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Content Analysis of General Science Text Book for 8th Grade

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Abstract

General Science textbooks have integrated contents of Biology, Chemistry, Physics and; Earth and Space, demand special attention of curriculum developers. This study aimed to explore the contents of General Science textbook of 8th grade taught in government and private schools of Punjab province. This qualitative nature research was conducted through content analysis design. The contents of Generals Science textbook of 8th grade were broken down in terms of Piagetian developmental levels by using instrument Curriculum Analysis Taxonomy (CAT) and cross validated with one of the originators of CAT. The findings show that majority of contents of General Science textbook were at Concrete Operational level while a small number of contents demands Formal Operational level. It was recommended that the distribution of contents should follow model based on Piagetian development levels and the selection of contents should be on the basis of breadth and depth of the concepts.

Keywords: piagetian developmental levels, curriculum analysis taxonomy (CAT), science contents, general science textbook

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Introduction

The quality of science education is associated with science textbooks. Different measures were promised for the improvement of science education and reviewing the science textbooks of different grades (National Educational Policy, 2009). The teaching methodology, assessment; and other activities in the classroom and science laboratory depends upon the content of the science books. The results of Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA) have provided evidences for different educational systems to reconsider their content, teaching method; and assessment processes (DeBoer, 2011 & Lieger, 2015). Educational experts update the science curriculum to keep pace with the modern scientific knowledge and ultimately introduced complex, abstract, and difficult concepts in science textbooks at lower grades. The Curriculum Wing, Ministry of Education (MoE) is a sole body at federal level that develops curriculum of science and all other subjects in Pakistan. But the textbooks are published by the respective provinces. These textbooks were developed on the basis of the instructional objectives; and students are supposed to achieve at the end of each academic year (Mahmood, 2006). In government schools, as well as, in some private schools, these textbooks means as sole instructional material for teachers and students.

Developing curiosity, understanding of scientific thinking and depth of science concepts is the major focus of teaching of science which can only be achieved through science textbooks (National Curriculum Development, 2006).Unfortunately, different science textbooks in Pakistan are the collection of information only and unable to promote critical thinking; hence causing rote memorization particularly at school level among students (Aly, 2007). Similarly a gap between the content being taught through science books and daily life problems was reported (Reiss, 2004).

The science curriculum consists of too difficult concepts that students were not able to be comprehend of their respective grade (Stabback, 2016).This complex nature of science subject demands intellectual ability to comprehend it. The ability of an individual to integrate the understanding of single concept or more complex concepts to develop a new concept is the key behind meaningful learning and understanding of science concepts afar from rote memorization (Nieswandt, 2007).

While developing science textbooks, writers must have certain model of curriculum before them to develop the textbooks (Fan, 2010).The

contents of science textbooks of different areas differ significantly in their nature and complexity. When different areas of science are combined together and presented in a single integrated science textbook; it is referred to "General Science textbook" because it consists of different areas of science, i.e. Biology, Chemistry, Physics, and; Earth and Space. The logical sequence and link among the contents, inter-disciplinary as well as intra-disciplinary, makes the content more complex and demanding and difficult to teach those concepts (Vazir, 2003).If selection of logical sequence and link among contents for the General Science textbooks based on some "appropriate model", then it involves students actively in the learning process and leads towards conceptual understanding based on constructive inquiry (Joyce, Calhoun, & Hopkins, 2002).

The problem of non-agreement on the selection of content is not new, the content of the different General Science textbooks at different grades reflects non-agreement among authors regarding what to include in these books (Curtis, 1942).Whereas the American Association for Advancement of Science (AAAS), after evaluating elementary schools textbooks, was also incapable to approve any single science textbook as up to the mark in the USA (Budiansky, 2001).The reason is that students need a specific cognitive level to comprehend the contents of General Science textbooks at any grade because for meaningful learning and understanding of scientific concepts present in General Science textbooks need to be at or near the appropriate cognitive level of an individual (Adey & Shayer, 1994).

These cognitive levels are termed as Piagetian Developmental Levels (PDLs) based on the work of Piaget (Adey & Shayer, 1994). The contents of science textbooks can be further divided in terms of Piagetian Developmental Levels (PDLs) based on areas of science to form a General Science textbook. Such textbooks do not follow Piagetian Developmental Levels. The selection of science contents in textbooks based on any given psychological development model may be comprehended more by the students as compare to any science textbooks developed without such model (Ginsburgh, 1996). The content selection without any psychological model lead to cramming and rote learning among students. The rote memorization of content presented in science textbooks, hinders the actual academic achievement and understanding among the students (Maoldomhnaigh, 2004).

Presently, science courses, in large quantity, were being taught at different grades have abstract and difficult for most students to comprehend (Shirazi, 2017). This is because it is difficult to develop compatibility between students' comprehension level and content

demands of science textbooks. The comprehension levels of students and content difficulty level can compared by applying different types of taxonomies. Content analysis of textbooks by using different taxonomies are in terms of the formulated objectives, e.g., Context Input Process Product Model (CIPP), Objective Analysis Model, Goal Free Model and Naturalistic Approach (Posner, 2004). To decide the appropriateness of the content to be taught at certain grade can be measured through these taxonomies. Shayer and Adey (1983) presented Curriculum Analysis Taxonomy (CAT) to measure content level in terms of Piagetian Development levels (PDLs) which is considered important in the developed countries.

There are two parts of CAT taxonomy; the first one describes about different aspects of the cognitive levels of the child's interaction and explains six functions in terms of five stages of PDLs, starting from Pre-Operational to Late Formal Operational levels. The second one describes the development of schemas which are required to comprehend the science concepts. It is explained under the umbrella of nine types of problems encountered by children in terms of four levels of Piagetian Developmental Levels, i.e. Early Concrete, Late Concrete, Early Formal and Late Formal levels.

Table 1

Curriculum Analysis Taxonomy Headings

Taxonomy 1 Headings		Taxonomy 2 Headings	
1.1	Interest and investigation style	2.1	Conversation
1.2	Reasons for events	2.2	Proportionality
1.3	Relationship	2.3	Equilibrium of system
1.4	Use of models	2.4	Mathematical operations (physical sciences)
1.5	Type of categorization	2.5	Control of variables
1.6	Depth of interpretation (for descriptive passages)	2.6	Exclusion of irrelevant variables
		2.7	Probabilistic thinking
		2.8	Correlational reasoning
		2.9	Measurement skills

(Source: Adey &Shayer, 1994, p. 33)

The analysis of curriculums GCE (O-Level) science curricula of the 1970s and 1991 National curriculum for science in England and Wales based on Curriculum Analysis Taxonomy stated that most of the contents can be comprehend by students who are Formal reasoning levels (Shayer, 1991).When the contents of 6th, 7th and 8th grades science textbooks of Punjab were categorized by applying Curriculum Analysis Taxonomy (CAT) and found that 14% demands thinking at the Late Formal level, only 7% of the curriculum of 8th grade is of Concrete Generalization level, 79% is of Early Formal level (Iqbal, 1997). When science curriculum of Philadelphia (USA) was analysed on the basis of Curriculum Analysis Taxonomy (CAT); the majority of contents revolves around reasoning abilities of higher thinking levels (Angela et al, 2017). Similarly different General Science textbooks of different grades in South Korea were analysed by using Curriculum Analysis Taxonomy and the results showed that demand of the concepts taught in textbooks are higher than the present cognitive levels of students of the specific grade (Shin et al., 2003; Kim et al., 2004 & Song et al., 2005).

The use of Curriculum Analysis Taxonomy (CAT) for categorising the contents of science textbooks in terms of Piagetian Development Levels (PDLs) is an evident of these researches. In Pakistan the textbooks of the science subjects is taught as collection of information rather than in depth understanding of the contents (Faize, 2011). This leads towards rote memorization and cramming and it hinders to internalize the science concepts by the students. To keep the pace with advance knowledge; new science curricula are full of abstract and complex concepts. The induction of science content demanding higher thinking ability may results in understanding and comprehension by the students. In Pakistan, like the other developing countries, standardized and generalized process of curriculum development prevailing in the developed countries was ignored. (Haider, 2016).

Objective of the study was to analyse the content of General Science Textbook for 8th grade published by Punjab Textbook Board through curriculum analysis taxonomy according to Piagetian Developmental Levels.

The research questions were; i) Do the contents of General Science Textbook follow any Piagetian developmental levels model?; ii) Do the contents of Biology follow Piagetian development level?; iii) Do the contents of Physics observe Piagetian development level?; iv) Do the contents of Chemistry follow Piagetian development level?; v) Do the contents of Earth and Space observe any Piagetian development level?

Methodology of the study

The research was qualitative in nature and content analysis design was applied to collect the data. The Generals science textbook of 8th grade published by Punjab Textbook Board was selected for this research study. This design was applied to breakdown the contents in terms of Piagetian development level because it has provision to quantify the qualitative data into categories etc. (Frankel & Wallen, 2009). The selected contents were analysed on the basis of five themes; i.e. "Early Concrete (2A)", "Mid Concrete (2A/2B)", "Mature Concrete (2B)", "Early Formal (3A)", and "Mature Formal levels (3B)" by using Curriculum Analysis Taxonomy (CAT).

Procedure of Curriculum Analysis Taxonomy (CAT) of General Science Text Book

The General Science textbook at 8th grade was analysed through applying CAT in three steps.

a) The content of the General science textbook at 8th grade were broken down in terms of PDL.
b) Two Ph.D. scholars having more than ten years of teaching experiences at school level, also having area of specialization was educational psychology, counter check the analysed the content of the 8th grade General Science textbook by using CAT.
c) More than 30 out of 71 contents were cross validated with one of the originators of CAT.

This breakdown of content in terms of PDLs was tabulated in frequencies. This helped to calculate the percentages of contents of each cognitive level as compared to the total number of contents in the General Science textbook of 8th grade by using the formula;

$$\text{Percentage of content at any Level} = \frac{\text{Total no of contents at that level}}{\text{Total numbers of the contents in General Science textbook}} * 100$$

For example

$$\text{Percentage of topic at Mature Concrete Level} = \frac{\text{Total no of contents at Mature Concrete level}}{\text{Total numbers of the contents in General Science textbook}} * 100$$

Results

The detail of the contents present at different PDLs by applying Curriculum Analysis Taxonomy (CAT) of the 8th grade General Science textbook is discussed in table 2;

Table 2

Breakdown of the Contents in Terms of PDLs

Area	Early Concrete (2A)	Mid Concrete (2A/B)	Mature Concrete (2B)	Early Formal (3A)	Mature Formal (3B)	Total
Biology	3	2	11	4	0	20
Chemistry	9	3	5	3	3	23
Physics	2	1	4	7	1	15
Earth and Space	12	0	1	0	0	13
Total	26	6	21	14	4	71

Table 2 reflects that out of the 20 contents of Biology, there was no single topic that demands Mature Formal level, whereas 15% were at Early Concrete level, 10% were at Mid Concrete level, 55% were at Mature Concrete and 20% were at Early Formal level. In case of chemistry contents, out of the 23 contents 21.73% were at Mature Concrete level, 13.04% were at Mid Concrete level, 39.13% of the contents were at Early Concrete level, and 13.04% were at Early Formal and Mature Formal levels respectively. Whereas the 15 topics regarding the Physics, 13.33% contents were at Early Concrete level, 6.66% were at Mid Concrete level, 26.66% were at Mature Concrete level, 46.66% were at Early Formal level and 6.66% were at Mature Formal level. Out of the 13 contents of Earth and Space, 92.3% contents were at Early Concrete level and 7.69% were at Mature Concrete level (Figure 1).

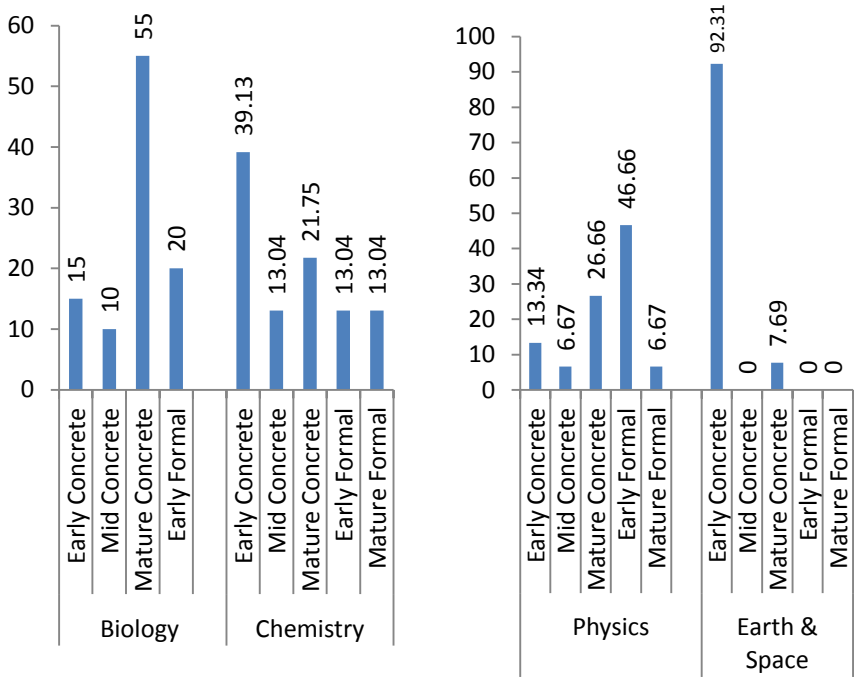

Figure 1: Breakdown of Biology, Chemistry, Physics, and Earth & Space contents in terms of PDLs (in %ages) by applying CAT of General Science of 8th grade

It is evident that from 71 total topics of the General Science textbook at 8th grade, 36.6% content was at Early Concrete level, 8.4% content was at Mid Concrete level, 29.5% content was at Mature Concrete level, 19.7% content was at Early Formal level and 5.6% content was at Mature Formal level (Figure 2).

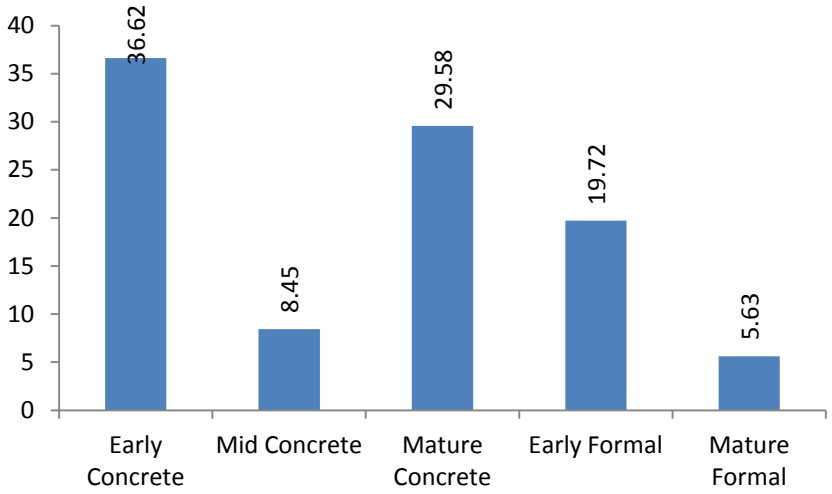

Figure 2: Breakdown of all Contents in terms of PDLs (in % ages) by applying CAT of General Science of 8th grade

The further analysis on the basis of PLDs shows that Earth and Space part of General Science textbook has the most content (92.13%) on Early Concrete level as compared to Chemistry (39.13%), Biology (15%), and Physics (13.34%) has least number of content on Early Concrete level. When content was compared on Mid Concrete level, it shows that Chemistry (13.04%) has the most content on Mid Concrete level as compared to Biology (10%), Physics (6.67%), while Earth and Space has no content at Mid Concrete level. At Mature Concrete level, content of all branches of science were present. Biology (55%) has the highest percentage while Earth and Space (7.69%) has lowest percentage of content. The content of Physics (46.66%) were at Early Formal level, followed by Biology (20%) and Chemistry (13.04%) and there was no content at Early Formal level of Earth and Space (Figure 3).

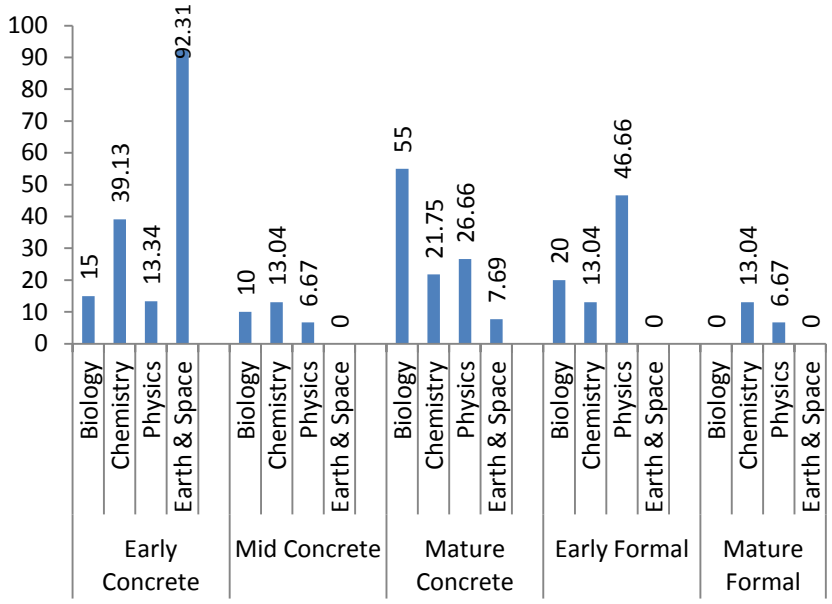

Figure 3: Distribution of PDLs across different areas of General Science textbook (in % ages) by applying CAT of General Science of 8th grade

Discussion

The uneven distribution in the contents of the General Science textbook of 8thgrade and similar patterns of uneven distribution in the portions of Physics, Chemistry, Biology and Earth & space can be clearly seen in the result of this research. The similar findings were reported by Shayer and Whylam (1978); Shin et al., (2003); Cepni, Ozsevgec and Cerrah (2004); Kim, et al., (2004); and Song et al., (2005). These researchers used the Curriculum Analysis Taxonomy (CAT) and categorized contents in terms of Piagetian developmental levels. It was also observed, there was no proper sequence of content in terms of PDLs which arise difficulty level and create boredom and enhances cognitive load among students. The high level cognitive demand of contents causes a hindrance in students learning and ultimately lowers the achievement. Curriculum developers and implementation authorities may ensure the consistency of content among different grades textbooks. It is also supported by the findings of Schmidt (n. d.) that major cause of low achievement in subject of science is the coverage of too much contents.

In Pakistan, the content selection and distribution of General Science textbook at 8thgradedo have some following of the age-stage model of Piaget in terms of Piagetian developmental levels but not fully followed (Ghazi, & Karim Ullah, 2015). It is generally recommended that contents with lower thinking ability (Early Concrete and Mid Concrete) should be more than the contents with higher thinking ability (Mature Concrete, Early and Mature formal level). Moreover, the sequence of the content should be from lower to higher thinking ability. In General Science textbook of 8th grade, both principles are ignored as there was no content of Formal Operational level in the portion of Earth and Space while in the portion of Biology very little content was included that demands higher order thinking ability. Since majority of the population in different countries does not strictly follow the Piaget's age-stage model that's why age-stage model of Piaget has been refined on the basis of research evidences reported throughout the world. Even this revised age-stage model is not being followed in the science curriculum of 8th grade in Pakistan. Hence it is need of the time to create awareness among the curriculum developers and textbook writes to follow this refined age-stage model of Adey and Shayer (1994) in true sense throughout the science curriculum on the basis of breadth and depth of the contents.

The analysis of content distribution in General Science textbook at 8thgrade reveals the uneven distribution in terms of PDLs among different portions of Physics, Biology, Chemistry, Earth and Space which shows that there was no close liaison among the authors. The reason may be that at school levels, in Pakistan, team of multiple authors write textbooks. So there is need of a professional body equipped with latest advancements to enhance the quality of science textbooks with respect to cognitive demands of students and may follow any latest model as well as.

Conclusions

It was concluded that almost all (92.31%) the content of Earth and Space demand Early Concrete level. A small part of the content of Biology and Physics was at Early Concrete level but about half of the content of Chemistry was at Concrete Operational level. On the other hand, the content that demands Mature Concrete level was for Biology was more than 50%, and for Chemistry and Physics was less than 30%. In the subject of Physics, 46.6% of the content was at Formal

Operational level whereas the demand for Formal Operational level in the content of Chemistry and Biology was 20%. It was also concluded that distribution of contents were not even according to different Piagetian developmental levels (PDLs). Similarly the distribution of contents among Biology, Chemistry, Physics and Earth and Space was also not regular. It is also concluded that on different Piagetian Developmental levels across all the areas of science and within the area, there was no model for distribution was observed. According to PDLs the highest level of content was at Early Concrete level (2A), after that was Mature Concrete level (2B) and it was followed by Early Formal level (3A). While at Mid Concrete level (2A/B) and Mature Formal level (3B), the content was small. As far as the area of Biology is concerned, the highest number of content was at Mature Concrete level (2B) and some was at Early Formal level (3A). But there was no content at Mature Formal level (3B) and about same number of contents at Early Concrete level (2A) and Mid Concrete level (2A/B) was found. Due to cognitive load among learners, a large number of content demands higher order of thinking (Early and Late Formal level) in the area of Physics and Chemistry. Most of the contents of General Science were at different sub-stages of concrete operational level where as some contents demands early formal level and mature formal level of thinking.

The results show that no rule regarding the level and thinking ability of the students was considered for selection of the contents. Hence it is concluded that there were serious flaws and unequal distribution in terms of Piagetian developmental levels within the contents of General Science textbook of 8^{th} grade.

Educational Implications:

The integrated curriculum based textbooks like General Science demands lot of efforts to be written for young children. In Pakistan, the textbooks are usually written by team of authors, ultimately causing gap between the contents of different parts of the integrated textbooks. It may be good effort if integrated curriculum based textbooks written by a single author as this practice can be seen by other reputed and well established publishers of foreign countries.

The one of the basic principles of curriculum development regarding the content arrangement is from simple to complex and

concrete to abstract. So it is recommended that the distribution of contents should follow Piagetian age stage model and development levels; further the selection of contents should be on the basis of breadth and depth of the concepts. Similarly it is recommended that content with lower thinking ability (Early Concrete and Mid Concrete) may be more than the content with higher thinking ability (Mature Concrete, Early and Mature Formal level). Moreover, there should be sequence from lower to higher thing ability.

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