A STUDY ON THE EPISTEMOLOGICAL BELIEFS OF UNIVERSITY TEACHERS IN INDIA

Mahima Chhabra[1] & Bharati Baveja[2]

[1]Department of Education, Ravenshaw University, Cuttack (India),

[2]Department of Education, University of Delhi, Delhi (India)

mahima.chhabra@gmail.com, bharati.baveja@gmail.com

Belief systems are crucial in shaping one's perception and are one of the major guiding forces behind our actions. Thus within a classroom, teachers' beliefs play a fundamental role in determining classroom practices. In addition research suggests they strongly affect the quality of student cognition as well as students' personal constructs. Therefore this area renders itself crucial for research. Our work aims at exploring vital aspects of this area i.e. interface between teacher beliefs and pedagogy. Semi-structured interviews were used to investigate how university teachers' epistemological beliefs influence their pedagogical knowledge. The outcomes explicitly exhibited that there remains a considerable gap between teaching and learning. The research strongly puts forth the growing need for creating platforms for university teachers, wherein interaction between their practices (and hence their personal constructs) and research could be discussed. This endeavour could significantly contribute towards facilitating teachers' professional development.

INTRODUCTION

Teachers are one of the major stake holders in the process of teaching and learning. They influence students' learning in more than one way. Their pedagogies and behaviour in the classroom is not only affected by their knowledge of the subject matter but also their conception about the subject, about the students, about learning or in other words their belief systems as a whole. There are numerous researches indicating that teacher beliefs in some way influence their instructional plan and instructional practice (Nespor, 1987; Pajares, 1992; Abd-El Khalick, Bell & Lederman, 1998; Lederman, 1992; Lederman, 1999). Furthermore, impact of teachers' beliefs do not restrict to their pedagogical practices but also have a bearing on the quality of student cognition (Maor & Taylor, 1995) and even students' personal constructs. Hence, it is not only important to concentrate on what goes on in the classroom; but what goes on in the learners' head and also what the teacher makes out of it. In order to appreciate this point, it is necessary to analyse teachers' perceptions and interpretations of the interactions within the classroom. Therefore, there is a need in research to unravel teachers' beliefs about what can be counted as knowledge, where knowledge is located, and how knowledge increases (Schraw & Olafson, 2008) - i.e. their epistemological orientation.

Keeping in mind the importance of this area, there is a growing body of research to explore teachers' beliefs through various means. Many studies have attempted to measure epistemological beliefs using self-report scales (Hofer, 2000; Schraw & Olafson, 2002), but according to some researchers, it is not an easy task to measure epistemologies (Hofer & Pintrich, 1997). The very nature of belief is not quantifiable, it "*does not lend itself easily to empirical investigation*" (Pajares, 1992, p. 308). Hence, such methods need to be used which help in digging beneath the surface of conscious to reach the subconscious relationship between epistemological orientation and perceptions of practice Researchers have also tried to

use methods like interview techniques to determine a holistic epistemological view (King & Kitchener, 1994; Perry,1970; Hewson & Hewson 1989; Luft & Roehrig, 2007), open-ended questionnaires (Yang, 2005), and content analysis of verbal explanations (Slotta & Chi, 2006), and written vignettes (Schraw & Olafson, 2002). Most of these researches have tried to classify teachers on the basis of their beliefs. For instance, Mulhall and Gunstone (2008) have tried to categorize a group of Physics teachers as 'traditionalists' and 'conceptual'. Study by Tsai (2002) explored the relationships among teachers' beliefs about teaching science, learning science and the nature of science. He categorized teachers' beliefs as either 'traditional', or 'process', or 'constructivist'. Schraw and Olafson (2008) while assessing teachers' epistemological and ontological worldviews, tried to place teachers on a continuum ranging from 'realist' to 'relativist'. Many researchers have espoused that participants belonged to singular epistemological worldviews (Schraw & Olafson, 2002) however, some others have also shown a fusion or mix of more than one epistemological orientation (Sfard, 1998; Patchen & Crawford, 2011).In our research, we have adopted a bottom up approach, where we are not defining any pre-categorization, and rather look at the themes emerging from the data.

In this research we have made an attempt to unravel university teachers' epistemological beliefs. Here, we mainly focus on exploring teachers' views on 'process of knowing' aspect of epistemology, i.e. learning. Novelty of the study could be derived from the fact that the participants are university teachers who do not have any formal orientation in the field of education. This is markedly different from contemporary researches which primarily focus on pre-university and school teachers. The teachers' beliefs, therefore, are assumed to be guided by their experiences as students and their practice as teachers.

RESEARCH QUESTIONS

1. How 'learning' is perceived by university teachers?
2. How 'learning' is assessed by them?
3. What is university teachers' perception about students' alternate conceptions?
4. How do they deal with alternate conceptions in the class?

METHODOLOGY

Participants for the study consisted of ten university Physics teachers from an urban university in India. This university offers courses starting from bachelors to doctorate level (B.Sc., M.Sc. and PhD).All the participant teachers for this study had taught both bachelors as well as masters level students with a typical class size varying from 25-35 students.

To explore teachers' perceptions and interpretations of the interactions within the classroom, detailed semi-structured interviews were conducted with them. The focus of study is on teachers' epistemological orientation, i.e. what can be counted as knowledge, where knowledge is located, and how knowledge increases (Schraw & Olafson, 2008). The interview was transcribed verbatim followed by content analysis. In addition, the teacher interviews were carried out without any explicit pre-framed categories which resulted in adoption of a bottom-up approach where we tried to ascertain themes emerging from the data.

Themes emerging from the data are presented under the broader sections corresponding to the above questions. To maintain the anonymity of teachers they have been referred to as T1, T2, T3.....T10.

DATA SUMMARY AND ANALYSIS

In the following section, a summary of data followed by its analysis has been presented under major themes.

Learning and Assessment of Learning

Learning was conceived variously by participants. For T1 and T5 learning is anonymous with 'application'. According to T5 most of the times it is difficult to immediately ascertain if students are able to make sense of the concept; only when they are able to apply that concept in the advanced courses, it shows they have learnt it.

T3 perceived learning to be able to understand various perspectives. Conceptualization for him meant going beyond and not restricting to what is taught in the class. He said, "*in case they have been taught with the physics perspective they should be able to understand in chemistry perspective on their own.* To shed some more light on the concept of 'learning', some teachers cited the modes they used to ascertain whether students have learnt. T2 said he deliberately committed mistakes and expressed his confusion and inability to solve further to students. He observed that if the concept he taught was learnt by students then, "*this class invests its brain collectively to help the instructor to get over the crises".* T4 dealt with majorly lab courses in which he generally used quiz and viva. In viva, he often tried to confuse students by providing incorrect hints. According to him, if the student caught the clue and attempted to prove the teacher wrong, it clearly indicated student understands of the concept. On the other hand, if the student accepted that wrong hint and tried to analyse the situation based on it, then it meant he did not understand and was trying to invent answers.

On the basis of differences in 'conceptualization' some teachers also tried to categorize students. T7 said that 'conceptualization' varied amongst students and he observed three categories "*some of them go really deep into the subject ... Some people would understand the concept but they cannot do anything with it and some people will generally find the difficulty in understanding the concept itself may be because of their background problem.*" T8 noticed two types of students, one who conceptualized theoretically and the other who tried to visualize the physical picture, and he endorsed a balance between the two approaches. For T3, exam questions were not only the medium to asses learning, but for categorizing the students also.

T4 used students' performance in an experiment as a mode to assess understanding and also perceived a categorization on that basis. According to him a huge fraction of students only followed the manual provided in the lab however another fraction, while following the manual also analyzed. He said "*they are trying to reinvent things with simple set up- how the experiment can be done in some other way which is physically feasible and correct. Hence there are people who just follow it and there are those who analyse*".

It is observed that amongst the given participant teachers, although the notions of 'learning' were varied, but they largely pointed towards the ability of the students to apply the concepts or learning as problem solving. T1 and T5 clearly mentioned about application, T3 identified learning from questions solved in tests, T2 through problem solving in class and T4 through the methods used in the lab by students to perform the experiment. These views indicate that for them, learning was not only restricted to internalizing or the process of cognition but extended to retrieval of the relevant information for solving the problem at hand. It included the use of 'memory' (to retrieve essential information), 'fine-tuning' and 'performance' (i.e. being able to solve problem). This is quite similar to the way Norman viewed learning as a

deliberate act of study of specific material so that it can be "retrieved at will and can be used with skill" (Norman, 1982, p. 3).He argues that if a learner cannot solve a problem , he has not learnt it. Apart from application , T2's view of identifying learning by the method of detecting errors in a problem points towards the notion of learning through group problem solving where the participants are constructing knowledge together. T5 also indicated towards gradual learning. When he said that it is difficult to ascertain learning immediately; it indicates that he is viewing learning as an evolutionary process which involves assimilation and accommodation so as to form new schemas which are qualitatively different from previous ones.

Another idea apparent from teachers' views was of 'reflective abstraction'. When T3, mentioned that whether a concept is used in chemistry perspective or physics perspective, but students should be able to appreciate it, that is students must understand the various perspectives of the concept, he indicated towards being able to identify and understand the focal idea of the concept from various forms it is applied in. The application may be in specific contexts, but through the process of reflection, students should be able to abstract and internalize the central embedded idea. T3's idea can also be looked at from the point that learning is being referred to as the ability to view and approach the concept learned through multiple modes and perspectives.

Diversity in Cognition

Almost all teachers acknowledged that there could be difference in students' cognition. However, the idea of 'different' was not the same for everyone. T3 was of the view that if the environment is the same, students should understand the same way. According to T1, ideally students should understand the same way and make same pictures in their minds which the teacher gave them. However he observed that some students didn't understand the same way rather adopted different ways. By 'different ways' he meant 'different techniques' of solving a problem here or making different pictures with the same core concept. T2 was of the view that students should build up their own understanding of the concept and not replicate teachers' understanding. He said "*I think everything we teach and do have an analytical side and has a phenomenological side and there has to be an optimal balance of these two.*" However, he firmly believed that although he gave scope of variety in conceptualization but all these understandings must converge. According to T4, students in beginning semesters followed manuals to perform an experiment resulting in similar understanding. At advanced level, students read the catalogues, which did not provide instructions for doing the experiment, thus students had to think how to perform the experiment due to which their understandings could differ.

T10 was not so sure and according to him students might be conceptualizing differently. His repeated observation was that students did not understand the concept immediately after they were taught. It was only after he took few classes and when he started using the concept, some kind of *foggy pictures* about the concept started emerging in students' minds. These foggy pictures were sometimes same and sometimes not but if students continued with this subject then after few semesters students' pictures might start resembling teachers' pictures.

According to T6, almost all the students learnt in slightly different way. He had observed that students came with many preconceived notions. So from all what is taught, students only picked out some parts which were closest to the notions they already had. Teachers attributed various reasons for difference in conceptualization by students. For T3 and T5, difference in environment could result in dissimilar conceptualization. From environment he meant

interaction of students with their seniors and other students. For T4, combination of interest or sincerity and intelligence level of the student varied from students to student and so did the level of understanding. According to T6, preconceived ideas of students, one of which was their area/topic of interest affected learning process. He observed that, from all what is taught, students only pick out some parts which are closest to the notions they already have.

Teachers identified differences in students' conceptions mostly through the questions students asked to the teacher or the responses they gave to teachers' questions in the class. Similarly T1 and T10 got a clue, about students' understanding, when they started asking questions in the class.T6 expressed that "*I am giving a mental picture to them, and then they will ask questions. Many times I realized ...I was trying to say something else, but then you will realise that this person already has some other mental picture and they are trying to connect to your mental picture.*" From these questions he realized that he needed to get into students' mind and teach from the perspective through which they understood.

Regarding the question of whether students conceptualize differently, although most teachers agreed, but their notions of 'different' only pointed at superficial level and not at conceptual level. For T1, 'difference' meant different techniques of problem solving theoretically and for T4 practically in lab; for T2, it meant the way of visualizing the problem (physically or solving mathematically). All teachers except T6 supported the belief that the concept can be understood only in singular way. At the conceptual level, there is only one correct way in which the concept can be perceived. Only T6 cognized the possible variation in the way students conceptualized. He also attributed this variation to the previous conceptual schemas with which students study the new material. When he said that students try to adapt whatever teacher teaches to their mental picture, he pointed towards learning involving the process of 'assimilation', hence suggesting that students tried to relate new information to their previous information. His ideas were in line with the constructivist ideas.

Alternative Conceptions

All teachers except T3 acknowledged that students did carry alternate conceptions. T3 believed that science students do not have any alternate conceptions, and he added that alternate conceptions are found in only arts courses such as history. On asking, then why some students give incorrect answers, he reasoned that those students are not hard workers.

Although all the other teachers agreed that students carry alternate conceptions, but their idea of alternate conceptions was varied. T9 cited some mistakes and mentioned that students remember the laws but they forget the conditions, and apply it in inappropriate situations. T2 explained alternate conceptions through an example where students picked ideas of potential energy, kinetic energy and total energy from the domain of Classical Mechanics to Quantum Mechanics which was again incorrect extrapolation.

T6 did not think that students were aware or conscious of their alternate conceptions, he said, "*they have a mental picture but ..., it is not conscious it is not fully thought of in their own minds also, so naturally it contains a lot of misconceptions*"

Teachers attributed various reasons for these misconceptions. T1 felt that since students might visualize concepts variously thus this difference might lead to misconceptions. T4 observed that sometimes students had some partial pictures which they tried to complete by themselves leading to misconceptions. He explained through an example, "*Like in vacuum technology, they don't know how a diffusion pump works completely, they just think ... that something is*

diffusing, so there has to be fluid." T6 found gradual shift in concepts from concrete to abstract as a reason for misconceptions.

Teachers identified students' alternate concepts through various modes. T1 cited two ways – one was through interaction in the class and second one was exams, T2 came to know about students' conceptions through the questions and problems he discussed in the class. Therefore he felt that class needed to take part actively in the discussions, but that was not the case with all the students, he had to provoke a lot of them to ask questions. He expressed that although he encouraged students to understand concepts in their own way but while doing so they should acknowledge that there were other ways of understanding also. He further added that in case any of students' representations were leading to wrong answer, then it was teachers' responsibility to correct their thought. T4 while handling lab, observed students committing mistakes in Quizzes because of their alternate conceptions, and in viva he noticed students making up the answers.

All teachers except T3 agreed that students while learning may carry misconceptions, but their notion of 'misconception' did not concur with the technical meaning associated with it in academic community. When T9 said that students remember the law but they fail to remember the conditions in which that law is applicable, he identified misconception with committing repeated errors due to inability of few students to either retrieve all associated information may be because they were unable to transfer data to long term memory in the first place. He also mentioned the errors in which few students inappropriately extrapolated the conceptual understanding from one domain (subject) to the other domain (subject), due to apparent similarities. It indicated that dissimilarities between the concepts have not been identified or focussed by the students while learning. T1 identified misconceptions with errors committed by students due to difference in problem solving techniques. Only T4 and T6 to some extent, pointed towards misconceptions arising due to inaccurate conceptualizing, i.e. focussing at the conceptual level. T6 attributed misconceptions to the formation of inaccurate gestalts, when partial information is provided. It indicated towards human tendency to perceive information in complete wholes rather than parts, hence when partial information is provided, mind tries to complete the picture through the closest information available, which many times lead to erroneous concepts.

Strategies to Deal with Alternate Conceptions

Most of the teachers dealt with 'alternate-conceptions' by re- explaining the concept. T1 said if a student's conception is wrong, he just pointed it out in the class so that everybody could benefit from it. T8 also mentioned that whenever he found a problem with students' perspective, he indicated the limitation in that. For lower semester students, T4 explained the concept again, but for higher semester students he just mentioned the point of divergence and asked them to find the solution on their own. T5 also revised the concept again, but while revising, he tried to change his pedagogy.

Since T3 did not believe that students could construct alternate conceptions, so whenever he found errors in exams, he only told them *"you have not done well, you have not worked hard"*. He further said that students should come to the teacher themselves to clarify their doubts. T6 dealt by asking students a trail of questions and as a consequence, they eventually hit a wrong solution and realise the inconsistency in their conceptions. Most of the teachers were of the opinion that their strategies worked, although not all of them checked for its success.

Regarding the approaches/ techniques used to deal with students' alternate conceptions, most of the teachers expressed that they repeated the concept or re- explained it. Even without checking if their strategies worked, most of them believed that their technique was effective in removing the alternate conceptions. Only T6 suggested an approach which, to an extent aimed towards 'conceptual- change' as suggested by Posner et. al (1982). Another crucial point brought out explicitly by T3, was that *students* need to approach the teacher to clear their doubts, which implied students need to identify their own alternate conceptions. Teachers failed to recognize students (or anyone else) are actually unaware of their alternate concepts because their interpretation of the concept fits their (personal) conceptual framework.

DISCUSSION AND CONCLUSION

Amongst the given participant teachers, notions of learning were varied and most of them viewed it as cognitive process. In spite of this, no evidence was found of their awareness about alternate conceptions. Regarding diversity in Cognition, teachers' perceptions varied but most of them considered diversity as deficiency in learning or diversity due to degree of learning. They could not view difference in learning as difference in conceptual structures which learners construct. All teachers except one agreed that learners may carry misconceptions but their notion of misconception did not concur with the technical meaning associated with it in the academic community. They associated misconceptions with the errors committed by students rather than recognizing them as personal constructs which did not align with the well negotiated scientific knowledge (of that time). The data indicated that varied interpretations of the same concept or diversity in cognition were not acknowledged by most of the teachers. The phenomenon of subjective construction of reality/knowledge was also not acknowledged by most of the teachers. Consequently, the technique of 're-explaining' was adopted by most of them. A few of them, however, did indicate towards the importance of making learners reflect on their own mental models.

Their notions about the process of knowing also indicate to some extent their conceptions about the nature of knowledge. While many of them believed that there is no variation as far as understanding of the concept is concerned, it depicts somewhat absolutist assumption about knowledge. It shows that knowledge is 'out there' for such teachers and not constructed by learners. There is plethora of research which has revealed that students' understanding of science ideas may not always match with those of scientists (Halloun & Hestenes, 1985; Goldberg & McDermott, 1987; Styer, 1996; Hammer, 1996). Hence existence of 'alternate concepts' in science is a common phenomenon. To address this issue, conceptual –change approach is suggested by many researchers (Posner et al., 1982), which involve recognizing that learners construct their own understanding based on their prior concepts which they have developed to explain their everyday experiences. From this perspective, learning occurs when new constructions are made and it is the role of the teacher to try to influence these so that the students are consistent with scientific thinking. Thus, most of the teachers seemed to be unaware of the process of knowledge construction among students. Hence a student might have idiosyncratic construction, but it is not recognized by the teachers. The results of the study indicate a gap between the way learners conceptualize (as revealed by researches across globe) and the way teachers view learning. This has direct implication on their pedagogical approaches. This gap can be bridged, when teachers reflect on their own epistemological beliefs about the nature of knowledge (science in this case), the process of learning and the pedagogical techniques to be used in the class to achieve desired learning. As beliefs are assumed to be affecting teachers' planning, decision-making and classroom interaction, it is worthwhile to explicate and reflect upon such beliefs. Teachers need to be cognizant of their

belief system in order to challenge the ones which are not congruent with the way learners conceptualize, and replace those with the more compatible ones. In order to make such alterations happen, this study makes a strong case for creating forums for university teachers where strategies of bringing out their beliefs are discussed. This attempt will subsequently, help teachers make active reflection an ongoing process of their professional life. Hence, this endeavour will not only contribute towards teachers' professional development but this will also help in creating a more conducive environment for learning.

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