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ASSESSING THE SECONDARY SCHOOL STUDENTS' CHEMICAL KNOWLEDGE ACROSS LEVELS AND SUB-CONCEPTS

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Abstract

Realizing the importance of chemistry in daily life, has become the compulsory part of education and science education all over the world. Johnstone drew attention to the existence of the three levels of chemistry: macroscopic, sub-microscopic and symbolic. These levels can be represented in the form of a triangle. The current study aims to assess the secondary school students' chemical knowledge across levels and sub-concepts. The students' data was collected through convenient sampling from public and private schools of Lahore. The data is analyzed applying independent sample t-test. The major findings of the study illustrate that students have high understanding at macro and symbolic level of chemical knowledge than sub-micro level. It is recommended that chemical education should be carved level wise from secondary to higher level of studies.

Key words: *Macro, sub-micro, chemical knowledge and symbolic*

Introduction

Science and chemistry education in particular is a veritable instrument for national development. According to Okon – Enoh, (2008) science is a way of seeking information (process) and also an accumulated knowledge resulting from research (products). Okoro (2013) sees science as a systematic investigation of nature with a view to understudy and harnessing them to serve human needs. Science may be regarded as the body of related courses concerned with knowledge. It consists among other component; Chemistry, Physics, Biology, Mathematics, Astronomy, Agriculture, among these, chemistry is vigorously described as the queen of science.

Realizing the role of science in achieving self-reliance and intellectual development, one tries to find the place of chemistry in science. Notwithstanding the negative role chemistry education does play globally, such as pollution and drug abuse, the positive roles are well known. Chemistry is the central in the drive of global sustainable economic development. It plays the major roles in food (fertilizers and insecticides), clothing (textile fibers), housing (cement, concrete, steel, bricks), Medicine (drugs), Transportation (fuel, alloy materials). Presently, man is experiencing an era in scientific and technological development that affects his life in one way or the other. Virtually everything we use daily involves chemistry.

Teaching and learning chemistry:

There are as many approaches to teaching and learning chemistry as there are chemistry Teachers. All school teachers nevertheless are required to follow a defined curriculum, which may be nationally defined.

Especially at the secondary level of schooling, these curricula emphasize preparation for tertiary-level education, even though it may be a small minority of learners who will follow

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this path in future. This divergence between minority expectations and majority needs is quite common around the World. Still, with a conference theme "Chemical Education for Human Development in Africa", we may pause to reflect on this divergence and question whether we support or do not support the aim implicit in this theme (Ried, 2014).

Systemic approaches to chemical education

Fahmy and Lagowski, (2011) have argued for and researched systemic approaches to teaching and learning of chemistry. An emphasis of these approaches is the inter-relatedness of things, especially the cross-links between vertical developments of concepts as are most often presented in concept maps.

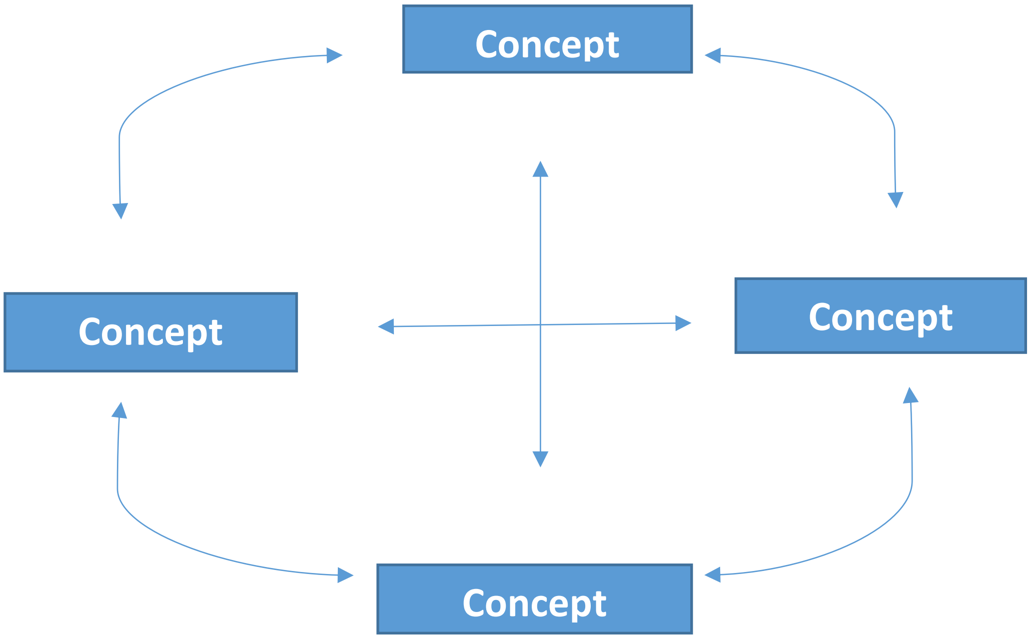
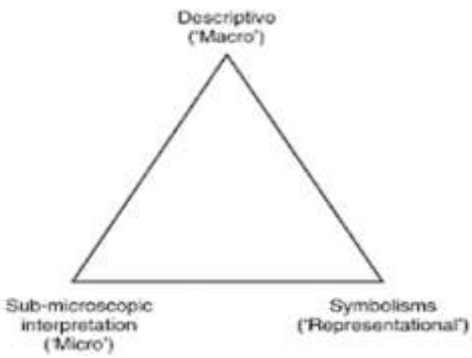


Fig2.1 SATLC: Closed-cluster concept maps

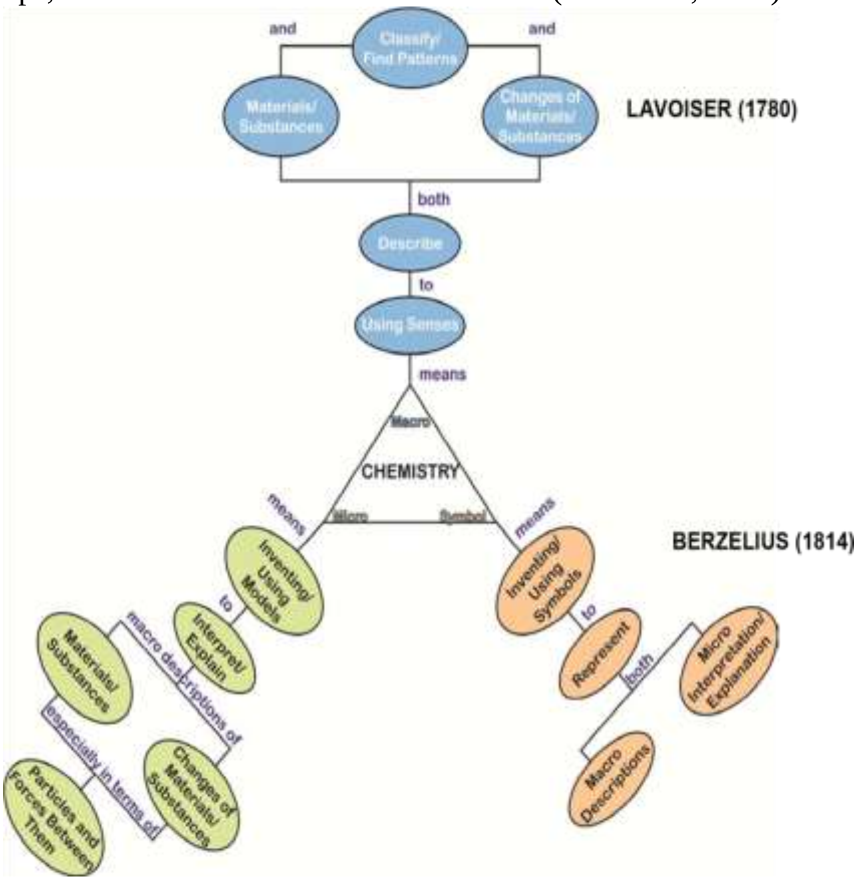
The chemist's triangle

Johnstone (1999) drew attention to the existence of what he called the three forms (or levels) of chemistry: macroscopic, sub-microscopic and symbolic (representational). These three forms or levels are not independent, but in fact closely related. This can be represented by a triangle with the three forms at the corners of the triangle. Macro; using senses to describe the material substances and changes in them. It is the simpler level. In other words, these are the concepts described briefly and clearly in the book. Sub-micro; to interpret or explain the macro concepts more deeply in material substances and changes in material substances especially in terms of particles and forces between them. Symbolic; means inventing or using symbols to represent both, macro descriptions and micro interpretations or explanations.



This may be recognized as one of the centrally-important closed-cluster concept maps of chemistry, which can assist teachers, learners and researchers. Being devoid of other indicators it can serve chemistry education at all levels and in all curricular contexts.

But alone it is but an aide-memoire that can be understood after experiencing its use. There is no better way of doing this than by exploring the points of the triangle and their interrelationships, with CHEMISTRY itself as the focus (Johnstone, 1999)



DALTON (1801)

Fig:3 levels of chemistry

Final Comments

There may be many other ways of conceptualizing the structure of chemical knowledge different from that proposed in this paper. We may find some of them more or less appealing or fruitful for educational purposes. However, the analysis, discussion, and reflection of each of them is likely to enrich our understanding of the discipline and challenge our assumptions about how best to teach chemistry and help others learn it. Undoubtedly, the triplet relationship is a very powerful, productive, and widely used metaphor for both teaching and doing educational research in chemistry, as well as in science in general. For these same reasons, we should be careful when using it in making planning and assessment decisions in the classroom. The abuse or misuse of the chemistry triplet as an instructional tool may increase students' confusion and lack of motivation towards chemistry (Johnstone, 1982, 2000). Given the different interpretations of the main components of the chemistry triplet, we should also be cautious when interpreting the results and evaluating the implications of research and curricular projects that rely on it as part of their theoretical framework.

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Research type:

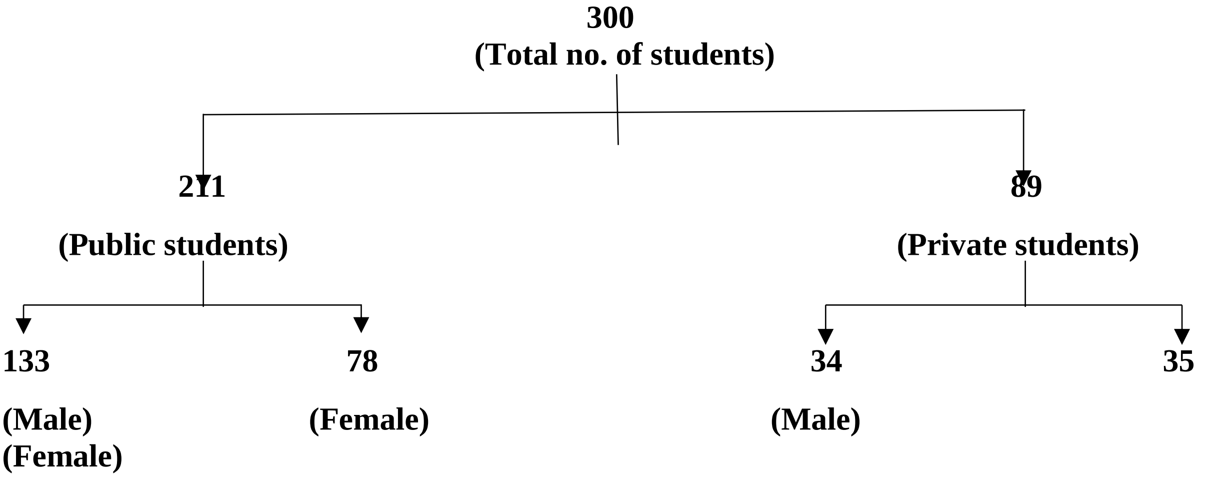
The research was quantitative in nature aims to assess the concepts of secondary school students at three levels of chemical knowledge for various sub topics of Chemistry. For this purpose, a test was prepared which was comprised of 75 items which yielded numerical data in the form of scores.

Population of the study:

Secondary school male and female students from public and private schools of Lahore constitute the population of the study.

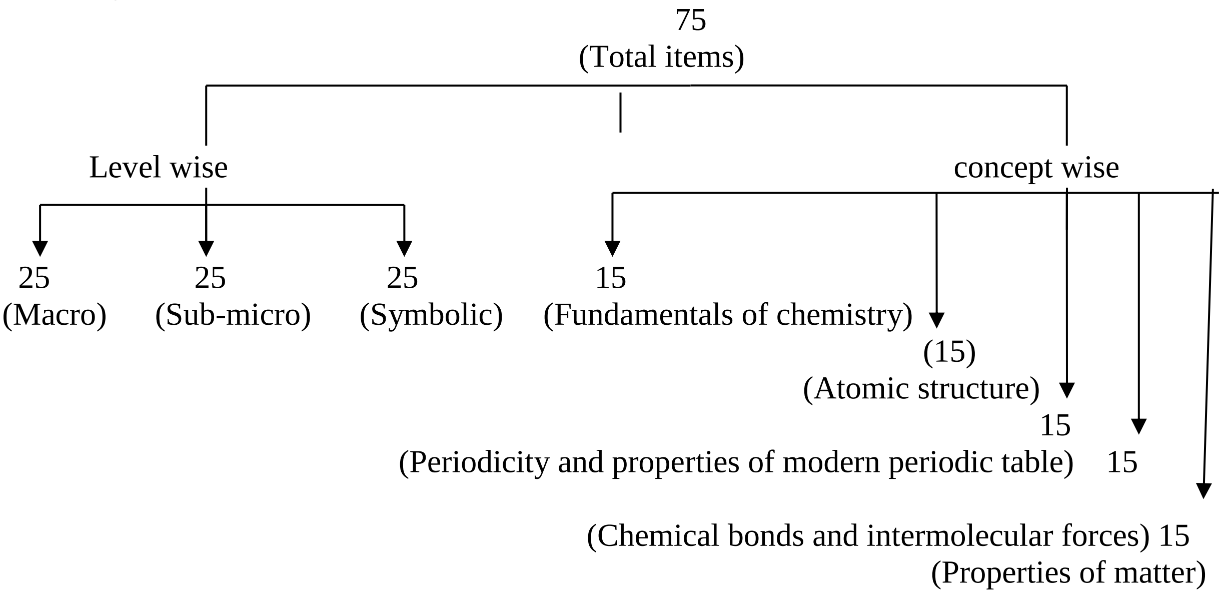
Sample of the study:

The sample of the study consist of 300 students, 211 from public sector (133 females and 78 males) and 89 from private sector (34 males and 35 females). Sample distribution is as under.



Development of Research instrument:

To assess the chemical knowledge of secondary school students. A test was prepared. Test was consisted of 75 items. These items were further bifurcated into two categories; one category assessing the students conceptual understanding of various levels of chemical knowledge; Macro, Sub-micro and Symbolic and the other category aimed at assessing conceptual understanding for various major concepts introduced in 9th grade curriculum of chemistry. The division of items is as under.



Data analysis:

Collected test from the students were coded and scored. The data thus collected was entered in computer by using SPSS software entered data was thus analyzed by applying mean and independent sample t- test.

Table 1 *Frequency of scores for the concepts of chemical knowledge at secondary level.*

		Frequency	Percent
Valid	Low	23	7.5
	Average	196	63.8
	High	81	26.4
	Total	300	97.7

Table1 shows the frequencies and percentage of scores for the concepts of chemical knowledge at secondary level. The frequencies and percentages of students who achieved low scores is 23 (7.5%), average scores is 196 (63.8%) and high scores is 81 (26.4%) respectively.

Table 2 *Frequency of scores at macro level of chemical knowledge.*

		Frequency	Percent
Valid	low	16	5.2
	average	221	72.0
	high	63	20.5
	Total	300	97.7

Table 2. Shows the frequencies and percentage of scores for the concepts of chemical knowledge at “Macro” level. The frequencies and percentages of students who achieved low scores is 16 (5.2%), average scores is 221 (72.0%) and high scores is 63 (20.5%) respectively.

Table 3 *Frequency of scores at sub-micro level of chemical knowledge.*

		Frequency	Percent
Valid	Low	31	10.1
	Average	218	71.0
	High	51	16.6
	Total	300	97.7

Table 3. Shows the frequencies and percentage of scores for the concepts of chemical knowledge at “Sub-micro” level. The frequencies and percentages of students who achieved low scores is 31 (10.1%), average scores is 218 (71.0%) and high scores is 51 (16.6%) respectively.

Table 4 *Frequency of scores at symbolic level of chemical knowledge.*

		Frequency	Percent
Valid	Low	39	12.7
	Average	221	72.0
	High	40	13.0
	Total	300	97.7

Table 4.Shows the frequencies and percentage of scores for concepts of chemical knowledge at “Symbolic” level. The frequencies and percentages of students who achieved low scores is 39 (12.7%), average scores is 221 (72.0%) and high scores is 40 (13.0%) respectively.

Conclusion:

Findings of the study help to conclude that 63.8% of the secondary school students lies in average range of scores for overall concepts of chemical knowledge, 7.5% in low and 26.5% in high. For all the three levels, the student’s understandings lies in average range, 72% for “Macro”, 71% for “Sub-micro” and 72% for “Symbolic” level of chemical knowledge, which indicates that the student’s level of difficulties is same for all levels. Similarly for all the various major concepts of chemical knowledge the students understandings lies in average range, 68.7% for the concept of “Properties of Matter”64.2% for the concept of “Fundamentals of Chemistry”, 59.3% for the concept of “Periodicity and properties of Modern Periodic Table”, 54.1% for the concept of “Atomic structure” and 53.4% for the concept of “Chemical Bonds and Intermolecular Forces”. It means that students find the concept of “chemical Bonds and Intermolecular Forces” more difficult.

Regarding the demographic variable of gender there is significant mean difference in the scores of secondary school male and female students regarding chemical knowledge at “Macro” level”. While there is no significant mean difference in the scores of secondary school male and female students regarding chemical knowledge at “Sub-micro” and “Symbolic” level. Similarly there is no significant mean difference in the scores of secondary school male and female students for the concept of “Fundamentals of Chemical knowledge”, “Atomic Structure”, “Periodicity and Properties of Modern Periodic Table” and “Properties of Matter”. But there is significant mean difference in the scores of secondary school male and female students for the concept of “Chemical Bonds and Intermolecular Forces” which means that male and female students have equal level of understanding for the first four concepts and it is different for the concept of “Chemical Bonds and Intermolecular Forces”. The scores of female students was better as compared to male.

Similarly, for the demographic factor of school type there is no significant mean difference in the scores of private and public secondary school students regarding chemical knowledge at “Macro”, “Sub-micro” and “Symbolic” level. Similarly there is no significant mean difference in the scores of private and public secondary school students for the concept of “Fundamentals of Chemical knowledge”, “Atomic Structure”, “Periodicity and Properties of Modern Periodic Table”, “Chemical Bonds and Intermolecular Forces” and “Properties of Matter” which indicates that all the private and public school students have almost same conceptual understandings across various major levels of chemistry.

Concerning the major areas of study, there is significant mean difference in the scores of secondary school students from areas of computer science and biological science regarding chemical knowledge at “Macro” and “Sub-micro” level but there is no significant mean difference in the scores of secondary school students from areas of computer science and biological science regarding chemical knowledge at “Symbolic” level which shows that at symbolic level areas of biological and computer sciences has no effect at chemical knowledge of students. Similarly there is significant mean difference in the scores of secondary school students from areas of computer science and biological science for the concept of “Fundamentals of Chemical knowledge”, “Atomic Structure”, “Chemical Bonds and Intermolecular Forces” and “Properties of Matter” but there is no significant mean difference in the scores of secondary school students from areas of computer science and biological science for the concept of “Periodicity and Properties of Modern Periodic Table”. It shows that students of biological sciences have higher level of understanding than the students of computer

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sciences and the concepts of "Atomic structure" and "Chemical bonding and Intermolecular Forces" are more difficult to students.

Recommendations:

Considering the data following recommendations are presented:

1. Start teaching level wise various major chemical concepts in primary and continue it in higher education.
2. To teach level wise various major chemical concepts successfully, it must be woven into curriculum content, structure and sequence at all grades.
3. It must be given to the in-service teachers.
4. Quality of chemical education should be improved both internally and externally in any institute.
5. Design and manage learning environment that provides students with the time, space and resources needed for learning chemical knowledge.
6. Chemistry Teachers should change their pedagogies in order to teach level wise major concepts of chemical knowledge.
7. The instructional leaders should be providing support and a frame work for improving quality of chemical education.
8. Chemistry teachers should improve their teaching pedagogies to make better understandings of sub-micro level, as the performance of students is much weaker at this level.

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