A CRITICAL REFLECTION ON THE SEQUENCING OF CONTENT RELATED TO THE CONCEPT OF ION IN NCERT CLASS IX SCIENCE TEXTBOOK

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Curricular textbooks prescribed by the respective boards, metaphorically, form the content Bible both for the teacher and the learner working at the grass root level. Teachers look up to the curricular textbooks as the guiding resource for the amount of content to be covered, the various subtopics and related topics to be dealt with and with prescribed extent of detailing. The present paper brings forth critical reflections of a TGT Chemistry teacher, teaching in a CBSE affiliated private school of Delhi since the past 13 years, who over years of teaching has been struggling with the sequencing of the content related to the concept of ion, mentioned in the NCERT textbook. The present paper is based on 'Action research' by the teacher to find out the most logical sequencing of the subtopics related to the content, which promotes conceptual understanding and discourages rote learning in the topic, which otherwise becomes a textbook compulsion. The paper presents alternative sequencing of content, which if suggestively changed in the NCERT Class IX Science textbook, then it will better portray the conceptual underpinnings of the content related to ion in a more transactionally and conceptually effective way.

Keywords: Concept of ion, NCERT Class IX Science textbook, content sequencing and action research.

Introduction

Class IX forms the major transitional class, wherein the journey from concrete towards the abstract finer concepts becomes more profound and transactional. Central Board of Secondary Education (CBSE) forms a major affiliation and recognition board across our country and NCERT (National Council for Educational Research and Training), forms the apex body which provides curricular textbooks as content guidelines for all the stakeholders.

Both teachers and students, consider the textbook as the ideal resource and method for addressing a concept, understanding it and unfolding it in the vaster conceptual database. One of the good attributes of a textbook is that it should be a self-read, i.e., learners should be able to read and understand the concepts themselves, through the flowing content of the textbook. This faces a major challenge, if the textbook do not have conceptual continuity and has scattered arrangements of concepts, which breaks the conceptual inter linkage and leaves the learner profoundly scattered is their understanding. Herein, the role of the teacher comes in, who understands the conceptual breakage and through their professional training and experiential wisdom, chooses an alternative path of sequencing for understanding, unfolding of the concepts in an evolutionary basis which is best suited according to logical comprehension and credibility. The present research paper

is a reflective note arising out of 'Action Research' on the best possible sequencing of content spiralling around the evolutionary understanding of the concept of ion formation and its applications.

Review of Related Literature

To come to an informed understanding of the topic addressed in the article, diverse published research articles served as a basis for evolutionary discourse of this research article. Some of the pertinent research articles referred to and their contribution towards developing a firm literary foundation for the present paper are presented in the given section.

Akalamkam (2013), gives a study that includes data collected by over 100 teachers and from 400 students regarding the sequencing of content in the subject physics. The study basically analyses the curriculum in the form of the content transacted as an intention and then compare it with the real output in terms of objectives and learning outcomes achieved. The study presents a reflective journey of a teacher through the theoretical domains to the ground realities of implementing the theory in the classroom scenario. This is further supplemented by Bansal (2014), who has presented a comparative analysis of NCERT and Eklavya science textbook to bring forth their apparent competitiveness in instilling and promoting scientific attitude in the learners. Through means of content presented in the textbook how the virtues of enquiry, eagerness, curiosity and scientific aptitude can be inculcated, are introspected in the text. It presents a reflective account of quality parameters expected out of theory and practice which is an inevitable framework for the present study.

Ebenezer *et al.* (2010), studies the significance of construction of common knowledge through a defined sequence of content in the chapters and analyses its effects on the extent of scorability in evaluation tests. It further studies how building of common knowledge goes through an apparent conceptual progress especially in context of scientific principles and inculcation of scientific attitude. This is very instrumental in the present research as it elaborates on the significance of conceptual building through textbook conceptual evolution. To supplement this study, de Posada (1999), provides a comprehensive analysis of Spanish science textbooks over their explanation of metallic bond structure. The study realised that the explanation of models was very metaphorical and prone to misinterpretation, which is not a good feature of a textbook content design. It also aimed to understand the role of the teacher in this apparent Spanish science revolution. The book is a theoretical insight into new reflective domains of new age progressive teacher, which finds common rootings with our present study.

Kulak and Newton (2014), have presented a study highlighting how learners studying biochemistry adopt a surficial understanding of the concepts and adopt the method of rote memorisation, rather than dwelling deep into the understanding of the subject matter. This further leads to lesser retention of the topic in the long run, further emphasising on the structuring of content in such a way as to promote constructive understanding rather than rote learning. This is one of the crucial link study for present research which emphasises on enhancing constructivism

in the science classroom through the tool of textbook. To add on, Kumar and Chauhan (2021) has elaborated on the relevance of topic wise question pool made readily available to the children via automated techniques, which helps in better understanding and comprehension of the subject matter. The sequencing of the content and its correlation with the question answers has been inquisitively addressed in this research article which supplements the present premise.

Leder and Leder (2018) has presented research work which premises itself on the analysis of the textbook content especially in the subject geography to attain the principles of education for sustainable development. It comes to the vicinity of textbook analysis, wherein it specifically studies how the content related to water aims at equally enforcing the principles of sustainable development. The study concludes with the assertion that major part of the textbook content involves memorisation and less of skill development. This brings an indirect yet universal reflection on the concept of sustainability, which is beyond disciplinary boundaries. It helps us to link the present study in the broader multidisciplinary perspective. While focussing on strengthening of constructivist strategy in the science classroom, Novak, Mintzes and Wandersee (2005), elaborated on the reasons behind learners adopting rote learning. They also discussed methods of how and when children correlated the concepts applied with their previous existing knowledge, which forms the base of theoretical principle for the present study.

The above-mentioned articles gave a broader perspective to the researcher to carefully weave in the spiral of this research article, which progresses with the next segment.

Current Sequencing of Topics Related to Concept of Ion in Class IX Science Textbook of NCERT—Conceptual Gaps

This research article will take the new science NCERT Textbook, published with rationalised syllabus 2023–24 as the standard reference. The previous publications of NCERT can also be studied as the sequence of the topics related to ions remains the same in the previous and the new publication, so the points of reflection described in the article are valid for both previous as well as new publication (2023–24). The rationalisation of syllabus has been done in accordance with the National Education Policy, 2020 vision of reducing the syllabus, so as to concentrate less on the vast syllabus covered on more on skill development activities, which the much needed aim and objective for contemporary education. However, this article revolves around one more important facet of NEP 2020 which aims to eliminate or at least discourage 'rote learning' to the best possible extent. This article reflects on how the present sequence of content around 'ion and its formation' promotes rote learning and if just the sequence be changed, then it may beautifully interweave the concepts involved and take away any need of rote learning and of course, make the topic much more conceptually interesting and convincing to the learners.

Chapter 3 (Atoms and Molecules), initiates with the chemical laws that govern the combination of particles in nature and then progresses towards the different particles namely atoms, molecules and ions. Atomic chemistry firstly forays into the domains

of symbols and then the concept of atomic mass. The concept of molecule is further explained in the arena of first elements and then compounds. Now, begins the story of the ion. This firstly gives in a basic definition and then mentions the type of ions. This comes in the arena of rote learning, rather a topic without any conceptual foundation as the concept of charged particles in atoms is not yet described in the textbook and would rather make way in the fourth chapter.

Chapter 4 (Structure of Atom), initiates with the concept of electron, proton and further leads to neutron after discussing the models regarding the basic structure of atom. An explanation about the concept of ion, reason for charge to come on it, without having any background about the presence of charged particles in matter is a conceptual flaw. If we have to move as per the sequence in the textbook, then the topic lies in the arena of 'rote learning' only, in which, we ask students to memorise as of now, that there are some types of particles which have charge and they can be classified into positive and negative but how it is formed, why it is formed is left for a later story that will unfold in the next chapter. To further, continue on the path of rote learning 'the concept of writing chemical formulae' follow pursues. The book gives a table mentioning the different ions and their symbolic representation, all of which has to be learnt, without any explanation to the child why sodium is Na^+ and not Na^- or Na^{2+} or Na^{2-}, why some ions are positive and others are negative, why number on charge for different ions is similar and variable for others, are the basic unanswered, unaddressed questions, left for later on, paving the road for 'rote learning' in present chapter. The topic further ventures into the concept of valency whose definition has to be learnt and values for the different ions has to be memorised. Rote learning at this particular stage becomes necessary as the next topic that follows is 'writing of chemical formulae of ionic compounds' which follows a three step procedure—we write the symbols first, then the valency or charge and finally we criss-cross the valencies to obtain the final chemical formula. The whole series of questions based on calculation of molecular mass, formula unit mass and ratio by mass of the combining elements in a compound, can be solved only when we first ascertain the chemical formula of the compound and yes without dwelling into the reason of a particular ion formation, the chapter dwells on 'rote learning' of the concept to write chemical formulae.

It is not that the answers to the above-raised questions are not explained in the textbook, but the same is done in the successive chapter which leaves the above-mentioned topics related to ion and ionic compounds majorly in the rote learning domain.

The successive Chapter 4 (Structure of Atom), also has a certain sequence of content which apparently suffers from conceptual discontinuity. After the topic of neutrons, they initiate with the rules for filling of electrons in different shell. This topic firstly should initiate with the total number of electrons or protons present in an atom, which should be covered under the heading of 'Atomic Number' but the definition and explanation of the same is actually mentioned in the end after the entire table of elements showing electrons filled in different shells is given. The same topic describes electronic configuration of noble gases and addresses questions of why an atom loses or gains electrons and how, and why it converts into an ion.

The conceptual sequence as observed in Chapter 3 (Atoms and Molecules) of Class IX Science NCERT Textbook can be illustrated in the form of following flow chart (Fig. 1).

The conceptual sequence as observed in chapter 4 (Structure of Atom) of Class IX science NCERT Textbook can be illustrated as shown in Fig. 2.

Through the tools of 'action research' and 'reflective teaching' with Class IX students of a CBSE recognised private school in Delhi, with over a decade of transactional experience on the topic, the researcher, also, a chemistry teacher for secondary classes, found that by just changing the sequence of topics around ionic chemistry mentioned in Chapter 3 (Atoms and Molecules) and Chapter 4 (Structure of Atom) of the textbook, the topic can be addressed in a much more scientific and logical way.

Suggested Alternate Sequencing of Topics

The present section is a culmination of reflective analysis and tested pedagogical sequence (over a decade) in the Class IX classroom of a CBSE recognised private school in Delhi, whose sole aim is to suggest

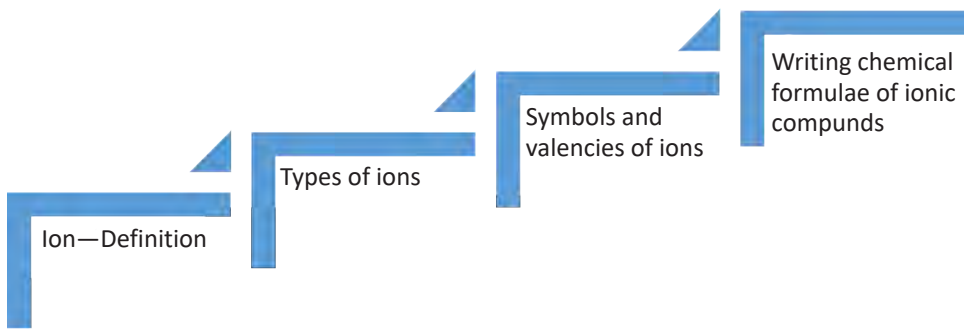

Fig. 1. Illustration of Apparent Conceptual Sequencing of Topics Related to Ion in 'Chapter 3: Atoms and Molecules' of Class IX NCERT Science Textbook (Fig. 2)

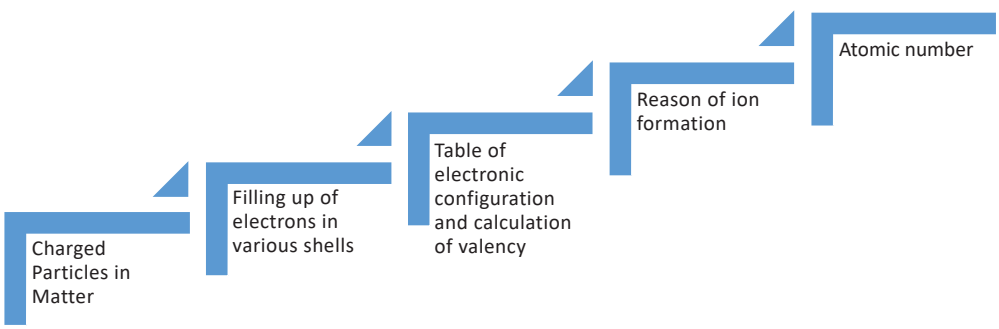

Fig. 2. Illustration of Apparent Conceptual Sequencing of Topics Related to Ion in 'Chapter 4: Structure of Atom' of Class IX NCERT Science Textbook

a change in the sequencing of the subtopics related to understanding of the concept of ion and ionic compounds, so as to have the evolutionary content in the textbook on lines of conceptual understanding and not rote memorisation.

In Chapter 3 after the basic explanation about atoms and molecules, before the initiation of concept of ion, it is inevitable to explain about the charged particles in matter, namely, electrons, protons and neutrons. So, the entire explanation regarding the discovery and properties of subatomic particles should be given first. Then, the description regarding basic structure of atom should continue, first with initiation to the concept of 'Atomic number' then unfolding the steps of filling up of electrons in various shells, further exploring the domains of stability of an atom and the need to form an ion. This will lead to an inevitable calculation regarding valency or charge on an ion. Calculation of valency in secondary science classes and oxidation numbers for higher secondary science will inevitably come in the domain of logical reasoning calculation as against an absolute number without charge to be memorised.

Once the above is established, it will be very theoretically spontaneously easy for the students to understand what an ion is, what are its two types, why the valency of a particular ion is a specified number and not the other? This further now, can be extended to the topic of writing chemical formulae, which now needs no rote memorisation as the child is able to calculate both charge and valency of the ion on his own through detailed reasoning and logic. The suggested sequential path of content in this direction can be illustrated as follows (Fig. 3):

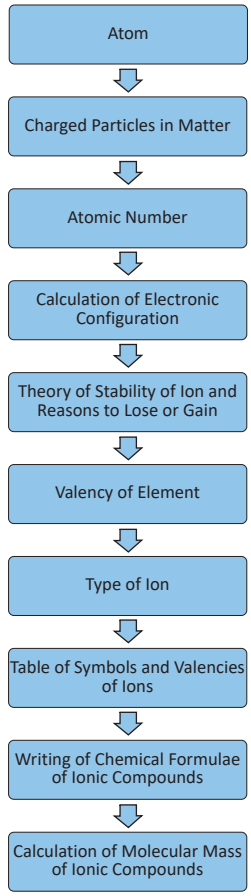

Fig. 3. Illustration of Suggested Evolutionary Sequential Path Related to Pedagogical Content Development Revolving Around the Concept of Ion

Following of a reasoning based pedagogical approach not only paves the way towards promotion of scientific enquiry and skills but also creates a vibrant pedagogical environment in which the cognitive domains are stimulated and a true 'Child Participatory' classroom is created on the guiding principles of NEP 2020. If the textbook content can be arranged to promote conceptual understanding and discourage rote learning, then the textbooks will be

empowered tools and guiding forces for the creation of a new education era envisaged by NEP 2020.

Conclusion

NEP 2020 has established in high ordeals of being part of a movement, wherein we move away from the era of darkness of rote learning to the era of enlightenment of conceptual understanding and reasoning. It is the era of teachers emerging as trained reflective practitioners who sincerely involve themselves in 'action research' in the classroom to critically reflect on the pedagogical tools available to them and how to improvise them further on true lines of 'Child Centred Learning'. This research paper reflects on the sequencing of content related to the concept of ion and ionic compounds as given in Class IX Science NCERT textbook and explains how the lack of reasoning about formation of ion and calculation of valency in Chapter 3 (Atoms and Molecules), majorly puts this topic in 'rote learning domain'. The paper suggests an alternative subtopic sequence, which is proven through pedagogical experiences and which if adopted will not necessitate rote learning for comprehension of the same. The suggested path evolves from the subatomic particles to description of atomic number, this continues towards writing of electronic configuration and ascertaining reasons for the stability of an atom. This now leads to the reasoning behind how and why an ion is formed, dwelling into the arena of charge and valency of the ion. The suggested modification hopefully will provide an easy guiding textbook for both teachers and learners, who will not have to struggle with the why and how of ionic chemistry in Chapter 3 and will not necessitate them to adopt rote learning for moving ahead with syllabus. It is pertinent to reinforce that the reflection done as part of this research paper is one of the pedagogical approaches to deal with the topic, as against the existing sequencing in the NCERT textbook that apparently follows another way of philosophical approach. However, the scope of this paper includes action research work to further establish the discussed comparison.

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