually. It seems from the data, students attribute the importance of working or learning - whether in classroom or in the laboratory, they are strongly driven by the fact that their performance is measured and reflected by exam scores. They believe that they can perform better in exam if they are given opportunity to do work on individual basis. Wallace and Kang (2004) in their study put such aspect as influence of culturally based beliefs of exam preparation which differs from school, curriculum, and society and education system of a country as a whole. The (Royal Education Council, 2012) states that the teaching-learning process is founded on enabling students to pass examinations rather than fostering the skills of rational inquiry, learning how to learn, effective problem solving, etc.., The findings indicate that despite the positive aspects of working in group or acquisition of knowledge and skills, passing the exam is regarded by students as their important priority.

Högström, Ottander and Benckert (2010) found out importance of learning perceived by students during the lab-work is influenced by teacher-student interaction. They pointed out that teachers’ action is also very important in order to help students understand what to learn from a laboratory.
exercise. The role of teacher in this study requires the act of facilitator which is fulfilled from the students’ response. Students responded positively towards teachers’ probing questions that helped them to find answer for themselves. Students feel such activities were very helpful in building teacher-student relationship. Basey, Sackett and Robinson (2008) say that students are genetically adapted to want labs that are time efficient. The current study strongly acknowledges the issue of time factor raised by the students. The two lab-based instructions were of 3 hours each that were implemented separately in two lab sessions. The activities and the result of chemical reaction can be obtained within 10-15 minutes maximum. One logical explanation could be their lack of experience working for such hours in the lab as they are accustomed to 45-55 minutes of regular class instruction. The activities involves planning, designing, data collecting, interpreting and concluding which consumes more effort and time than the regular class. Use of more class time as disadvantage is mentioned by (Deters, 2005) in his study. The need for more time for such approach was also seen by (Gormally, Brickman, Hallar & Armstrong, 2011) especially those depended on collaborative group efforts. They suggested beginning with simpler activities with students unfamiliar with inquiry, first introducing the approach and then gradually increasing the level of difficulty. However, Hodson (2014) mentioned of students making errors in observing, measuring or recording, mishandling apparatus and failure to finish data collection in the time available. It is interesting to find out from the data that students’ inability to recognize simple lab-equipment and their function like basic measuring cylinder, burette, conical flask etc., are of concern and students’ reluctance in using glass equipment, fear of chemicals probably have resulted in hesitation and extra caution.

The connection between time factors as an issue with nature of lab-based inquiry is clearer from the previous research but the lack of hands-on experience with simple laboratory equipment may possess a challenge in its use and implementation of such approach. In this case study, such challenges and difficulties of students may have originated due to lack of experience and low knowledge on laboratory work which are the outcome of practice and system. It is because as stated by (Kim & Tan, 2011) it is not just the issues of background, materials or time but also the complex schema of experiences, values and traditions of knowledge and teaching in our society. Therefore, lack of experience with experimental techniques points the beginner to emphasis fully on the skills required to complete task.

5. Conclusion and Implication

The qualitative result from this study documents students’ perception, difficulties and challenges of students towards lab-based inquiry lesson based on their little experience or lack of experience. Overall, students showed positive perception towards such approach. The satisfaction and confidence are well expressed. They enjoyed working in groups and showed appreciation of how they learned by setting up experiment and procedure without the tutors’ help. The positive aspects are mostly in aligning with previous research. Almost all students state that such experience was new and important for their understanding and that they thoroughly enjoyed and like to have more opportunity to learn from such approach in future.

However, even though students enjoy working in group, some students prefer to work individually. The students tend to regard examination where performance is evaluated individually and the benefit of working in group for these students is valued less. The use of fewer members in group, a pair or three with individual responsibility would provide more opportunity to work on individual basis and also to avoid group domination. The study points out an issue “time factor” not only attributes to nature of inquiry approach but also with the experiences of students working in the laboratory. The lack of experience or little experience in laboratory in the implementation of lab-based inquiry approach is confronted by students’ lack of knowledge about laboratory materials and
its usage. Fear of chemical and to handle fragile glass apparatus may have resulted in hesitation and extra caution. The logic says that such problems might have led to experimental error resulting in slow mechanism, incorrect result and repetition of procedures all over again – may have contributed to time consumption. The study suggests the need of students’ experiences and knowledge in laboratory work especially in handling basic laboratory equipment and its uses. The students should be provided with more opportunity on such basic field to avoid such problems and also to develop their experimental skills including observation. Such remedies are important to overcome time limitation and efficiency.

Bruck and Towns (2009) suggested that it is very important to assess students’ conceptual knowledge and skills prior to undertaking the inquiry activity. For lab-based inquiry approach, knowledge and skills of laboratory materials, handling and usage of simple apparatus are found very important. To overcome the issues, introduction of basic lab materials from early stage of schooling, opportunity to work in lab system, increase frequency of visit to the laboratory and project work on use of materials and equipment should be encouraged in schools from lower grade. To allocate a separate lab class to study the technique and familiarize with its uses and skills would be more effective. Learning and understanding the nature of experimental error is important for introductory students’ experience.

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