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TEACHER CONCEPTIONS OF SCIENCE TEACHING AND LEARNING AT THE UNDERGRADUATE LEVEL

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ABSTRACT

In this research article teacher conceptions and beliefs about teaching and learning in chemistry at the undergraduate level are explored. It further examines their relationship with the teaching practice. Using a case study design, the research paper presents a case report of a tertiary chemistry teacher. The data was collected using semi-structured interviews with open-ended questions. Using the constant comparative method of data analysis the interview data was analysed to investigateteacher beliefs and practices around the following themes: objectives of learning chemistry, engagement with chemistry curriculum, role of teachers, lesson plan and role of students. The study found that teacher beliefs guide and influence classroom practice.

Keywords: Teacher beliefs, Teaching practice, Chemistry education, Higher education

INTRODUCTION

This research paperis based on a larger study which the researcher is pursuing for her doctoral researchthat intends to explore and examine teacher conceptions about teaching, learning and assessment in chemistry and their relationship with the teaching practices at the undergraduate level in University of Delhi. The study is being pursued as most faculties at the tertiary level in India are trained in the content of their profession and not in educational theory and practice. Thus, it becomes necessary to understand the interaction of teaching and learning in higher education where majority of the classes aretaught in a lecture format. In a typical undergraduate science classroom, the teacher is free to engage the students in the teaching and learning process in whichever way he/she thinks as appropriate. The success of the teaching approaches and methods of the lecturer in enhancing the learning of students could be questioned as there is no general understanding let alone consensus about what constitutes good teaching and learning.

In this context, the question of what teachers need to know about teaching is being critiqued and discussed at length in the education community. Since the 1970s, a portion of the research aimed at improving teaching has focussed on *teacher cognition* (which includes knowledge, beliefs and thinking of teachers) and has primarily been conducted with primary and secondary school teachers (e.g. Ethell&McMeniman, 2000; Kagan, 1990; Wideen et. al., 1998), which has implications for teachers at tertiary level. Such research has revealed that teachers' personal beliefs and theories play a crucial role in teaching practice (Kagan, 1990; Pajares, 1992; Levitt, 2002). It also emphasizes that the ways in which teachers conceptualize curriculum, knowledge, teaching and learning greatly influences the manner in which they plan and conduct their lessons. However, very few similar studies are reported at the tertiary level (Kane et al., 2002; Mc Alpine & Weston, 2000). Hence, it is not clearly known how teachers in the university setting develop their conceptions, beliefs and ideas about the teaching-learning

process. Though, some researchers have begun to look into this area as well. According to Richardson (2005):

> Even so, when they are confronted with the same teaching context, different teachers adopt different approaches to teaching. Some researchers have ascribed this to constitutional attributes to teachers themselves: to different styles of lecturing, styles of thinking or personality characteristics. However, others have argued that different approaches to teaching reflect different underlying conceptions of teaching (p. 677).

It implies that the educational beliefs and presumptions of the teaching staff influence the manner in which they conduct teaching in higher education (Trigwell et al., 1994; Trigwell and Prosser, 1996) and that there may be consequences for the learning outcomes in students (Trigwell et al., 1999).

TEACHER BELIEFS

Teaching is known to be a highly complex cognitive activity. The educational researchers are of the opinion that teacher beliefs play a major role in teachers' decision making about curriculum and instructional tasks. In recent years, there have been numerous efforts to organize beliefs into types, and examine their impact.

Nature of beliefs

Like people, teachers also hold beliefs about everything. For many it appears to exist in tacit form and is not easy to express. Hence, as a global construct, belief cannot be easily investigated empirically, rather it must be inferred. Pajares represented belief as a 'messy construct' that needs a common definition which can be operationalized and examined more effectively. The nature of teaching and the teacher's function is often not distinctly delineated and educational beliefs are largely predisposed to turning into what Nespor (1987) called an 'entangled domain'.

Kagan (1990) described teachers' beliefs as: 'the highly personal ways in which a teacher understands classrooms, students, the nature of learning, the teacher's role in the class-room, and the goals of education' (p. 423). Also, they act as filters through which they allow in or filter out new knowledge that is regarded as compatible or incompatible with existingbeliefs (Nespor, 1987; Pajares, 1992). They are strong predictors of behaviour.According to Pajares (1992), 'the beliefs teachers hold influence their perceptions and judgments, which, in turn, affect their behaviour in the classroom, or that understanding the belief structures of teachers and teacher candidates is essential to improving their professional preparation and teaching practices' (p.307).

Teacher beliefs and practice

In science education, the relationship between teacher beliefs and practice is widely studied and is well documented at the primary and secondary levels(Abell, 2007; Veal, 2004). However, at the tertiary level very few studies have been conducted (Davidowitz&Rollnick, 2011; Trigwell et al., 1994; Trigwell and Prosser,1996).In higher education too, there is a need to study about the beliefs as teachers may hold varying beliefs about teaching as a profession, and science teaching in particular. Kane et al. (2002) emphasize that doing research into teacher beliefs will highlight the significant role that teacher beliefs can play in the development of teaching practice in higher education. They further argue that to understand university teaching completely one cannot ignore teacher beliefs about teaching and that there must be a systematic scrutiny of the relationship between teacher beliefs and classroom practices.

In India, teacher beliefs and practices have been studied on various aspects of science education at the primary and secondary level (Nargund-Joshi et al., 2011) but not so at the tertiary level. Hence, it is crucial to comprehend how science lecturers in our universities with no formal teacher training perceive their roles and internalize teaching and learning as they plan their lessons, scaffold instruction and assess students' learning in science. Thus, in order to comprehend tertiary teacher conceptions and beliefs about chemistry teaching and learning the following research questions were used to guide this study:

1. How do teachers perceive learning in chemistry?
2. How do teachers perceive their role as teacher of chemistry?
3. How do they go about teaching chemistry?
4. How do teachers perceive the students' role in the teaching and learning process?

METHODOLOGY

The purpose of this study required the use of qualitative method such as case study to gain an understanding of tertiary science teacher conceptions of teaching and learning. It was believed that doing a case study would help explore (Best & Kahn, 2005; Creswell, 2012)and bring to surface how teachers think and what they value when it comes to teaching and learning of chemistry at the undergraduate level in University of Delhi.

Participant

In this research paper, a case study of Payal (pseudonym) is presented to explore her conceptions of chemistry teaching and learning. She is in her mid-thirties and has a PhD in Chemistry. Her area of specialization is physical chemistry. She has 10 years of teaching experience. Payalteaches physical chemistry to students enrolled in BSc Programme Physical Sciences course in one of the colleges in University of Delhi.The normal duration of her class is 55 minutes.

Payal belongs to a family where most of them were or are in the teaching profession. Hence, she thinks that the ability to teach is in her blood and it comes very easy to her. During the interviews she mentioned that though some of her teachers have definitely influenced the way she teaches, but mostly it has been her own effort right from her inception into the teaching career at the undergraduate level in University of Delhi.

Data collection and Analysis

Since the researcher is also teaching undergraduate chemistry students at one of the colleges in Delhi University, the participantfor the study, Payal was approached over the phone. Based on her willingness to participate in the study, the researcher conducted semi-structured interviews (two of them lasting about 120 minutes in all). The questions for the interviews stemmed from the understanding the researcher had developed about beliefs and practices being intertwined as recorded in literature. During the course of the interviews, Payal was asked variousopen-ended questions to explore and examine her understanding on the following five themes: objectives of learning chemistry, engagement with chemistry curriculum, role of teachers, lesson plan and role of students.

The interviews were recorded using a digital voice recorder and the interview data was transcribed using a computer. The interview data was then organisedand coded using NVivo11 pro qualitative data analysis software. Data analysis was carried out using constant comparative method of data analysis. It is here emphasized, that the data collected includes beliefs and practices as reported by the participant. It was not possible to go beyond this and conduct classroom observations as allowing an observer in a classroom is a very alien thought at tertiary level in India.

RESULT

It is believed that teacher's personal experience of teaching and learning as student could influence the way s/he conceptualizes teaching and learning and in a way impact his/her practice (Abell, 2007, Boz&Uzuntiryaki, 2006). Hence, this section begins with research participant Payal's experience as a student of chemistry, followed by some significant themes exploring teacher conceptions and beliefs to get a glimpse of teaching and learningprocesses at the undergraduate level in University of Delhi.

Participant's experience as a student of chemistry

As a student, Payal could learn Physical Chemistry very easily as compared to Inorganic and Organic Chemistry because it's very 'logical and systematic.' She really liked some teachers because of the way they taught. According to her, these teachers had clarity of thoughts and they 'knew' what they were teaching and were systematic. Payal recollected that if the teachers were systematic and made connections with what they were teaching then she would understand very easily. But she could not follow some teachers who were not systematic, as the clarity was lost.

...from the basic things you realize that it is very simple and you feel little enthusiasm in learning all that. And then later on introduces the harder concepts.

Objectives of learning chemistry

For Payal, learning in chemistry is 'everything', it's'everywhere around us...' She emphasized the importance of learning chemistry because one thing or the other that is being used in daily life has chemicals and 'you must know how these chemicals are affecting you.'Thus, her general approach while teaching students is to emphasize on the significance of 'what they are studying? How it is beneficial to them?' She also gives great importance to the chemistry laboratory exercises as she believes that when the students 'do it themselves they learn more.'

Engagement with chemistry curriculum

According to Payal, the number of classes assigned per week by university for the chemistry syllabus of BSc Programme Physical Sciences is less in number. '...So it is very clear... you don't have to go in much depth…because you will not be able to finish the course.'Moreover, the level of depth is also somewhat defined by the kind of questions that are asked in the examinations. She points out that 'they are asking simpler questions' in the university examinations for this course.Hence, with the limited number of classes assigned per week,she keeps the subject straightforward for her students in order to finish the course in time and teaches them from the university examination point of view.

…They have a lot of subjects to study so for them it should be simple and clear. Simple means the course has to be completed and also from an exam point of view.

Roles of teachers

Payal believes that a teacher shouldtake classes regularly and properly. Secondly, the teacher should be able to'...make the student think why he is learning certain things' in the chemistry class.According to her, what happens is that the students just 'concentrate' on books and not on their surroundings. They restrict themselves to whatever the teacher teaches them. Thus, the 'most important thing' is to 'engage' the students in the class, so they can relate to their environment and be able to inquire. She strongly feels that if the students learn to inquire instinctively then a 'teacher succeeds.'Thus, in order to actively engage her students in the classroom, she asks them questions and gives them numerical problems to solve and later on takes tests as she wants them to learn and 'be able to know'chemistry.

...So sometimes, not always, they come up with answers, that might be stupid but they are thinking and you are engaging the student to study.

Lesson plan

Usually she takesa topic from the chemistry syllabusthat she has to teach her students and prepares for her classes by reading from various books and internet resources and organizes her lectures accordingly. She does not carry notes or mathematical derivations written on sheets of paper. She is able to remember and does everything related to the topic in the class in front of the students while explaining them each and every step. She feels that her students also realize this and are motivated, that if she can then they can also do it. Nevertheless, she does not consider it 'bad to carry notes' to classes but the teacher should not just use and focus on them alone while teaching in the class. She herself carries them at times to remember what she has to teach next or if she wants to dictate something to the students.

Payal aims to teachchemistry topics systematically to her students so that they are 'able to understand.' She does numerical problems simultaneously and does not leave them to be done at the end. She thinks that since the formula is 'fresh' in their minds so they can apply it easily and conceptualize the problems better. While doing this,she also diligently prepares them for the university examinations so that they can score well.

...because if I teach very well but if my students are not able to score marks then it's of no use...so I have to…focus on the exams also…

The use of chalk and board is a 'must' for Payalto teach effectively in the class, especially, when she has to 'logically' explain the steps of a mathematical derivation. In such a situation, she does not use PowerPoint presentation as she thinks that students would not understand it then. She believes that students are focussed and 'grasp better' when they copy from the blackboard as the teacher writes on it. Nevertheless, she sometimes incorporates PowerPoint presentations when certain topics, like solid state, that require the use of videos or animations where the students can visualize the molecular structures properly. She considers it easier to show them to the students using a PowerPoint presentationbecause it would take time to draw such structures on the blackboard.

Role of Students

A good chemistry student, according to Payal, is the one who is diligent, regular and attentive in classrooms and should have an inquisitive mind. She also emphasized that in chemistry it is very important for students to have good observation skills. Also, the ability to infer from observations in the chemistry laboratory exercise is equally important.

She believes that students play a very crucial role in the teaching and learning process. If they are 'inquisitive'then a teacher would prepare well for classes to be able to answer all their queries and in the process students would learn the topic 'very nicely' while 'going to the depths of the topic.' Also, as a teacher goes about explaining the topic to the students, 'you evolve new strategies, you evolve new explanations...' to make them understand it 'very easily.' For example, for a topic like solid state, she searches for various online 'new videos' or presentations to gain more clarity and help her students visualize the molecular structures. Thus, she firmly believes that, 'if you have got good students, you will become a good teacher' and on the contrary, she does not 'feel like teaching' the indifferent students.

Over the years, Payal has come to realize that the best place to learn and evolve as a teacher is the classroom. While trying to answer her students' queries, many ideas strike her on how to teach and improvise, making it 'even more simpler' for them.

…I had already taught this topic several times and then...I realized there was yet another way to teach the same thing. So from classroom teaching, you evolve a lot because you learn a lot at the moment only.

DISCUSSION AND CONCLUSION

In this research paper, the researcher has attempted to peep into the mind of a tertiary chemistry teacher Payal, in order to capture her conceptions of teaching and learning in chemistryat the undergraduate level in University of Delhi. The analysis of the interview data based around the following themes: objectives of learning chemistry, engagement with chemistry curriculum, role of teachers, lesson plan and role of students, clearly reveals how her beliefs about teaching and learning chemistry guide and influence her teaching practice.

These beliefs have come into being through her own experience of teaching and learning as a student of chemistry, followed by her experience as a teacher of the subject.The practices of teaching that she encountered as a student led to her beliefs about good/bad teaching, which later impacted her own teaching practices. For instance, she likes to teach systematically because that's how she learnt best with clarity. She does not teach the way some of her teachers taught who did not organise their lectures properly. Moreover, her teaching practices are inspired by the way she learnt chemistry and she strives to make her classroom experiences if not better, equally interesting, motivating and challenging for her students. Over the years, her beliefs and practices have synergistically influenced each other and have evolved simultaneously. Moreover, in some ways they have influenced the advancement of her knowledge of the subject as well as her pedagogical content knowledge (Shulman, 1986).

Through reflection on her teaching and classroom experience she has developed a good understanding of chemistry teaching and learning which conforms to the ideas of effective teaching in science as explored and examined in literature (Lederman, 1999; Water-Adams, 2006; Tsai, 2007) For example, instead of adopting a didactic teaching format, she emphasizes the importance of engaging the students in the learning of chemistry in the class through inquiry and developing a good conceptual understanding of the subject taught. Though not trained to teach in this manner, she probably draws from the way she was taught by her teachers at tertiary level. However, even though she adopts a teacher/ student interaction strategy with the intentions that her students gain the conceptual understanding of chemistry (Trigwell and Prosser, 1996) yet her approach represents teaching as a mere transaction of knowledge and not being truly student-focussed as suggested by the constructivist view of teaching and learning (Boz&Uzuntiryaki, 2006)

Nevertheless, this case study provides valuable insights into the teacher conceptions of teaching and learning in chemistry at the tertiary level.

CONFLICT OF INTEREST: None

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