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PROSPECTIVE CHEMISTRY TEACHERS' EXPERIENCES OF LEARNING DIFFICULTIES AT THE UNDERGRADUATE COURSE

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Abstract

Chemistry is one of the science subjects, students are taught at Undergraduate level in teacher education institutes to prepare them for prospective teaching chemistry in schools. The focus during the internship is on diagnosing, planning, and teaching science. The tremendous increase in students' failure is seen in examinations conducted by university. One of the most important factors, which prevent students' meaningful and permanent learning, is the non-seriousness during the teaching learning process in the classroom and during practical sessions. The purpose of this research is to identify and analyse learning difficulties in Chemistry of prospective teachers in National Level Teacher Education Institutes including RIEs and suggest remedial measures for overcoming the identified difficulties. The prospective chemistry teachers enrolled in four-year integrated teacher education programme were selected by intensity sampling. A systematic and elaborate instructional session, questioning approach, were employed to detect misconceptions. The results indicated that these prospective teachers have certain misconceptions in various concepts related to basic chemistry concept Atomic structure at undergraduate level. The findings of this study concluded that chemistry teaching practice needs regular and smooth learning for the prospective teachers in their development as a teacher.

Keywords: Internship, Chemistry Concepts, Undergraduate level

1. Introduction

At the undergraduate (UG) level of learning stage where students initiate to engaging themselves seriously in the role of teacher, they play a significant role in understanding the

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subject; concept maps can improve understanding of chemical concepts, help building connections among abstract concepts and work as a misconception correcting tool. (Gahr, 2003). An educational institution performs a major role in providing learning experiences to lead their students from the darkness of ignorance to the light of knowledge (Nieuwenhuis, 2012). Teachers are the key people to play an important role to bring about transformation are teachers. The National Council of Teacher Education (NCTE-1998) emphasizes the role of teachers in improving quality concerns in Teacher Education Institutions. How much of the subject has been really understood by the student? Has effective teaching– learning process really brought out by them? These are questions which must be ask by an individual. The quality of prospective teachers is very important and it influences students' learning, their achievement and their decision to pursue further study in the sciences and vertical modalities. The study conducted in this area suggests that many students find science difficult in particular, physical sciences like chemistry and physics (Pfundt & Duit 1994, 1997, 2000). Many students are doing a given subject, say chemistry, not by choice but because it is a required part of a program or other major (Dalgety 2003). Such students studying chemistry generally with low self-efficacy towards it i.e., they are not confident about their own ability in studying the chemistry.

Chemistry is small in its unitary philosophy, but centrally it has been considered as large discipline that is ever expanding into biology and materials science. It plays a significant role in academia, industry, and public life. Chemistry is a subject involving fundamental scientific knowledge, reasoning skills, abstract concepts, and problem-solving calculations. Furthermore, the student is required to make the transition between macro and micro levels of matter, since the subject includes the study of interactions between indescribably small particles of nature, which cannot be envisaged or measured by simple physical means. Chemistry is one of the prerequisite subjects for the study of engineering, technological, medical, biological and other applied science courses in the colleges (Mahajan 2005; Nakhlehz 2002). By not fully and appropriately understanding fundamental concepts, many students have trouble understanding the more advanced concepts that build upon these fundamental concepts (Reid 2007).

2. Rationale of the Study

Chemistry studies at university level are difficult in the sense that the subject is complex and based on advanced theories and intense research. At the same time, there is consensus that it should be possible to find ways of better supporting students' first steps into the chemistry discipline. A central question for the field of chemistry education, therefore, is to develop our knowledge of how to enhance teaching so as to better support students' learning of chemistry and make their undergraduate studies more intelligible and meaningful by knowing the difficulties in various topics/concepts of chemistry. In summary, we can say that the students going to practice teaching in the final year of their course need a conceptual understanding of the subject and it can be assumed that many first- second year students of chemistry at the university along with a need to develop human capital for Science and technology in the region necessitates a deeper understanding of the educational challenges facing these student cohorts. This study thus sought to investigate learning difficulties for entrant level chemistry students in this complex, multicultural, tertiary educational context. The knowledge about the different procedures, principal of theoretical concepts is somehow, difficulties for their learning would contribute to improve this kind of classes. In this work, we focused on the analysis of those procedures that allow the understanding of the learning difficulties that appear in the understanding of the concepts of chemistry at university level. This work could provide strategies to improve those practices. If we attempt to imitate scientific work, the concepts of chemistry should provide opportunities to make meaningful learning, because science enterprise is much more that following a recipe book or using a certain technique. Chemistry is one of the science subjects, students are taught in Undergraduate level in teacher education institutes to prepare them for prospective teaching chemistry in schools and if not properly handled affects their performances at the national level. The focus during the internship is on diagnosing, planning, and teaching science. According to the National Policy on Education Chemistry education should be emphasized in the tertiary institutes in terms of teaching and learning, because Chemistry as an academic discipline plays a vital role in unifying other science subjects. But the problem is that students fail in chemistry at alarming rates at undergraduate level for years now. The tremendous increase in students' failure is seen in examinations conducted by university. One of the most important factors, which prevent students' meaningful and permanent learning, is the non-seriousness during teaching learning process in the classroom and during practical sessions. The purpose of this research is to identify and analyse learning difficulties in Chemistry of prospective teachers in Teacher Education Institutes including DESM Regional Institute of Education located at different centres in the country and suggest remedial measures for overcoming the identified difficulties with the following objectives:

- To study content related learning difficulties in the concept of Atomic Structure among four-year B.Sc. B.Ed. Prospective teachers.
- To study the difficulties experienced by prospective teachers in correlating the concepts associated with Atomic structure.

3. Methodology and Research Design

3.1. Setting and participants

The M.D.S. University, Ajmer hereby institutes the following ordinances under the scheme governing admission, course of study, examination and other matters relating to the degree of B.Sc. B. Ed programme under the Faculty of Education. The first-year course comprises two papers namely CC 2 (I) - Paper I- Inorganic Chemistry and CC 2 (II) - Paper II Physical

Chemistry. Participants in this course are Bachelor of Science students in their first year. They have had other previous courses at senior secondary level on this topic chemistry and have no internship experience.

In the study, the data were collected from 80 prospective teachers from the first year of the institute. Moreover, the items were developed by considering the objectives of the study. As stated, the topics were selected from the criteria adopted in the workshop considering the previous year experiences felt by the faculty members of the Institute as well as other reputed organizations working for higher education in the field of Chemistry. The present paper describes the results of atomic structures.

3.2. Design of the study

The research design is a descriptive one. This is because the study aimed at collecting and presenting information obtained from the students' responses to the questionnaire/item distributed to them to fill and write the response in the blank space provided to them for each item. It is also an ex-post facto research as the researcher took into consideration the influence of independent variables such as stream Physics, Chemistry and Mathematics (PCM) and Chemistry, Botany and Zoology (CBZ) on the chemistry topics perceived as difficult as this cannot be manipulated. The researcher considered two groups in this study: PCM and CBZ. This particular cycle of the study investigated the fundamental conceptual chemistry knowledge of all students registered in first and second year of B.Sc. B.Ed programme of the institute. The research study was carried out on theoretical concepts, principals, mechanisms involved in Chemistry classes at undergraduate level. The study was carried out in a selected sample of prospective teachers of the Institute. The data were collected by conducting a test by the investigators and faculty members of the Institute. A questionnaire/test consisting of 45 questions from the current syllabi of B.Sc. B.Ed first year and second year separately for each year.

3.3. Data collection tools

One set for first year prospective teachers in the form of Questionnaire/test structured questions were developed in the Institute by the Faculty members from the institute as well as from outside institutes. Two workshops, one for five days and another for three days, were organized to develop and finalize the questionnaire. In the first workshop the topics were chosen on the basis of experiences gained by the faculty members while teaching and detailed discussion was held for the same. Then each faculty member were asked to develop the items as assigned on the topic and the same was presented before the committee members for finalization.

This tool comprises tests from the field of chemistry and having items such as multiple choice with one or more correct answer, match the column questions, assertion and reason type questions and fill in the blank/one-word questions. All the questions were designed in such a way that students got the opportunity to give the reason for the opted answer (maximum 25 words) in each question. The items comprise from the concept related to Atomic Structure including fundamentals.

The questionnaire was designed to study the students' difficulties in Learning Chemistry among institutes' students of classes' first year studying B.Sc.B.Ed. Programme of the Institute. The questionnaire was designed in such a way that each part of the prescribed syllabus covered, and the topics were chosen by a core group of resource persons. The questions were designed, comprising basic concepts of chemistry for first year students.

3.4. Data analysis and interpretation

The data were analysed to address the two purposes of the study. The present research study deals with two objectives: first to study content related learning difficulties in the concept of Atomic Structure among four-year B.Sc. B.Ed. Prospective teachers and to study the difficulties experienced by prospective teachers in correlating the concepts associated with atomic structure connecting to other important concepts of chemistry. The analysis of the data is done qualitatively as well as quantitatively wherever needed.

Here we are discussing the results for the concept of atomic structure only. For the development of effective teaching strategies, it is important to know what difficulties students have with the concept of Atomic structure. Therefore, this section gives an overview of findings for the first question of the study: "What learning difficulties do lower undergraduate level students encounter while being taught the concept related to atomic structure?" To answer this question, the selected questions were all framed for difficulties concerning the topics. The concept of atomic structure in this study is divided into sub-concepts namely Schrödinger equation, radial probability density, radial probability distribution, angular node and allowed energy levels for Schrödinger equation. This concept includes several sub concepts and comprises total 06 questions and their responses are given in the below table.

Table 1. Item wise responses for atomic structure

Topic: Atomic Structure	PCM		Sub Total	CBZ		Sub Total	Total
Item (1-6)	M(16)	F (23)	39	M(7)	F (34)	41	80
Item 1	8	13	21	1	14	15	36
Item 2	9	16	25	4	22	26	51
Item 3	6	6	12	2	7	9	21
Item 4	2	1	3	1	1	2	5
Item 5	6	5	11	2	13	15	26
Item 6	2	8	10	1	9	10	20

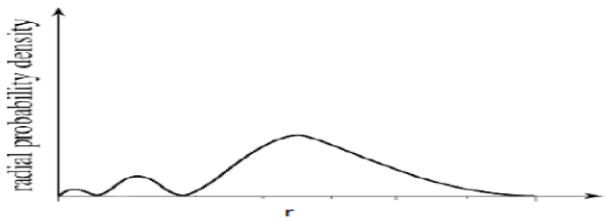
Based on understanding of the concept, analysis has been divided into two groups: (i) students responded correctly with proper explanation and (ii) students responded wrongly and explained accordingly. The following section describes students learning difficulties related to the understanding of atomic structure in general and Schrödinger wave equation, significance of Ψ and Ψ2, radial and angular wave functions and probability distribution curves in specific. The misconceptions were Identified and categorized according to student of Response Index (CRI) method (Hasan 1999). CRI has 6 levels of choice to determine the degree of certainty of students (degree of certainty. a) if the answer is guessed (totally guess answer), b) if the answer is almost guessed (almost guess answer), c) if the answer is doubtful (not sure), d) if the answer is sure, e) if the answer is almost certain (almost certain), and f) if the answer is certain.

- ❖ The first item was deliberately asked for wave function

1.	In quantum mechanics, a physically acceptable wave function (solution to the Schrodinger equation) must be: -	Responses percentage (Correct Answer Showed in Bold)
	(a)Discontinuous	20%
	(b) Imaginary	15%
	(c) Single valued	45%
	(d) infinite	20%

These aspects were considered on the basis of choice opted by the students for particular items. The incorrect responses after analysing it was found that students' having certain misconceptions regarding understanding of Atomic structure at a certain level and minutely it was analysing each of the items mentioned under Atomic structure. The rest of the sample i.e. 55% pupil teachers chosen the option either a, b & d which were further analysed and found that 36.36% students select the option 1 i.e. discontinuous which was supported by answer based on Schrödinger equation, concept of nodes, degenerate waves concept of photon and having a perception relates to misconceptions. The second option i.e. imaginary was also opted by 13.63% of the sample and mainly responded towards quantum mechanics. Students with the perception of Quantum mechanics have a balanced perception ability between Quantum and physical nature of wave function. At this level we can say that more than 50% of the students having certain misconceptions about the understanding of the concept of wave function.

❖ The next item was related to radial probable density concepts.

2.	The plot of radial probability density (4πr2R2) against r for an electron in np orbital is given below. The value of n is- 	Responses percentage (Correct Answer Showed in Bold)
	(a) 2	11.25
	(b) 3	63.75
	(c) 4	10
	(d) 5	15

Although 63.75 % of the students responded correctly but the remaining 36.25% of the sample including PCM and CBZ group having certain misconception and learning difficulties in understanding of graph as well the radial probability concept. 17.24% of the sample clearly indicates that the radial probability is linked with azimuthul quantum number and it is also related to the density, these students understand concepts partially or not intact. This partial understanding that causes students to work on problems in accordance with the concepts they understand.

❖ The third item was related to radial probability distribution curve and radial nodes

3.	The radial probability distribution curve obtained for an orbital wave function (Ψ) has 3 peaks and 2 radial nodes. The valence electron of which one of the following metals does this wave function (Ψ) correspond to-	Responses percentage (Correct Answer Showed in Bold)
	(a) Cu	23.75
	(b) Li	21.25
	(c) K	28.75
	(d) Na	26.25

The correct responses were obtained only for 26.25 % of the students. However, 23.75% of the samples connect this with equal to number of valence electron. 21.25% of the sample stated that potassium having higher reactivity hence it has 3 peaks and 2 nodes. The result reveals that there a need of understanding of radial distribution and its application in relation to valence electron should be given emphasis during regular teaching process in classrooms. The data also suggested that Radial distribution curve gives an idea about the electron density at a radial distance from the nucleus should be made understanding among students and the idea that every curve in a radial distribution plot should have an integrated area equal to one should be cleared among students. The idea about the position of the principal (i.e., largest) maximum depends on n and l should be discussed in the details.

- The fourth item discussed the concept of Schrodinger equation and its relation to the existence of d orbitals.

4.	According to Schrodinger wave equation allowed d-orbitals are-	Responses percentage (Correct Answer Showed in Bold)
	(a) 3	18.75
	(b) 5	35
	(c) 6	6.25
	(d) 10	40

Around 93.75% of the sample responded wrongly. They chose the wrong option and correlated the number of allowed d orbitals according to electron distribution in the orbitals. Most of them chose second option which indicates 5 and some of the students also chosen 10. However, the concept behind the fifth and final d-orbital consists of three regions of high probability density: a torus with two pear-shaped regions placed symmetrically on its z axis was not explained by any one of student. One feature of d orbitals that no one notices is the odd shape of the dz^2 orbital relative to the other 4 orbitals. Why is it that the d_{xy}, d_{xz}, d_{yz}, and dx^2-y^2 orbitals all have 4 lobes while the dz^2 orbital consists of two lobes with a torus about the centre? The answer lies in a mathematical curiosity. When the Schrödinger equation for l= 3 is solved, one obtains 10 solutions, not 9. Physical reality allows only five orbitals, so the dz^2 orbital is a result of the “averaging” of two of the solutions.

- The fifth item was framed on the understanding about angular node of 2pz orbital

5.	The angular node of 2pz orbital is located at-	Responses percentage (Correct Answer Showed in Bold)
	(a) n = 2	17.5
	(b) between n = 2 and n = 3	22.5
	(c) between n = 1 and n = 2	22.5
	(d) nucleus	32.5

About 22.5 % of the sample responded that the option indicated that the node of 2pz is located as n=2 as relates with principal quantum number means not able to understand the concept of nodes and its location. 22.5% of the sample responded that node is present between n=2 to 3 it seems that these students do not have an idea about the concept behind location of the orbital and its implications. This entire group of students do not have the idea that as the angular momentum of the electron increases, the density distribution becomes increasingly concentrated along an axis or in a plane in space. Only electrons in s orbitals with zero angular momentum give spherical density distributions and in addition place charge density at the position of the nucleus.

- The sixth item was framed to know the concept of energy levels. This question was related to the understanding about implications of Schrödinger equation for allowed energy levels.

6.	For E= 1 eV the allowed energy levels from the Schrodinger equation is / are-	Responses percentage (Correct Answer Showed in Bold)
	(a) 0	25
	(b) 1	21.25
	(c) 2	26.25
	(d) 3	27.5

Although the huge number of students i.e. 75% responded the opted the wrong option showed that this part of the topic should be cleared before entering to next or higher level. Around 53.33% of the students’ responses show misconceptions about understanding the concept at all.

If we see the analysis about all the items for atomic structure, we can conclude that the concept and sub concept related to the topic having certain misconceptions and needed proper explanation. The percentage of students' misconceptions on atomic structure and sub conceptions was 63%, 43% on sub concepts, 45% orbital sub concepts, and 76% Schrödinger equation.

4. Results and Conclusion

In this study, the students’ understandings of the concept of atoms were analyzed. The study exposed that the concept of the orbit from the Bohr atomic model has an impact on the students’ learning of the other atomic models. Specifically, the Bohr atomic model has an adverse effect on learning the electron cloud model. Preliminary analyses showed that there are significant students’ misconceptions regarding the characteristics of the atom such as identity and properties. Although PCM students’ performance was significantly higher compared to the CBZ students’ misconceptions were also present to a significant degree. The difficulty here may be that students have difficulty believing in something they cannot see. The student must “overcome immediate perceptions which lead him to a continuous static view of the structure of matter. There is ample evidence that the particle model is difficult for students to grasp, and, whether it is introduced early or later, there is no doubt that it must be fully mastered at this level for students to be fully successful in chemistry.

The results showed that students have some misconceptions about the understanding of the concept of atomic structure. The results clearly indicated that the basic concepts about atomic structure are hardly understood by some students that participated in this study, though all have been familiar with these concepts since classes at chemistry in their classes for years. Some students have difficulty in explaining how the Bohr model has an implication in understanding the structure of atoms. In light of these results, it should be said that teachers should be supported with professional development. These misconceptions were handled and reduced or altered in significant ways over the course of four years of study. Thus, it would appear that the concurrent teacher education programmes at the Regional Institute of Education are successful in addressing learners’ misconceptions and deepening their understanding of chemistry concepts related to fundamentals of chemistry. Pre-service teachers that studied higher level chemistry and mathematics for the Leaving Certificate were found to hold fewer misconceptions than their peers and they also utilized these concepts during internship programmes.

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