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A Study on the Influence of Text Presentation in Textbooks on Conceptual Change Learning among Higher Secondary Students

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A B S T R A C T

The present study was undertaken to study the influence of text presentation in biology textbooks on conceptual change learning with respect to learning of biological concepts. Content Analysis of manifest content related to concepts such as 'Magnification' and 'Resolution' presented under the section 'Microscopy' from two biology textbooks namely 'Biology Course Book for Advanced Subsidiary and Advanced Level' and 'Biology Textbook for Tamil Nadu Board of Higher Secondary Education' in relation to nature of text presentation. A total of 60 biology students from Grade 12 were randomly selected from a local school. They were divided into two groups namely Group A and Group B (each group comprising of 30 students each). Group A students were provided with manifest content extract the 'Biology Textbook for Tamil Nadu Board of Higher Secondary Education' whereas the Group B students were provided with manifest content extract from the 'Biology Course Book for Advanced Subsidiary and Advanced Level'. The Group A students were taught by 'Traditional Chalk and Talk Method' about Magnification and Resolution using Formula and Definitions. The Group B students were taught the same concepts by 'Inquiry Method' using Illustrations, Examples, Worked-out Numerical Problems and Activities. The learning in the two groups was analyzed using assessment tasks. The results of the study revealed that students from Group A were able to write only the basic definitions of magnification and resolution without appreciating the importance of Magnification and Resolution in Microscopy whereas students from Group B were able to write not only the basic definitions of magnification and resolution but also appreciated the importance of Magnification and Resolution in Microscopy by solving numerical problems related to magnification and by reasoning out the importance of resolution with respect to sizes of different cell organelles. The study recommends that textbook writers should ensure that for conceptual change to happen, the content of biology should not be presented as a mere body of knowledge instead it should provide opportunities for the learners to investigate think and interact with the society.

Keywords: Content Analysis; Conceptual Change; Chalk-and-Talk Method; Inquiry Method; Text Presentation.

1. Introduction

It is obvious that the entire realm of biological phenomena and biological processes revolve around the most fundamental, structural and functional unit of all living organisms namely "the cell" and that the branch of biology dealing with the study of cells is called 'Cell Biology'. This branch of biology is an integral component of biology syllabi of all school educational curricula. Several research studies have reported that primary and secondary school students have developed conceptual problems concerning 'Cell Biology' (Flores et al 2003, Lewis & Wood Robinson, 2000, Marbach-Ad and Stavy, 2000). According to Fernandez & Tejada (2018), it has been reported that during the learning of cells, students find the structural aspects of the cell to be more problematic followed by the functional aspects of the cell. Widespread learning difficulties concerning sizes, scales, magnification and resolution have also been reported (Fernandez & Tejada, 2018). A review of the empirical investigations that collected students' conceptions, before, during and after a specific learning-strategy and also after students had been taught following their respective national curricula (e.g., Hackling & Treagust, 1984; Dreyfus & Jungwirth, 1988, 1989; Zamorra & Guerra, 1993; Díaz de Bustamante & Jiménez Aleixandre, 1997; Lewis & Wood-Robinson, 2000; Marbach-Ad & Stavy, 2000; Flores et al., 2003) reveal many general and significant problems in learning cell biology namely (i) confusion about terms such as cell, cell wall, cell membrane, gene, chromosome, allele etc. (e.g., Díaz de Bustamante & Jiménez Aleixandre, 1999; Lewis & Wood-Robinson,

2000; Flores et al., 2003), (ii) problems in understanding the different levels of organisation of multi-cellular organisms (e.g., Schäfer, 1979; Hackling & Treagust, 1984; Dreyfus & Jungwirth, 1988, 1989; Zamorra & Guerra, 1993; Knippels, 2002; Verhoeff et al., 2008; Flores et al., 2003) (iii) problems in understanding cell processes such as mitosis or DNA replication (Lewis & Wood-Robinson, 2000; Marbach-Ad & Stavy, 2000) and (iv) use of an anthropomorphic view (Zamorra & Guerra, 1993; Dreyfus & Jungwirth, 1988, 1989; Flores et al., 2003). According to Atilla Cimer (2012), the aforementioned learning difficulties in biology are attributed to the nature of topics, teaching styles, study and learning habits of the learners towards the topics and lastly due to insufficiency of resources. Atilla Cimer (2012) is also of the opinion that in order to overcome learning-difficulties in biology and to make biology learning more effective, strategies such as teaching biology through visual materials, teaching biology through practical work, teaching biology through connecting the topics with daily life have been suggested. All these aforementioned strategies are basically instruction-based strategies. Apart from instruction-based strategies, can non-instruction based strategies help overcome learning difficulties in biology? Can textbooks be a part of the solution? This study aims to understand the role of textbooks on conceptual change learning. The study focused on the influence of text presentation on conceptual change learning with respect to learning of concepts such as 'Magnification' and 'Resolution' in Microscopy. The biology textbooks considered in this study are 'Biology Course Book for Advanced Subsidiary and Advanced Level' and 'Biology Textbook for Tamil Nadu Board of Higher Secondary Education'. Among these two textbooks, the former is followed in many schools internationally including India and the latter is followed in schools of Tamil Nadu only.

1.1 Theoretical Foundation

The whole processes of teaching and learning deals with conceptual change in the learner where restructuring of existing knowledge and beliefs happen. Conceptual change can defined as the process of building an existing conception to form a new explanation while retaining explanation of the original extant conception. In other words through conceptual change the new knowledge is constructed over the existing prior knowledge. The idea of conceptual change forms the basis of constructivism where the learners construct their own knowledge through their experiences received. The term 'conceptual change' was first introduced in Kuhn's (1962) notion of 'Paradigm Shift' and since then several theories on conceptual change like Posner et al's (1982) 'Conceptual Ecology Perspective', Chi's (1992) notion of 'Ontological Shift', Vosniadou's (1994) 'Framework theory of Conceptual Change' have been developed. According to the theory of conceptual change by Posner et al. (1982), scientific conceptions must be intelligible, plausible, and fruitful for successful conceptual change to occur. When learners are presented with new contradictory scientific ideas they revise their pre-instructional naïve theories (Chinn & Brewer, 1993; Vosniadou, 1994). Vosniadou (1994) views conceptual change as the process of restructuring personal theory through adding new information without changing the framework theory. Conceptual change is influenced by many factors such as culture and society (Moje & Shephardson, 1998; Vosaniadou, 1994), emotions (Gregoire, 2003), epistemological beliefs (Windschitl, 1995), motivation (Pintrich et al 1993), personal practices and beliefs (Chi, 2009) cognitive and developmental factors. Apart from these, textbooks also have an influence on conceptual change. Textbooks that deviate from the traditional textbook design and which follow conceptual-change textbook design bring about conceptual change (Mikkila Erdmann, 2002). Traditional textbook design present science as a series of related but fairly discrete topics (like plants, animals and cells) with a few or no connecting textual units between these different topics and that the coverage of many concepts are in-breadth instead of in-depth (Roth, 1990). Traditional textbook texts have also been criticized for their knowledge organization and lack of explanatory coherence (Beck et al., 1991). According to Mikkila Erdmann (2002) science textbooks are seen as an unexplored resource in promoting conceptual change. Therefore in this study the influence of text presentation in biology textbooks of two educational boards namely Cambridge International Advanced Subsidiary and Advanced Level and Tamil Nadu Board of Higher Secondary Education on conceptual change learning with respect to learning of concepts such as 'Magnification' and 'Resolution' in Microscopy was undertaken.

2. Methodology

Content Analysis of manifest content related to concepts such as 'Magnification' and 'Resolution' presented under the section 'Microscopy' from two biology textbooks namely 'Biology Course Book for Advanced Subsidiary and Advanced Level' and 'Biology Textbook for Tamil Nadu Board of Higher Secondary Education' in relation to nature of text presentation. A total of 60 biology students from Grade 12 were randomly selected from a local school. They were divided into two groups namely Group A and Group B (each group comprising of 30 students each) and the Group A students were provided with manifest content extract the 'Biology Textbook for Tamil Nadu Board of Higher Secondary Education' whereas the Group B students were provided with manifest content extract from the 'Biology Course Book for Advanced Subsidiary and Advanced Level'. The Group A students were taught by 'Traditional Chalk and Talk Method' about Magnification and Resolution using Formula and Definitions. The Group B students were taught the same concepts by 'Inquiry Method' using Illustrations, Examples, Worked-out Numerical Problems and Activities. The learning in the two groups was analyzed using assessment tasks as illustrated in the flow charts presented in Figures 1, 2 and 3.

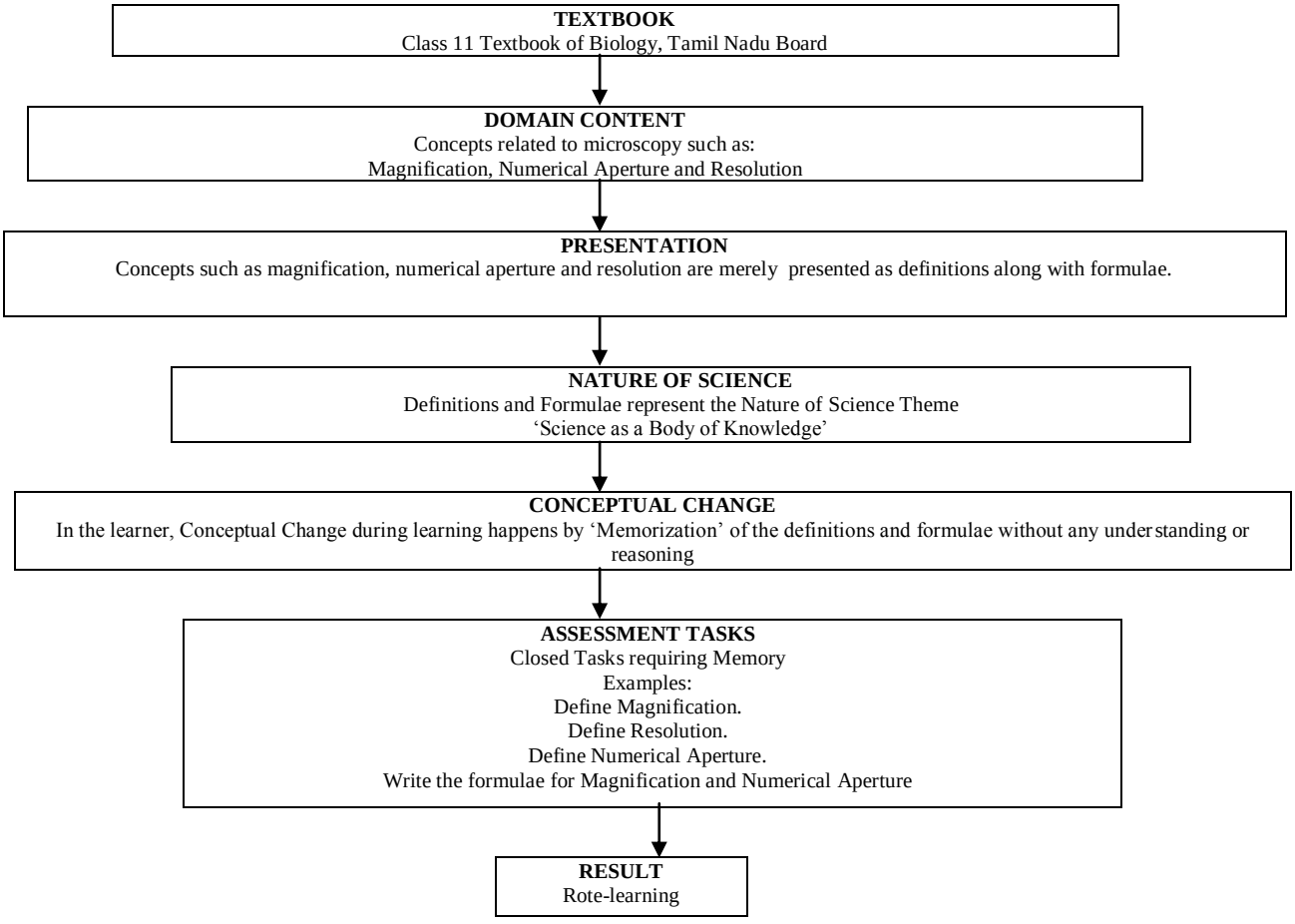


Figure 1: Empirical Evidence – 1 (Learning Situation 1)
Illustration of Conceptual Change in the learning of concepts like 'Resolution', 'Numerical Aperture' and 'Magnification' using TN Biology Textbook

Figure 2: Empirical Evidence – 2 (Learning Situation 2)
Illustration of Conceptual Change in the learning of the concept 'Magnification' using AS-A Level Biology Textbook

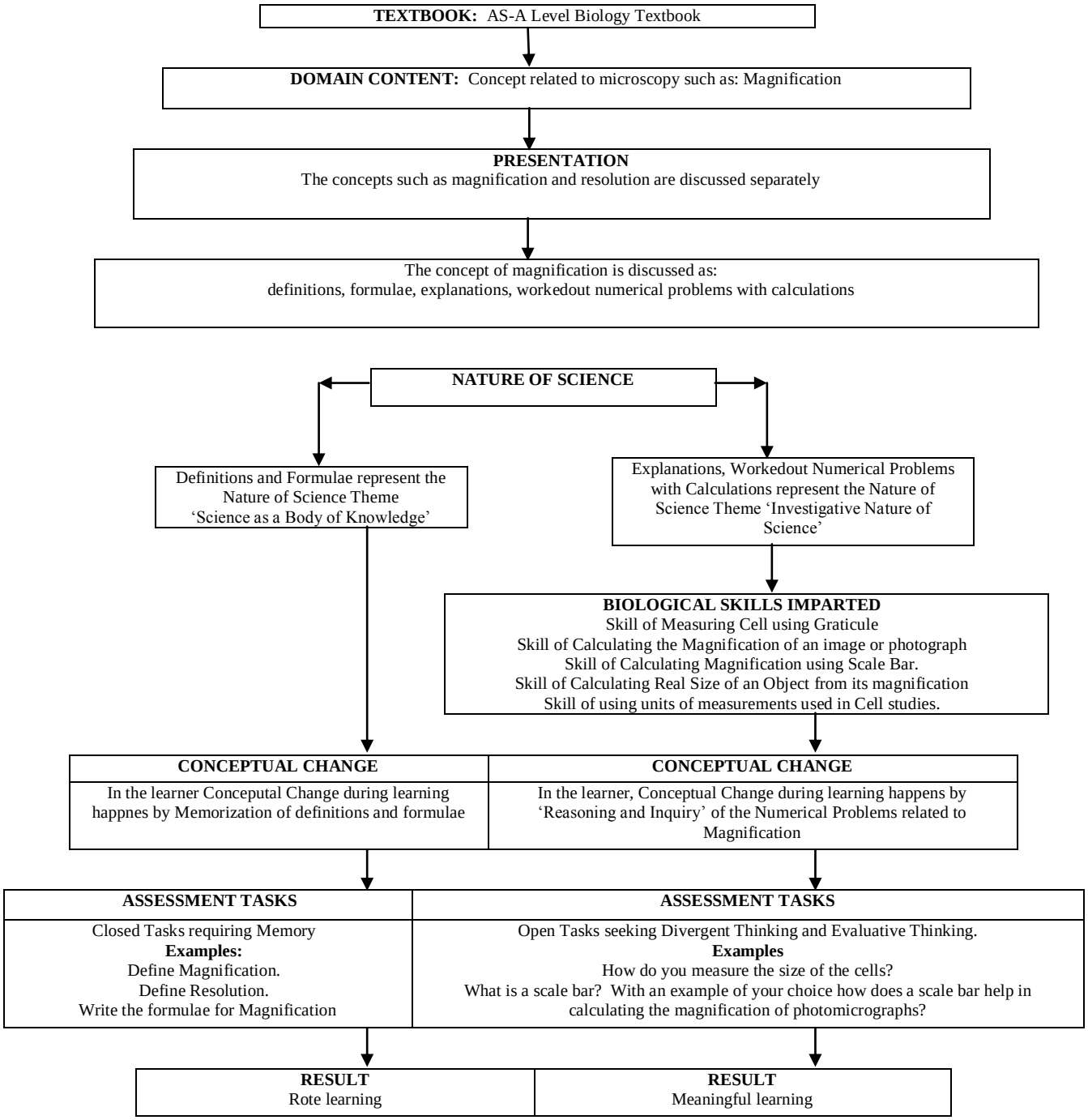


Figure 2 (continued)
Learning Situation 2: Learners' Naïve Knowledge and Gained Knowledge with respect to learning of the concept 'Magnification' from AS-A Level Biology Textbook

LEARNERS' NAIVE KNOWLEDGE

When the concept of Magnification is introduced to the class, the learners relate 'Magnification' to the word 'Magnify'.

They provide the meaning of the word 'Magnify'.

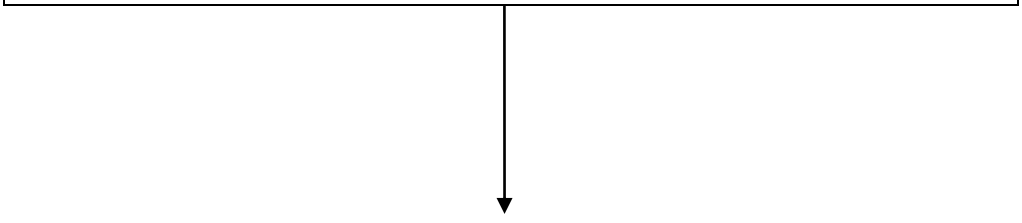
'(To) Magify' means 'To enlarge something' or 'To make something big'.

They also provide an example of Magnification:

During Photocopying or Xerox Copying we sometimes enlarge a portion of a page or a text

(Here Naïve Knowledge is influenced by everyday experiences with natural phenomenon and events.

Also the explanations provided by novices include scientifically non-formative explanations based on their daily experiences).



GAINED KNOWLEDGE

Definition of 'Magnification' and formula for magnification.

Skill of Measuring Cell using Graticule

Skill of Calculating the Magnification of an image or photograph

Skill of Calculating Magnification using Scale Bar.

Skill of Calculating Real Size of an Object from its magnification

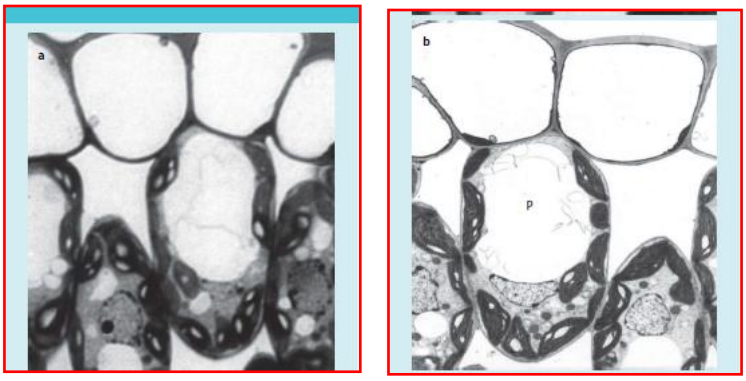
Skill of using units of measurements used in Cell studies.

Conceptual Change from the perspective of 'Knowledge-as-Elements'

In the above situation the naïve knowledge is a collection of quasi-independent knowledge elements. During conceptual change process, the elements and interactions between the elements are gradually revised and refined through addition, elimination and reorganization to strengthen the network. This clearly supports conceptual change from the perspective of 'Knowledge-as-Elements' who believe that all of the various elements in a student's conceptual network are subject to progressive knowledge construction (Ozdemir & Clark, 2007).

Figure 3: Empirical Evidence – 3 (Learning Situation 3)
Illustration of Conceptual Change in the learning of the concept 'Resolution' using AS-A Level Biology Textbook

1. The authors introduce the concept of Resolution by asking the readers to compare two micrographs of the same specimen at the same magnification but one observed under a Light Microscope and the other observed under Electron Microscope. Of the two micrographs the authors highlight that the micrograph observed under Electron Microscope is much clearer due to its high resolution.



A B

Figure 1.9 Photographs of the same types of plant cells seen **a** with a light microscope, **b** with an electron microscope, both shown at a magnification of about ×750.

2. After this explanation, the authors provide the definition of Resolution.
3. The maximum resolution of a light microscope is also provided.
4. The effect of magnification can be felt only up to the limit of resolution and beyond the limit of resolution any further magnification leads to blurring is well explained. All these concepts are well highlighted.
5. The concept of resolution is also well linked with the Nature of Light.
6. The reason why mitochondria are seen under light microscope whereas ribosomes are not visible is well reasoned by the authors: 'the limit of resolution is one half of the wavelength of light used'.

Figure 3 (continued)

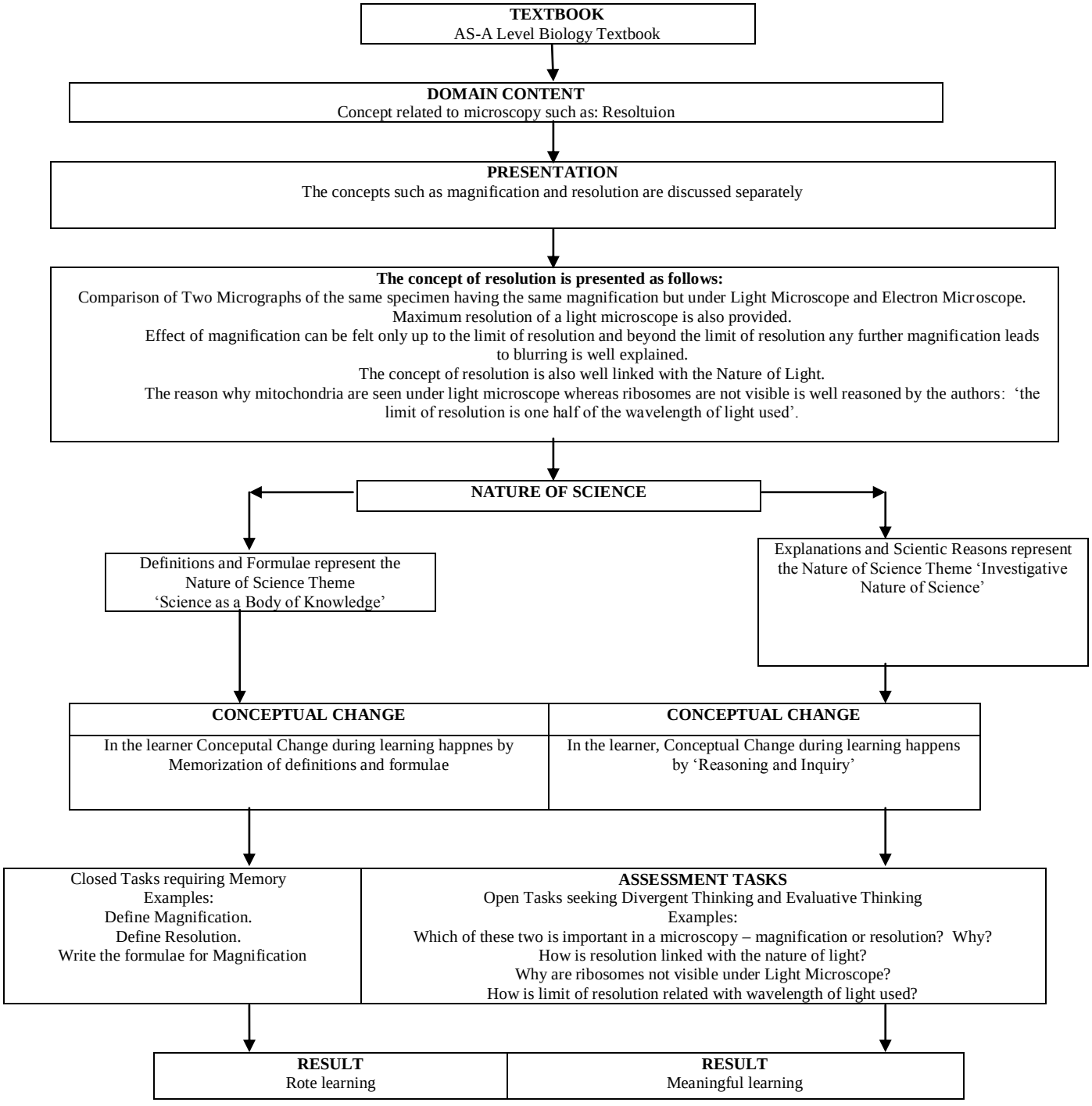


Figure 3 (continued)

Learning Situation 3: Learners' Naïve Knowledge and Gained Knowledge with respect to learning of the concept 'Resolution' from AS-A Level Biology Textbook

LEARNERS' NAIVE KNOWLEDGE

When the concept of Resolution is introduced to the class, the students respond by talking about New Year Resolution. They also provide the meaning of the word 'resolution' - 'a firm decision to do or not to do something'.

Some students refer resolution in terms of Pixels and MegaPixels of a smart phone. They discuss about Pixels Per Inch (PPI). Greater the PPI, higher is the resolution.

(Here Naïve Knowledge is influenced by everyday experiences with natural phenomenon and events. Also the explanations provided by novices include scientifically non-formative explanations based on their daily experiences).

GAINED KNOWLEDGE

Definition of Resolution.

For the same specimen having the same magnification but viewed under a Light Microscope (LM) and an Electron Microscope (EM), the image under an EM is more clearer than the image under LM.

Maximum resolution of a light microscope is 200nm.

Effect of magnification can be felt only up to the limit of resolution and beyond the limit of resolution any further magnification leads to blurring is well explained.

The concept of resolution linked with the Nature of Light.

The reason behind why mitochondria are visible under light microscope whereas ribosomes are not visible

The relationship 'limit of resolution is one half of the wavelength of light used'.

Conceptual Change from the perspective of 'Knowledge-as-Elements'

In the above situation the naïve knowledge is a collection of quasi-independent knowledge elements.
During conceptual change process, the elements and interactions between the elements are gradually revised and refined through addition, elimination and reorganization to strengthen the network.
This clearly supports conceptual change from the perspective of 'Knowledge-as-Elements' who believe that all of the various elements in a student's conceptual network are subject to progressive knowledge construction (Ozdemir & Clark, 2007).

3. Results

Group A: When manifest content is presented in the form of definitions and formulae and taught based on these definitions and formulae using Traditional Chalk and Talk Method, learning did not happen by conceptual change rather it happened by rote learning. Students from Group A were able to write only the basic definitions of magnification and resolution without appreciating the importance of Magnification and Resolution in Microscopy.

Group B: When manifest content is presented in the form of reasons and illustrations and taught based on illustations, examples and numericals using Inquiry Method, learning did happened by conceptual change. Students from Group B were able to write not only the basic definitions of magnification and resolution but also appreciated the importance of Magnification and Resolution in Microscopy by solving numerical problems related to magnification and by reasoning out the importance of resolution with respect to sizes of different cell organelles.

4. Discussion

Textbooks determine what is being taught and learnt in classrooms (Abd-El-Khalick et al, 2008). Textbooks support learners in the learning process (Garcia-Barros et al 2005) by motivating them to learn, by representing information, by guiding them to acquire knowledge, by guiding students to acquire learning strategies and by providing self assessments (Mikk, 2000). The content of the textbooks and the way the textbooks are used have a direct impact on the student learning (Robitaille & Travers, 1992). A textbook will be optimally effective if the contents of the text is written and adapted in such a way that it allows most of the pupils (during the time available to them and with or without the guidance of a good teacher) to study and assimilate the subject knowledge and develop the skills specified in the curriculum as measured by tests and examinations administered at different levels (Johnsen, 1993). The quality of a textbook can be judged by the extent to which attributes present in the textbook will facilitate learners to acquire the desired learning outcomes (Swanepoel, 2010). A textbook of good quality is a 'good learning tool' (Chambliss & Calfee 1998); it makes the learners achieve the intended learning outcomes (Bernier, 1996) and enhances their ability to deal effectively with skills, concepts and content of the subject (Nitsche 1992). The quality of the textbooks also has great impact on the quality of instruction (Lemmer et al, 2008) and it is imperative that teachers use the best science textbooks available (Roseman et al 2010). Teachers consider textbook as a vehicle for implementing the intended curriculum in the classroom (Malcom & Alant, 2004). According to Lemmer et al (2008), Ogan-Bekiroglu (2007), Pepin & Haggerty, (2003) and Kesidou & Roseman, (2000), some teachers function well without the use of the textbooks, however studies world-wide show that textbooks are routinely used by teachers in classes. Newton & Newton (2006), Henson (2004), Issitt (2004) report that some teachers use a variety of textbooks to provide them with examples of high quality teaching strategies, activities and assessment tasks. It is rightly pointed out by Tyson (1997) and Wong (1991) that qualified and experienced teachers will use, supplement and discard portions of the textbook according to his/her learner's needs. Henson (2004) is of the opinion that inexperienced or unqualified teacher may use and overuse the textbook, because it provides a feeling of safety. Increased learning achievement can be achieved through the evaluation of textbook quality (Taylor, 2008, Brandt, 2005). Textbook evaluation contributes to the professional development of teachers (Malcom & Alant, 2004) and aids curriculum implementation (Davis 2003, Iszak & Sherin, 2003).

5. Conclusion

Textbook is a ubiquitous tool in science teaching and learning. During schooling textbooks are often used as the primary organizer of the learning contents that students are expected to master and that textbooks provide detailed explanations of the topics to be learnt. Many learners and teachers of biology presume that biology is a subject that can be mastered by rote learning and the reason behind this perception is attributed to the textbooks and their authors who present biological content as an encyclopedia of mere facts and technical jargons. Textbooks with attributes for active engagement of the learners are meant to stimulate learning through conceptual change. The findings in this study clearly highlights that the naïve knowledge is a collection of quasi-independent knowledge elements and during conceptual change process, the elements and interactions between the elements are gradually revised and refined through addition, elimination and reorganization to strengthen the network. This clearly supports conceptual change from the perspective of 'Knowledge-as-Elements' who believe that all of the various elements in a student's conceptual network are subject to progressive knowledge construction. Textbook writers should ensure that for conceptual change to happen, the content of biology should not be presented as a mere body of knowledge instead it should provide opportunities for the learners to investigate think and interact with the society. Encyclopedic coverage of biological content delimits biology as a body of knowledge thereby amputating the spirit of thinking, analysis, reasoning and evaluation within the learner thereby giving more scope for misconceptions. Through this study it is suggested that the biology textbook writers should concentrate on core concepts rather than having an encyclopedic coverage of many concepts.

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