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The Effective Role of Practical Work & Theoretical Work in Teaching and Learning Physics at Graduate Level

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ABSTRACT

This qualitative study focused on college level physics teachers in India using semi-structured interviews and observations to explore their understanding about the relationship between practical works and theoretical work developing students" conceptual knowledge of physics. Recent studies indicate that practical work helps college science students easily and effectively learn the concepts and theories of physics. However, the college physics teachers in India in this study did not provide students with practical work during classroom teaching. Rather, they provided practical work in separate practical classes. Although the teachers believed that practical work made their teaching and also students" learning easier and effective, they did not offer frequent practical demonstrations in teaching the contents of physics.

INTRODUCTION

Education in general and science education in particular, is important for developing methods and standards of living. The development of a society without science education is unimaginable. Scientific knowledge depends on evidence. The acceptance of knowledge achieved through science education is high because of its practical dimension, application& Theoretical work; hence priority is given to science education all over the world.

REVIEW OF LITERATURE

Some countries that are struggling to achieve developed nation status have undertaken the challenge of placing greater emphasis on science (Ishak & Mohamed, 2008) and they are spending more money in improving the quality of science education (Kasanda, 2008). Researchers such as Halai (2008), Kasanda (2008), Ranade (2008) have found that poor quality science education is common in many developing countries; and moreover, in these countries, the number of students studying science at graduate level is very small, while even fewer pursue science to tertiary level (BANBEIS, 2007; Ranade, 2008).

Although results of different studies have shown various reasons for science students" poor

content knowledge in developing countries, researchers such as Cook and Taylor (1994), Thair and Treagust (1999), Millar and Abrahams (2009), Nivalainen, Asikainen, Sormunen, and Hirvonen (2010) have argued that lack of practical work is an important factor. In many countries, physics as an individual subject is seen as abstract, difficult to understand and to conceptualise and the concepts of physics are usually learnt via rote memorisation, where the teachers transfer physics content knowledge to the students, filling their minds with facts, concepts, principles and laws (Ishak & Mohamed, 2008). Many studies have shown that practical work and theoretical plays a positive role in science teaching and learning by making it comparatively easier to understand; and can strengthen students‟ content knowledge.

Students are the future of a nation, and scientifically literate students can build a developed nation. Since Graduate level is the foundation level for higher education, it needs to be as strong as possible. Physics is one of the most important subjects among the mathematical and natural sciences. Students who want to do higher education qualifications in physics or want to study in the fields of engineering or medical sciences must have a strong background knowledge of physics. Emphasis should be on providing graduate students with clear and standard basic physics content knowledge, which they understand and can utilise in their future study, in their daily lives, or in doing research activities.

Although many studies show that practical activities play a key role in teaching and learning physics, some studies [Asikainen & Hirvonen, 2010; Ishak &, Mohamed, 2008; Kasanda, 2008; Taylor & Dana, 2003; and Zacharia, 2003] have shown that the main reason for students‟ failure to learn is science teachers‟ poor content knowledge, while others [Halai, 2008; Ranade, 2008; and van Driel, Beijaard, & Verloop, 2001] have found that teachers‟ lack of pedagogical content knowledge of science teaching is responsible. Some researchers suggest that well-designed teacher education programmes can help teachers to develop both subject matter knowledge and pedagogical content knowledge so that they can effectively teach their students. As a teacher and also as a teacher educator, I believe that teachers‟ subject matter knowledge and pedagogical content knowledge of physics teaching are the preconditions for effectively teaching physics. The goal of providing science students with clear and standard physics content knowledge can be successfully achieved if the conceptual

knowledge is supported by the inclusion of practical work.

Teachers‟ practical knowledge consists of sets of beliefs and knowledge (van Driel et al., 2001), which have direct impact on their actual teaching and their interactions with students. It is essential to understand teachers‟ understanding and beliefs about the role of practical work in teaching and learning physics at graduate level. Although a small number of relevant research studies on the role of practical work have been conducted in developed countries and very few in developing countries, most of those are non-empirical. That is why I conducted a qualitative research study, where the main objectives were to understand teachers‟ beliefs regarding teaching and learning physics, and regarding the role of practical work in teaching and learning physics, because „to understand teaching from teachers‟ perspectives, we have to understand the beliefs with which they define their work

RESEARCH QUESTION

The research question to guide my study is “How college physics teachers understand the relationship between practical work theoretical work and developing conceptual knowledge of physics in India Two sub-questions underpin the main question.

1. What important ideas do physics teachers in India hold which they think determine what they teach?
2. How conducting practical is classes prior to theoretical classes beneficial to the student?
3. How do they teach: what pedagogies do they use and what kinds of practical activities, theory and do they provide for their students?

DEFINITION OF TERMS

College physics teachers: The teachers who teach physics in Graduate level (B.sc level)

Practical work: Practical work includes the physics experiments or demonstrations selected for the science students to do or observe at laboratory sessions in Graduate level . It also includes the hands-on activities used to teach and learn the concepts and theories of physics.

Classroom teaching: Teaching the theories and concepts in classrooms.

Practical class: Classes for doing practical experiments.

Conceptual knowledge: The knowledge of the facts, concepts, principles and laws of physics.

Demonstration method: A process of directly and practically presenting facts or concepts or theories in classroom. In this method, teachers

use a variety of teaching aids and verbal statements.

Lecture method: Teachers present the lessons only through verbal statements.

Question-answer method: Teachers check student understanding by asking questions after first delivering a mini-lecture on the lesson.

SCIENCE EDUCATION AND PHYSICS TEACHING AND LEARNING SYSTEMS IN GRADUATE IN INDIA

Physics and chemistry are compulsory subjects for science students at graduate level and they have to choose two other subject options. There are several science subjects for them to choose from, such as biology, computer education, higher mathematics, agriculture study etc..

As in other science subjects, there are separate classes for teaching theoretical content and teaching practical experiments in physics. The class for teaching theories and concepts is called the theoretical class or classroom teaching, while the class for teaching practical experiments is named the demonstration class. The class where students do the practical experiments is termed the practical class. The demonstration and the practical classes are done in the laboratory and the theoretical classes are taught in classrooms.

According to the physics curriculum, teachers are instructed to use demonstration methods for teaching physics content in the classroom and also for teaching practical activities for doing practical experiments.

OUTLINES THE VIEWS

This paper outlines the views of physics teachers about the role of practical work in developing conceptual knowledge of physics and also my views from the observations of their teaching and students‟ learning.

The findings will be presented as main themes with subthemes under each main theme.

EMERGING THEMES

The data were grouped into five emerging main themes under which there were several subthemes. The main themes are: (1) Teachers‟ perceptions of the relationship between practical work theoretical work and developing conceptual knowledge of physics; (2) Teaching methods; (3) Factors hindering teaching and learning practical work; (4) Role of teachers‟ training on teaching practical work; and (5) Role of teachers‟ attitudes towards practical work.

[1.] Teachers' perceptions of the relationship between practical work, theoretical and

developing conceptual knowledge of physics for students

The role of practical activities in teaching and learning physics and also the purposes of teaching and learning physics at graduate in India. This theme is divided into four subthemes that emerged from the participants" responses and from my field notes of observations of their teaching.

a) Teachers valued practical work in teaching and learning physics

According **MrArun Jain** a physics teacher in LBS College ,Jaipur for 8 years, indicated that students are not able to achieve a clear understanding of physics concepts without doing practical activities. He said:

I think that in teaching physics, the importance of practical activities is enough, because until I practically show students, or let them practically do those activities, they will not be able to get a clear conception of the contents. When I theoretically teach them, just after that I should teach the related practical work.

He believed that theoretical learning supported by practical work allows students to better utilise their knowledge in the future. He continued:

It makes learning effective, and very effective. When students achieve knowledge through practical work, I hope that they can utilise that knowledge; and that knowledge will be useful for their real life.

Dr.Mahesh Mishra with the experience of 9 years physics teaching in R.R College, Alwar and Dr. **Minal Bafana** with 11 years physics teaching Agarwal P.G.College, both expressed the view that the knowledge achieved using practical work becomes stable because students can do it and observe it by themselves. Dr.Mahesh Mishra stated:

It (practical work) has a very important role in teaching and learning physics. [....]The reason is that they (students) can practically observe what happens; they can do it on their own. That is why the learning becomes more stable.

Dr.Minal Bafana :

It makes learning effective. When they (students) do practical work, the unclear concept that they had, becomes clearer to them, because they are doing it themselves. Since they are observing things to happen, it becomes easier to remember. The knowledge they get by doing practical work, becomes stable for a longer time in their memory.

Moreover, students more easily understand the concepts.

Dr.Mahesh Mishra further clarified her thoughts about the usefulness of practical work.

We mostly need the practical work. I believe that if I could teach my classes in the laboratory, it would be the best, because I could teach them the theories and concepts using the practical instruments. Then my teaching would be more fruitful. When I would explain the content, I could practically show that. They would have clearer understanding.

[2.] Purposes of teaching and learning physics

By teaching and learning physics at graduate level, I understand that students will know some theories, and they will also do some hands-on activities/practical activities so that they will be able to do different experiments. [....] They will become interested in doing different experiments, and also become confident to do practical work, because from the confidence of doing small experiment, the confidence of doing big thing will be developed among them.

[3.] Practical work makes teaching and learning physics easier.

According to myself teaching using practical activities is easier than teaching only using lectures, because the lecture method is time consuming regarding assisting students to understand the physics concepts. I added that when he uses practical work in her classroom teaching, students easily understand the content. I said:

When I teach practical class, I can easily teach them. It is easier than theoretical teaching. When I orally teach a topic, it takes time to assist them to understand. But if I teach them with practical work, they easily understand. I understand that practical work makes my teaching easier.

[4.] Practical work makes learning interesting and effective.

According to me that if a theoretical knowledge of physics is provided along with some practical activities, students become more interested in their learning. hestated that from their experience when students are more interested in their learning, they are more likely to be more effective learners.

I, highlighted:

Practical knowledge makes the theoretical knowledge more effective. When I provide

them with any practical activity, I find that their interest in study increases. They become more attentive. Their knowledge becomes more stable [.....] and their participation also increases. They become more interested in achieving the knowledge.

[3.] Demonstration of practical experiment

According myself

At first, I teach a demonstration class on an experiment, and then I ask them to prepare a rough exercise book. In a subjective class, I demonstrate to them how to use the apparatus. Before teaching a practical class, I provide students with an overall idea about the experiment in the theoretical class. I show them how to do the experiment, and help them understand. Then I let them do that experiment.

[4.] Practical activities in classroom teaching

The practical work plays a very important role in teaching and learning physics, all of them usually did not provide students with any practical activity in their classroom teaching.

In the theoretical class, I ask them to prepare a small electric circuit, where some inputs are given, and they are asked to find out the output. It is just like as students usually do in a science fair. I ask them to do this type of task, which is out of activities of the practical class.

I provided students with practical activities while teaching the content related to a practical experiment.

The topic on which there are practical experiments included into the board syllabus, I teach those topics using practical activities and ask them to do those activities so that they can achieve a complete knowledge of those topics.

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[5.] The length of time for practical classes

the duration of practical classes was around 2 hour, which, according myself , was short.

The factor that mostly creates a problem is the limitation of time. It is not enough. If it would be three hour, or three hour and 20 minutes, it would be better.

While observing the practical classes it seemed difficult to complete an experiment within 2 hour . Most of the practical classes that I observed lasted for around 2 hour Extract from my field notes:

Three hours time is needed to do one experiment." During observations of his practical classes

[6.] Practical class as part of the weekly routine

Although each student can attend only one practical class each week, I have thought that it was enough for teaching the small number of practical experiments.

Since there are only eleven experiments in the syllabus, and we get more than twice the eleven practical classes, we can provide them with the proper practical knowledge about those eleven experiments. Sometimes, if necessary, I teach some extra classes to complete all experiments.

[7.] Problems with irregular attendance of students

I Have faced difficulties in properly teaching the students who attended irregularly. They asserted that the students who attended irregularly themselves also faced difficulties in properly doing practical experiments.

I found that few groups were not doing well. I have monitoring them. that those students, who were not regular in the demonstration class, were facing difficulties.

CONCLUSION,

The aim of this study was to investigate physics teachers‟ perceptions of the value of practical work and its importance in developing conceptual knowledge of physics at Graduate level in India colleges .The findings of my study indicate that providing theoretical knowledge of physics accompanied by essential practical work can ensure effective teaching and learning of physics.

SUGGESTIONS FOR FUTURE RESEARCH

The focus of this study was to explore college physics teachers‟ perceptions of the relationship between practical work & theoretical work and developing conceptual knowledge of physics

Further studies could also be done into teachers‟ perspectives of the impact of professional development training on teaching and learning physics at college level; to understand college science students‟ perspectives on teaching and learning physics that includes practical activities; or to explore students‟ beliefs of the role of practical work in teaching and learning physics.

RECOMMENDATIONS

The findings of this study lead to the following recommendations regarding the effective teaching and learning of physics at college level in India . They are:

- Necessary equipment could be provided in such quantities that the teachers in government college

and also in non-government college can teach all the theories and concepts of physics using demonstrations, by which students gain clearer conceptual knowledge of physics.

- A sufficient amount of equipment for doing a wide range of practical experiments enables a large number of students to participate in practical work – this equipment must be available in as many college as possible.
- The class size must be small so that every student can get the opportunity to do practical experiments through hands-on participation.
- In order to complete an experiment within the scheduled time length, teachers must teach separate demonstration classes before the students do that experiment in the practical class.
- There could be a specific laboratory for doing practical work.
- Correctly calibrated instruments must be provided. If necessary, practical equipment could be replaced or resupplied to the college , and regular monitoring should be maintained to support that need for equipment.
- To ensure student's effective learning, all theoretical as well as practical physics classes should be taught in the laboratory, so that teachers can use the necessary equipment to explain the theories and concepts of physics.
- The time allocated for practical classes could be increased.
- The practical classes could be set at the beginning of the day whenever possible when students have the capacity to pay full attention to their learning.
- To ensure effective teaching and learning, only the teachers with higher education in physics should teach both the theoretical and practical classes of physics. For this purpose, a number of subject based teachers could be appointed in college according to the number of science students.
- There could be initial teacher education programmes and also on-going professional development training programmes for physics teachers for teaching practical experiments in practical classes and also for teaching the theories and concepts of physics using related equipment for demonstrations.
- In order to reduce the load of classes, the teacher/student ratio could be increased; and sufficient number of subject-based teachers for each subject could be appointed in each college .
- Posts for laboratory assistants could be created in order to reduce teachers‟ work load and also for the proper maintenance of laboratory equipment.
- Proper and regular maintenance of the equipment must be ensured.
- How many experiments and what experiments must be done, and how many classes must be taken for teaching and learning: these details could be mentioned in the syllabus handbook.

- Practical classes during teacher training and actual teaching practice should be monitored, as are the theoretical classes.
- Regular attendance of students must be ensured.
- Awareness of the value of practical work in teaching and learning of physics and in developing students" clear conceptual knowledge of physics must be developed in administration staff as well as among the physics teachers.

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SHORT BIOSKETCH

Ph.D. *M.Tech.* GATE, JEST, BARC, MPhil, M.Sc. (Physics Specialization in Micro wave Electronics)

Dr. Sumit Kumar Gupta Dean, Faculty of Science Parishkar College of Global of Excellence Jaipur in the Department of physics, With over **15 years** of teaching, research, and administrative experience, he has held various administrative positions as the Head of Department in various degree colleges and engineering colleges and has a vast experience of teaching in IIT-JEE

Dr. Sumit Kumar Gupta had been associated with Maharishi Arvind Institute of Engineering and Technology, Jaipur for last 8 year as Associate Professor. Prior to that, he was associated with Agarwal PG College, Subodh PG College, Global Institute of Technology, Joythi Vidhyapeeth University Jaipur, as faculty positions for 7 years. In his 15 years teaching, administrative and research duration, he has published **23 research papers i**n highly reputed **UGC Approved International Journals**. He has participated in **14 National and International Seminars** and delivered over **18 lectures in the international and national conferences.** He has been Participated **5 Workshop** in Reputed NIT,IIT campus . He has been selected as **Speaker keynote in 3 International Conference in material science 2017, London Dubai, & USA** .He has written **7 books for B.TECH engineering**. He has been appointed as **37 International editorial Board member in UGC approved Peer Reviewed, Thomson's Reuters International Journals** .He guided **12 M.sc (physics) Projects, 3 MPhil (Physics) thesis, 10 MTECH Projects** and **4 students on going Ph.D. my Supervision. 55 students** has published international paper **in UGC approved Peer Reviewed, Thomson's Reuters my Supervisions. He served as members: Life Member Indian Science Congress Association,**

Member of Instrument Society of India (2003-2004), Life Member, Rajasthan Ganita Parishad, Rajasthan, Indian Physics Society Member, **National Academy of Science, India** Member**, Indian Physics Society,** Member, **American Physics Society** Member, **ocean Future Society** Member, **National society of Professional Engineers (NSPE)** Member, **International Association of Engineers (IAENG)**. Member, **Arizona Science Center (Member 1461638)**Member, **Society of Industrial and Applied Mathematics**, Member, **Institute for engineering research and publication (IFERP) . IEEE Member. Vigyan Bharati Member He was also appointed as examiner of various Universities and colleges : Rajasthan Technical university Kota, Mohan lal Sukhadiya university Udaipur, University of Kota, Gyan vihar University Jaipur, Poornima University Jaipur, Board of Secondary Education Ajmer ,vanasthali University ,Niwai ,Jaipur National University , University of Rajasthan**

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QUESTIONNAIRE REGARDING CASE STUDY FOR FACULTIES:

For my research, the college level physics teachers are the respondents. I will use around eight openended questions to consider their teaching, which will be supplemented by additional probing questions. The questions are as follows:

1) What do you understand by teaching and learning physics at college level?

2) What pedagogies do you use for teaching physics?

3) What kinds of activities do you provide for your students?

4) What is the role of practical activities in teaching and learning physics, according to you?

5) How often do you ask your students to conduct practical activities?

6) Can you give me some examples of the types of practical activities you or your students have done?

7) How important is it for the students to do practical activities themselves to help them learn physics concepts?

8) According to you, what factors enable you to teach well?

9) According to you,

a) What factors hinder teachers to conduct practical work?

b) What inhibits students to participate in practical work?

PROBING QUESTIONS

The main questions will be supplemented by the following probable questions:

1) Between the subject matter knowledge and the pedagogical knowledge, which one is the most important skill for teaching physics? Why?

2) Providing the content knowledge of physics using only the lecture method is enough for making students understand. Do you agree or disagree? Why?

3) Do you agree or disagree with that practical work makes physics teaching easier? Why?

4) Providing theoretical knowledge of physics along with practical activities can ensure effective learning of physics. Give your opinion.

5) How important is it for the students to do practical activities themselves to help them learn physics concepts? Why?

6) Inquiry-based knowledge is necessary for conducting practical class. Do you agree or disagree?

7) Practical work makes lessons interesting. What do you think?

8) Do you believe that practical activities increase students‟ motivation towards learning? Give reasons for your answer.

9) Does conducting practical work make it difficult to control the class? Why, or why not?

10) Do the teachers need training for effectively conducting practical work in school? Why?

11) How many physics classes do you take per week?

12) Do you take practical classes?

13) Are there laboratory assistants or demonstrators in your school for conducting physics practical classes?

14) How many practical classes do you or the demonstrators take per week?

15) Is there any specific laboratory for physics practical work in your school?

16) If no, then where do you conduct practical classes?

17) Are there adequate laboratory equipments in your school?

18) Do you or the demonstrators face any barrier to conduct practical classes?

19) If yes, then what are the barriers?

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FEEDBACK QUESTIONNAIRE REGARDING CASE STUDY FOR STUDENTS

THE EFFECTIVE ROLE OF PRACTICAL WORK & THEORETICAL WORK IN TEACHING AND LEARNING PHYSICS AT GRADUATE LEVEL

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