Journal of Education & Social Sciences
Vol. 5(1): 19-38, 2017
DOI: 10.20547/jess0421705102

An Analysis of Achievement in Science, Piagetian Conceptual Frameworks and Attitude towards Learning Science among Elementary and Secondary School Children in Pakistan

Muhammad Tariq Bhatti * Wasim Qazi †

Abstract: *This study analyzed the 8th and 10th graders' attitude towards learning science (ATLS), required cognitive skills for science examination questions (SEQ), and patterns of actual cognitive skills (ACS), in accordance with the Revised Bloom's Taxonomy (RBT) and the Piagetian Conceptual Frameworks (PCFs). The sample of the study consisted of 564 (boys and girls) 8th and 10th graders of government elementary and high schools in Sindh province of Pakistan. The RBT applied to break down the 8th graders General Science examination questions in terms of Piagetian conceptual frameworks. A Cognitive Science Achievement Test (CSAT) based on the RBT administered to measure the students' scores in science. In this study we applied causal comparative research design and stratified sampling technique for sample collection. The students' ATLS measured through Test of Science Related Attitudes (TOSRA, Fraser and Butts (1982)), whereas the existing PCFs of the students calculated by administering of the Group Assessment of Logical Thinking Test (GALT). The results showed that, the cognitive difficulty levels of SEQs found in uneven distribution at different PCFs, throughout examination questions. Most of the students were at different sub-stages of the Concrete Operational Level (COL) and a few were at Early Formal Operational Level (EFOL), while only four students out of 564 were at Mature Formal Operational Level (MFOL). In addition, the male students scored higher on the GALT in comparison with the female students. However, there was no significant difference found between the scores of eighth and tenth graders on the GALT. The findings concluded that a gap exists between students' reasoning ability and SEQ's difficulty level, and to increase in quantity of this gap, a decrease in ATLS occurs. Curriculum developers and paper setters need to follow a model in terms of RBT and PCFs for deciding the nature, level and complexity of the questions while developing science assessment techniques for all graders.*

Keywords: Achievement, attitude, conceptual frameworks, elementary and secondary schools, revised Bloom's taxonomy, science.

Introduction

A continuing lower level of academic achievement of students who are studying the elementary and secondary science courses, is a cause of great concern for those who teach this course at elementary and secondary schools. While the students are not satisfied with the learning pedagogy of their teachers and they find science examination questions (SEQs) more difficult. The students' performance in this course is comparatively low

*Iqra University, Gulshan Campus, Karachi, Pakistan. Email: mtbhatti2004@yahoo.com
†Iqra University, Gulshan Campus, Karachi, Pakistan. Email: whqazi@gmail.com

among the courses at the same level with a failure rate of more than 45% during the years 2008 and 2012 (Education Department, 2014). This has led the researchers to undertake the following tasks: a) analyze the students' ATLS, b) examine the examination questions, and finally, c) investigate the students' PCFs.

Education improves the living conditions of a nation in two ways; first, it improves the social conditions and, second, it enhances the economic status (Hudson, 2007), in addition, education develops intellectual maturity and forms better work force too (Nasr & Kono, 2011). In Pakistan, the quality of education generally, and science education, particularly, is in decline (Memon, 2007) in spite of the fact that various policy makers and almost all governments have tried their level best to improve the quality of education which also includes science education. However, Shah (2010) summarizes that science education in Pakistan at elementary and secondary levels is facing new challenges. In addition, Shah (2010) is of opinion that, education generally and science education particularly, needs to be developed as per the rate of other developing countries of South East Asia. Students' achievement in science depends on many factors (Parveen, 2010; Tahir, 2007). Teachers' teaching styles, curriculum, the examination system and the nature of the questions, students' and their parents' attitude towards science Melehat, Gezer, and Sahin (2014), and examination results are some of the factors that may affect the students' achievement in science in two ways, first, the level (beginners, intermediate, and advance learners) of achievement and, second, the quality (poor, acceptable, and exceed expectations) of achievement (Parveen, 2010). In examinations, mainly, the nature of the questions are incorporated Melehat et al. (2014) and as grouped in a certain manner, are those external factors that may largely affect the students' achievement in science in both ways, the level and quality of achievement (Akhtar & Shagufta, 2009).

In mathematics and science, Revised Bloom's Taxonomy (RBT) has been used to prepare lesson plans with special focus on categorizing the thinking skills (Amer, 2006; Aly, 2006; Parker, Wall, & Cordery, 2001). Similarly, the RBT has also been applied for rubric formed to assess the cognitive development of the children. In addition, RBT may also help a teacher to prepare formative questions in accordance with the adequate cognitive level of a child (Akhtar & Shagufta, 2009), and aligns the course aims with the objectives (Aly, 2006). Experts in science education (Anderson, 2006; Hudson, 2007; Iverach & Fisher, 2008; Khan, 2008; Oliveira, 2010; Romiro, 2015; Saad & Saouma, 2012), advocate the multiple use of assessment of students' achievement in science at different courses of time. However, conventional assessment methods, such as annual examinations were only conveniently used to evaluate students' factual knowledge and memory (Toyin, Jamie, & Stuart, 2013), on the other hand, the assessment of learners' conceptual framework (CFs) is more important than any other indicator. A CF is a predictive attribute that shows the level of concepts and their assimilation with other schemas in an individual's long-terms memory (Bischoff & Anderson, 2001). The students' CFs are generally neglected in assessing them. The assessing methods can also be categorized in terms of Piagetian Conceptual Frameworks (PCFs). The studies compared the cognitive difficulty of assessment introduced in mathematics and science tests at elementary and secondary levels and the students' current PCFs. Ron (2008) introduced the Assessment of Conceptual Development for this purpose. These studies Rader (1975); Gray (1978); Hartford and

Good (1976); Polk and Goldstein (1980); Tschopp and Kurdek (1981) compared the cognitive difficulty of assessment introduced in mathematics and science tests at elementary and secondary levels and the students' current PCFs, and indicated the mismatch between cognitive difficulty of test questions, and the students' PCFs. Hartford and Good (1976); Rader (1975); Ron (2008) proposed four key elements necessary for constituting any evaluation test; first, concentration not just on the outcomes of the teaching, but on learners' thinking processes, second, focus on students' self-initiation for intrinsic motivation, third, learners' active participation in the learning process; and finally, a deeper stress on opportunities focused on developing learner's thinking and intellectual maturity and focus on students' different backgrounds in the developmental process. (Tahir, 2007) revealed that assessment is based more on the memorization of texts in Pakistan than in any other educational or cultural setting. There is a need of modification of their national assessment approaches and techniques in accordance with learners'-centered approach.

Bird (2010) and Elsa (2011) argue that if misalignment exists between SEQs and students' PCFs, it may hinder students' abstract reasoning and other higher order thinking skills too. This gap also negatively affects (Kelvin, 2001; Matusov, 2001) students' self-confidence and in turn destroys the students' ATLS, and as a result, their cognitive skills cannot develop in accordance with the age-stage model of (Piaget, 1970). A host of researches indicated that most of the elementary and upper elementary students reach the concrete operational stage (Rima, 2014), however, according to Piaget's age-stage model the students of elementary school must reach at the FOL (Barbara & Tambra, 2008; Campbell, 2006; Gwendolyn, 2010; Nasr & Kono, 2011)

One of the most important reasons of students' poor performance in science subjects can be traced back to the evidence that Pakistan is one of those countries where assessment, testing, and evaluation get low priority in the field of learning, especially, the quality of learning in science and technology fields (Akhtar & Shagufta, 2009). According to Radmehr (2010), annual SEQs often fail to assess Higher Order Cognitive Skills, on the contrary, they promote rote learning (Khan, 2008). Indeed, in Pakistan, the standardized evaluation methods and assessment tests are rarely applied in science subjects at elementary and secondary levels (Memon, 2007; Tahir, 2007). In the same way, the teacher prepares tests by him/herself without adopting/adapting any taxonomy of educational objectives, or Piagetian developmental model. Hence, the teacher-made tests cannot gauge (Mahmoud, 2014) the proper cognitive skills of a child. Therefore, they need to develop an evaluation and testing tool that can measure the intellectual skills of school children properly (Akhtar & Shagufta, 2009).

Literature Review

Science Examination Questions (SEQs)

Meta-analysis of the achievement in science on SEQs shows (Rima, 2014) that Pakistani eighth graders performed poorly on questions which demand abstract thinking and operational reasoning, conceptual and procedural understanding, analyzing the phenomenon and creating solutions for a difficult problem. In the same way, Shah (2010) found a mismatch between students' achievement in science and cognitive demands of science curriculum at elementary and secondary schools in Pakistan. In another study, the cognitive and knowledge process dimensions of the RBT properly show this limitation of the science course SEQs (Talat, Abro, & Jamali, 2013). The presence of gradual increase in cognitive difficulty of SEQs, makes students ready to think on their own, find solutions to the problems in a cooperative manner including the attainment of science knowledge by reflective practices.

Piaget's Conceptual Frameworks (PCFs)

Due to the rapid development of cognitive psychology (Yusuf, Avsar, Yavuz, Uygun, & Ozdil, 2013), the understanding of the students' hypothetical reasoning, metacognitive abilities, and abstract thinking skills have become critical for addressing the issues related to the quality of science education. Therefore, appropriate intellectual maturity is the most important aim of science education, as well as different learning models and assessment tools applied for gauging the cognitive skills of the learners (Yusuf et al., 2013). The PCFs are mental processes which indicate students' understanding levels of abstract and concrete concepts, such as, thinking at lower and higher levels, reflective practices, and perceptions (Nasr & Kono, 2011; Khan, 2008; Kousar, 2009). Similarly, the environmental factors such as, the learning environment of the school, over-stress on completion of course material, preparing students for qualifying in annual examinations (Yusuf et al., 2013), and finally, over emphasis on answering the SEQs instead of developing adequate PCFs of learners hinder the proper conceptual development of the students in elementary and secondary schools (Bush, Daddysman, & Charnigo, 2014). Lower rates of PCFs can affect the students' ATLS negatively (Yusuf et al., 2013).

Misalignment between Different Cognitive Levels and Types of Science Exam Questions

A gap between students' PCFs and the types of questions asked in the examinations, influence the elementary school students' ATLS (DeAvila & Pulos, 1979; De Lisi, 1979; Hartford & Good, 1976). Therefore, in either case of too easy or too difficult SEQs (Rima, 2014) discourage the students from active participation and meaningful learning (Egan & Judson, 2009; Elsa, 2011). Experts in science education (Anderson, 2006; Romiro, 2015; Saad & Saouma, 2012) advocate the multiple use of assessment of students' achievement in science at different courses of time. However, conventional assessment methods, such as annual examinations were only conveniently used to evaluate students' factual knowledge and memory, on the other hand, the assessment of learners' CFs, is more important than any other indicator. The RBT not only allows a teacher to assess his/her students' existing cognitive levels, but helps the students to increase their higher order thinking skills too (Husna & Faridah, 2012). The hierarchy of the RBT can be applied to curriculum development, improving the classroom situation, assessment (Forehand, 2005; Huitt, 2009) and evaluation, proper cognitive development (Crowe, Dirks, & Wenderoth, 2008), and provides the teacher with classified questions (Aly, 2006; Eber & Parker, 2007) categorized at six levels of cognitive development. The RBT consists of two dimensions; first the cognitive process dimension, and second, the knowledge process dimension. The first cognitive process dimension includes six levels; 1) remembering, 2) understanding, 3) applying, 4) analyzing, 5) evaluating, and 6) creating Anderson (2006), while, the knowledge process dimension has four levels; 1) factual, 2) conceptual, 3) procedural and 4) metacognitive.

Analysis of SEQs According to the RBT

As mentioned in foregoing paragraphs, the questions at certain levels of the cognitive dimension of the RBT can improve the cognitive skills of the students; these questions in a hierarchy can also enhance the achievement of students as well. Literature on the "types of questions asked" concludes that the use of questioning strategies by instructors has a major impact on the quality and quantity of student achievement in science (Winne, 1979). In another study, (Ron, 2008) found that the types of questions asked during exam, especially, when higher order thinking questions are used, increased the students' science achievement. Research on the types of questions asked focuses either on the instructor's ability to ask higher order questions or offers the learning in question development for instruction and assessment, is deeply needed (Reeves, 1990).

The presence of gradual increase in cognitive difficulty of SEQs, make students ready to think on their own, to find solutions to the problems in a cooperative manner, including the attainment of science knowledge by reflective practices (Andre, 1979; Usha & Murthy, 2011). According to Egan and Judson (2009), school graders are directly related to PCFs, generally, age and intellectual maturity increase with an increase in a graders level, which in turn improves the reasoning ability of an individual, whereas only one research was available indicating the effect of locality on PCFs of the students (Shah, 2010).

On concluding the foregoing sections, it can be said that students generally differ with each other in their thinking skills and performances. Their thinking skills have direct association with their cognitive developmental levels. These cognitive developmental levels are generally explored with the use of PCFs.

Methodology

It is assumed that the misalignment if exists between the unevenness of cognitive difficulty of SEQs and students' current PCFs, may negatively affect students' learning and ATLS. To analyze this misalignment, the data collection and analysis was broken down into five major steps. The first step involved analyzing the SEQs of eighth and tenth graderss in terms of cognitive levels by applying the RBT, and PCFs by applying Group Assessment Logical Thinking Test (GALT). Next the PCFs of eighth and tenth graders were determined, after which the eighth and tenth graders students' ATLS were evaluated. The last step included exploring the effects of this gap between students' existing PCFs and the cognitive difficulty of SEQs on the ATLS of eighth and tenth graders.

All male and female science students in eighth and tenth grades from rural and urban elementary and high schools of the Sindh province were the population of the study. This study used a multistage convenience sampling techniques; in the first stage of sampling, two districts (i.e., Sukkur and Khairpur selected for accessibility to data and the suitability of the sample for the purpose of the study) out of 23 districts of province Sindh were selected on the basis of the sample situated spatially and administratively near the area where the researcher conducted the data collection and the members of the population were homogenous. This study focused on analyzing the PCFs, cognitive levels of the RBT, and students' ATLS. For data collection, this study used three research instruments; the first was, Group Assessment Logical Thinking Test (GALT), the second was, Test of Science Related Attitudes (TOSRA), and the third was, Cognitive Science Achievement Test (CSAT).

Data Analysis

Descriptive Analysis

The description of the sample between two districts on the basis of graders level, elementary or high school, male or female, rural or urban is presented below in the Table 1.

Table 1
Students' Classification on Graders Level, Sex, School Level, and Area Type between Two Districts

District	Gender		Area		School Type		Graders	
	Female	Male	Urban	Rural	High	Elementary	Eighth	Tenth
Sukkur	114	141	111	144	86	169	199	56
Khairpur	143	166	147	162	116	193	195	114
Total	257	307	258	306	202	362	394	170

Students' distribution was 45.6% and 54.4% respectively for female and male from both districts (Sukkur, Khairpur). The 45.7% of the students belonged to urban schools and 54.3% students were from rural schools. The graders level classification of the sample shows that 64.2% of the students were of 8th graders and 35.8% students were studying in the tenth graders. The data collection was restricted up to the 30 present students in a single class, in case of exceeding number of the students; the remaining students could continue their study with the other teacher.

Classification of Science Examination Questions (SEQs)

By applying the RBT, the classification of the SEQs as follows:

Table 2 reflects that from 77.75% of total questions of the SEQs were of factual knowledge, 22.25% were of conceptual knowledge, while the procedural knowledge and metacognitive level of knowledge were missing totally. However, the 52.25% of questions were of Remembering on cognitive process dimension of the RBT, 23% of questions were of Understanding on the cognitive process dimension of the RBT, 17.25% of questions were of Applying on the cognitive process dimension of the RBT, only 5% of questions were of

Table 2
Distribution of the SEQs According to the Revised Bloom's Taxonomy (n = 400)

Dimension	Remembering	Understanding	Applying	Analyzing	Evaluating	Creating	Total	%
Factual	162	69	57	13	7	3	311	77.75
Conceptual	47	23	12	7	-	-	89	22.25
Procedural	-	-	-	-	-	-	-	-
Metacognitive	-	-	-	-	-	-	-	-
Total	209	92	69	20	7	3	400	100
Percentage	52.25	23	17.25	5	1.75	0.75		

Analyzing on the cognitive process dimension of the RBT, 1.75% of questions were of Evaluating on the cognitive process dimension of the RBT, only 0.75% of questions were of Creating on the cognitive process dimension of the RBT.

Figure 1
Classification of SEQs separately on Factual Knowledge and Conceptual Knowledge)

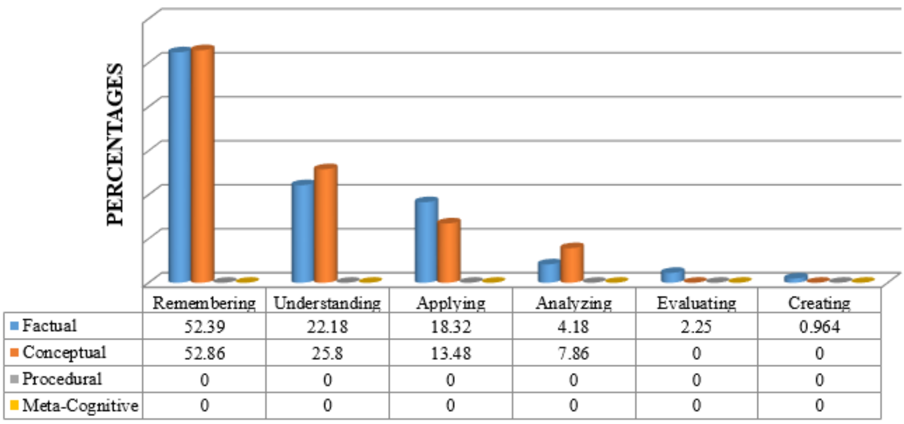


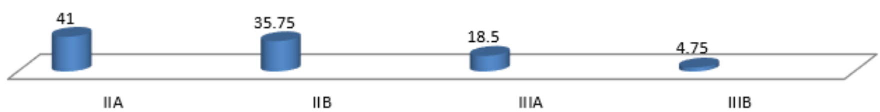
Table 3 shows that out of 400 SEQs, 41% questions recorded at Initial Concrete level (ICL), 35.75% questions analyzed at Mature Concrete level (MCL), 18.5% questions explored at the Initial Formal Operational level (IFOL) and only 4.75% of these questions belonged to the Mature Formal Operational level (MFOL). These questions were classified into five different fields of science included 59 questions of Man and Modern Technology, 91 questions of chemistry, 114 questions of Physics, 88 questions of Biology, and 48 questions about the Geological History of Pakistan. The questions related to Man and Modern Technology recorded as 38.98% at ICL, 33.89% at MCL and 27.11% at IFOL, not a single question was related to the MFOL. The chemistry questions were explored, 37.36% on ICL,

Table 3
Classification of the Questions in Accordance with PCFs (Topicwise)

	Concrete Operations		Formal Operations		Total
Knowledge Specification	Initial Level IIA	Mature Level IIB	Initial Level IIIA	Mature Level IIIB	
Man and Modern Technology	23	20	16	-	59
Chemistry	34	31	14	12	91
Physics	41	39	27	7	114
Biology	39	32	17	-	88
Geological History Of Pakistan	27	21	-	-	48
Total	164	143	74	19	400

34.09% of the MCL, and 15.38% at IFOL, and 13.18% were at MFOL. Similarly, the Physics related questions recorded as, 35.96% at ICL, 34.21% MCL, 23.68% IFOL and only 6.14% of MFOL. The classification of Biology questions analyzed as, 44.31% ICL, 36.36% MCL, 19.31% IFOL, not a single question of FOL was found. Out of the 48 questions about the Geological History of Pakistan, 56.25% questions were on the ICL, and 43.75% were at MCL.

Figure 2
Overall Percentages of the PCFs of Annual SEQs



Classification of Students' General Science Achievements on Cognitive Science Achievement Test (CSAT)

By applying Cognitive Science Achievement Test (CSAT) based on the Revised Bloom's Taxonomy (RBT) the classification of the students' science achievement scores of both districts were identified:

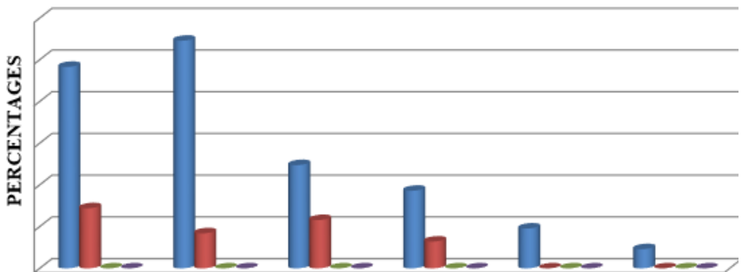
Table 4 reflects that from 87.58% of overall students' science achievement scores on the CSAT were at Factual knowledge, 12.41% were at Conceptual knowledge, while the procedural knowledge and metacognitive level of knowledge were totally missing. However, the 31.02% of students were scored on Remembering on the cognitive process dimension of the RBT, 31.91% of students were of Understanding on the cognitive process dimension of the RBT, 17.55% of students were of Applying on the cognitive process dimension of the RBT, only 12.41% of students were of Analyzing on the cognitive process dimension of the

Table 4
Distribution of the Students' Science Achievement Scores on Cognitive Science Achievement Test (CSAT) (N = 564)

Knowledge Dimension	Remembering	Understanding	Applying	Analyzing	Evaluating	Creating	Total	%
Factual	142	162	87	63	27	13	494	87.58
Conceptual	33	18	12	7	-	-	70	12.41
Procedural	-	-	-	-	-	-	-	-
Metacognitive	-	-	-	-	-	-	-	-
Total	175	180	99	70	27	13	564	100
Percentage	31.02	31.91	17.55	12.41	4.78	2.3		

RBT, 4.78% of students were of Evaluating on the cognitive process dimension of the RBT, only 2.30% of students were of Creating on the cognitive process dimension of the RBT.

Figure 3
Distribution of the Students' Science Achievement Scores on CSAT (N = 564)



	Remembering	Understanding	Applying	Analyzing	Evaluating	Creating
Factual	24.15	27.29	12.38	9.3	4.78	2.3
Conceptual	7.21	4.2	5.79	3.21	0	0
Procedural	0	0	0	0	0	0
Meta-Cognitive	0	0	0	0	0	0

Figure 4

Overall Distribution of Students' Science Scores for Cognitive dimension of RBT

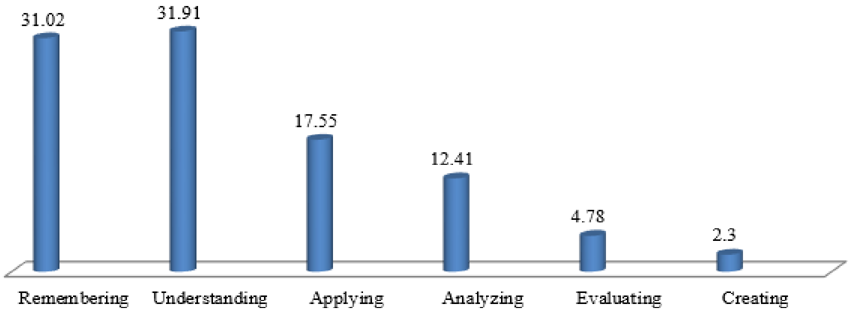
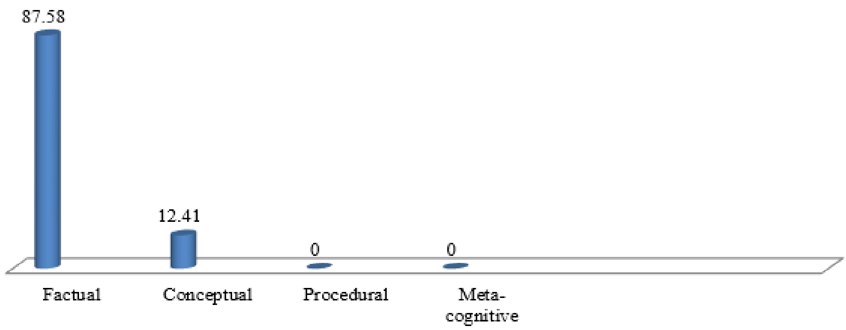


Figure 5

Overall Distribution of Students' Science Scores for Knowledge dimension of RBT



Students' Distribution at Different PCFs

Table 5

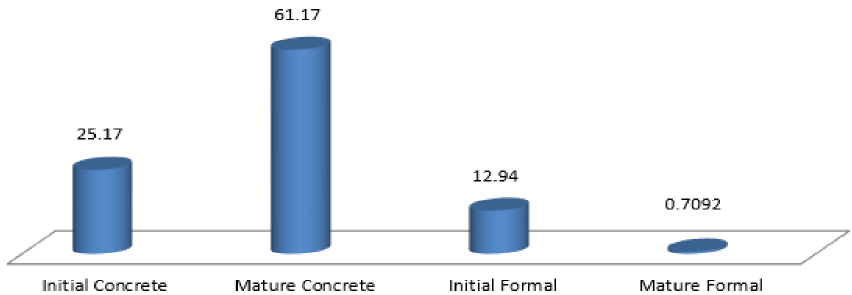
Distribution of Students at PCFs

Students	Initial Concrete (IIA)	Mature Concrete (IIB)	Initial Formal (IIIA)	Mature Formal (IIIB)	Total
ALL	142	345	73	4	564
Eight Graders	91	243	60	-	394
Tenth Graders	51	102	13	4	170

N = 564, eighth graders = 394, Tenth Graders = 170

Table 5 describes that, out of 564 students 112 students in both grades (eighth & tenth) were on ICL, 345 were at MCL, 73 were at IFOL, and finally, only 4 students were at MFOL of the PCFs. Furthermore, eighth graders of both districts out of 394, 91 students were at ICL, 243 were at MCL, 60 were at IFOL, and no one at MFOL of the prescribed classification. However, out of 170 tenth graders, 51 at ICL, 102 were at MCL, 13 were at IFOL and four students were at MFOL of the GALT classification.

Figure 6
Students' Overall Classification of PCFs



Only 0.709% of students in both districts were at MFOL (IIIB), 12.94% of students were at IFOL (IIIB) in two districts, whereas 61.17% of students were at MCL (IIB) and 25.17% of students were at ICL (IIA). Similarly, 15.22% of students in eighth graders were at IFOL (IIIA), 61.67% of students were at MCL (IIB) and 23.09% of students were at ICL (IIA). However, 2.35% of tenth graders students were at MFOL (IIIB), 7.64% of students were at IFOL (IIIA), 60% of students were at MCL (IIB) and 30% of students were at ICL (IIA).

Gender Differences on TOSRA

Table 6
Gender Classification of Attitudes through TOSRA on t test Between Two Districts

Graders	Districts	Gender	N	Mean	SD	t	P
Overall	Sukkur	Male	141	124.14	12.16	-7.26*	0.001
		Female	114	123.39	11.2		
	Khairpur	Male	166	112.73	11.38	-6.37**	0.001
		Female	143	113.48	12.29		
Eighth Graders	Sukkur	Male	102	121.46	11.29	-7.37*	0.013
		Female	91	124.1	12.39		
	Khairpur	Male	106	122.39	11.48	-7.28*	0.003
		Female	95	123.49	12.39		
Tenth Graders	Sukkur	Male	50	121.72	11.06	-3.28**	0.004
		Female	36	123.59	12.28		
	Khairpur	Male	50	123.48	12.46	-4.28**	0.001
		Female	34	121.35	11.46		

*p< 0.001, **p< 0.01

Analyzing the results of Sukkur and Khairpur districts, showed that the t values of both districts (Sukkur district -7.26 & Khairpur district -6.37) were significant at p<0.001 and p<0.01 respectively, hence, it indicated statistically significant differences on standard deviations and mean scores between female and male students of both districts on TOSRA. The analysis of data showed that male students of Sukkur district had more positive ATLS than the female students of the same district, their mean scores (male students, M=124.14 & female students, M=123.39) and deviations (male students SD=12.16 & female students SD=11.20) were recorded respectively. On the contrary, in Khairpur district the female students had more positive ATLS than their district males, their mean scores (female students M=113.48 & male students M=112.73) and deviations (female students, SD=12.29 & male students, SD=11.38) were recorded respectively. Analysis of t test with mean scores of tenth graders, showed that the t values of both districts (Sukkur -3.28 & Khairpur -4.28) were significant at $p<0.01$. The female students of Sukkur district had more positive ATLS than the male students of the same district, their mean scores (female students M=123.59, male students M=121.72) and the standard deviations (female students SD=12.28, male students SD 11.06) were recorded respectively. On the contrary, the male students of Khairpur district had more positive ATLS than the female students of their district mates, their mean scores (male students M=123.48, female students M=121.35) and their standard deviations (male students SD=12.46, female students SD=11.46) were recorded separately. Analysis of the t test with mean scores in eighth graders, showed that the t values of both districts (Sukkur, -7.37 & Khairpur, -7.28) were significant at $p<0.001$. The female students of Sukkur district had more positive ATLS than the male students of the same district, their mean scores (female students M= 124.10, male students M= 121.46) and the standard deviations (female students SD=12.39, male students SD=11.29) were recorded respectively. Similarly, the female students of Khairpur district had more positive ATLS than the male students of their district mates, their mean scores (female students M= 123.49, male students M= 122.35) and their standard deviations (female students SD=12.39, male students SD=11.48) were recorded separately.

Analysis of the GALT

Table 7
Gender Classification of PCFs (PCFs) through GALT on the t test Between Districts

Graders	Gender	N	Mean	SD	t	P
Overall	Male	307	125.14	11.16	-4.26*	0.001
	Female	257	121.39	10.2		
Eighth graders	Male	208	111.46	9.29	-5.37*	0.013
	Female	186	121.1	10.39		
Tenth Graders	Male	100	131.72	13.06	-7.28**	0.004
	Female	70	121.59	11.28		

*p< .001, **p< .01

The Table 7 indicates that, male students (M=125.14, SD=11.16) performed better on the GALT than female students (M=121.39, SD=10.20), finally, the t value (-4.26) was significant at $p<.001$. However, t value (-5.37) was significant at $p<0.05$ for eighth graders, hence, on the basis of t value, it summarized that the female students of both districts secured better scores on the GALT than male students, in this way, their mean scores (female students M=121.10, male students M=111.46) and deviation were recorded (female students SD=10.39, male students SD=09.29) respectively. While for tenth graders students, the t value (-7.28) was significant at $p<.001$, hence, the male students (M=131.72, SD=13.06) performed better on the GALT than female students (M=121.59, SD=11.28) in eighth graders.

Gap between SEQs' Cognitive Difficulty and Students' PCFs with ATLS

Students' CFs were determined through the GALT, and distribution of questions about Science exam at different PCFs identified by applying the RBT. Now, the numbers of questions in the Science exam above students' comprehension levels were calculated by applying the formula:

per% of the questions at any cognitive level = total no. of questions at any level/
*total no. of questions in 30 * 100*

Questions were classified into three categories: 47% Questions above the understanding level of students; 27% Questions below the understanding level of students; 6% unclear questions to the students. Analysis Of Variance (One-Way) was used to analyze the mean score variations on TOSRA among students on difficulty levels of questions above/below the understanding of the students.

Variations in Difficulty Level of SEQs and Students' Gender on TOSRA

Table 8
Analysis Of Variance (One Way) on the Difficulty Level of SEQs Above/Below Understanding Levels of Male Students

	Σ of Squares	*Df*	Average Mean	F	p
Between Groups	4634.29	2	2317.45	6.54**	.001
Within Groups	78453.49	306	257.22		
Total	83087.68	308			

**p<.01

It was evident from the analysis that the F value (6.54) was statistically significant at $p<.01$ for all SEQs for all male students of both districts (Sukkur & Khairpur). It showed that variation in the difficulty level of SEQs had different attitudinal levels on TOSRA.

Variations in Difficulty Level of SEQs and Area on TOSRA

Table 9
Analysis Of Variance (One-Way) on Percentages of SEQs above/below Understanding of Urban Students

	Σ of Squares	*Df*	Average Mean	F	p
Between Groups	1376.34	2	688.17	6.18**	.978
Within Groups	58475.52	256	228.42		
Total	59851.86	258			

It was evident from the analysis that the F value (6.18) was statistically significant at $p<.01$ for all SEQs for all eighth graders urban students of both districts (Sukkur & Khairpur). It showed that variation in the difficulty level of SEQs had different attitudinal levels on TOSRA.

Conclusion

CSAT Analysis of the Science Course Questions of Annual Examination in Eighth Graders

The most of the SEQs identified at the remembering level of the cognitive process dimension and factual and conceptual knowledge dimension of the RBT. The other higher category of questions falls under the understanding level of the cognitive process dimension, and similarly, of factual and conceptual type knowledge. In addition, a majority of Science exam questions were at two sub-stages either of the ICL or MCL. However, some exam questions required the IFOL of thinking and, a very few, unacceptable amount of questions were on IIB level. This indicated that, during the formation of annual SEQs, students' cognitive ability levels were considered at lower levels (remembering and understanding). For the development of questions no cognitive model either the RBT or Piaget's developmental model were considered. In addition, it was clear that, generally, Physics questions require higher order thinking skills as compared to the questions of the Geological History of Pakistan or Man & Modern Technology. However, the Biology and Chemistry questions demand more procedural knowledge than any other sub-area. Technically, findings showed that paper setters neither RBT nor PCFs followed in preparation of SEQs. In addition, the SEQs were found misaligned with the students' cognitive levels in terms of the RBT and PCFs, finally, these questions are also unequally distributed on the RBT and the PCFs.

Distribution of Students at Different PCFs (PCFs)

The majority of the science studying students were either at IIA level, or MCL (IIB) level, however, some of them were on the IFOL (IIIA) level, or a few (only 4 students out of 564) showed skills on MFOL (IIIB) level on PCFs. Analysis of eighth and tenth graders showed mixed results, mostly; tenth graders had more developed PCFs than the eighth graders. Same way, the student's classification at different PCFs recorded in two districts (Sukkur & Khairpur), the majority of the students recorded at ICL and MCLs (almost 65%), a very small number of students recorded at an IFOL and MFOLs. There was a slight difference between the eighth graders and tenth graders on PCFs.

The TOSRA

The male students showed more positive ATLS in comparison with female students of both districts at both grades. Similarly, in Sukkur and Khairpur districts separately, again males had more positive ATLS than female students. On district basis, the female students of Sukkur showed a positive ATLS than the Khairpur district. The eighth graders had positive ATLS than tenth graders. Separate analysis of the data between two districts showed eighth graders are more willing to learn science than the tenth graders. The students of elementary schools showed more positive ATLS than the high school children.

The GALT

The male students reflected higher GALT scores than female students in the overall sample between both districts. Similarly, male students of tenth graders recorded better results on GALT than female students. However, only female students from eighth graders perform better than male students of GALT. Similarly, in Sukkur and Khairpur districts separately, again females had better results than male students on GALT. On district basis, the male students of Sukkur showed higher scores than the Khairpur district, and analysis of female students did not show any significant difference between both districts. There was no significant difference between the scores in eighth and tenth graders on the GALT. The students of tenth and eighth grades got high scores on GALT in district Sukkur. The eighth graders in Khairpur district did not show variation within the group scores on the GALT. The students of Sukkur district in eighth graders recorded variations within the group on the GALT, urban students performed better than the rural students. The students of eighth and tenth graders of both districts in urban areas performed equally better on the on the GALT. Similarly, then there was no variation among the students of rural schools in both districts. However, the students of elementary schools secured better scores than the high school children on the GALT.

ATLS of Students at Different PCFs (PCFs)

Students with variation in their PCFs showed different levels of ATLS on TOSRA. Furthermore, students at ICL reflected the negative ATLS in comparison with the higher cognitive maturity. The findings of the investigation revealed that, positive ATLS has a positive relationship with cognitive maturity. Students of both districts (Sukkur & Khairpur) were, somehow, different at PCFs, showed a great variation in their attitudes. The male students with varying in their PCFs reflected significantly different ATLS. The male students of eighth and tenth gradersr were same with their ATLS as both graders students have the same PCFs of ICL and MCL, though, the tenth graders were better at IFOL and MFOL than the eighth graders, but, their attitude levels were same. The students at ICL (IIA) had a less degree of positive ATLS than the students of MCL (IIB). Similarly, the students of the MCOL had lower scores on TOSRA which showed their lesser degree of positive ATLS than the students at IFOL. In addition, students with IFOL showed a lower degree of positive ATLS than the students with MFOL. Furthermore, the same pattern of higher the cognitive maturity greater the degree of positive ATLS; lower the cognitive skills lesser the degree positive ATLS was found in urban and rural; elementary and high school children; eighth and graders; and Sukkur and Khairpur districts respectively.

Effects of Gap (between Cognitive Difficulty of SEQs and PCFs) on TOSRA

The findings of the study revealed that, the difference in level of cognitive difficulty of exam questions showed different levels of a positive attitude of the learner. Therefore, the higher the level of cognitive difficulty of the exam question, the greater the degree of positive ATLS. The students with 47% of questions of higher comprehension level have a higher degree of positive ATLS than students with 27% of questions of lesser cognitive difficulty. However, the 6%, unclear questions affected negatively the ATLS, as it created a disequilibrium for cognitive learning.

Recommendations

Nearly, 65% of the sample represented the two sub-levels of PCFs; ICL and MCOLs, therefore, it is recommended that the paper setters should incorporate SEQs addressing these levels. Furthermore, the curriculum planners must introduce the science concepts covering these two levels majorly. In addition, the findings of the study advocated that the SEQs should be raised up to higher order cognitive skills (Analyzing, Evaluating and Creating), so that the students can grow more in their cognitive maturity. This study was unique in providing empirical results of the misalignment between PCFs and cognitive difficulty of SEQs in Pakistan, while throughout the world an extensive work has been done so far in this area e.g., (Barbara & Tambra, 2008; De Lisi, 1979). Therefore, in Pakistani context, there is a need of such type of studies at large scale. Only a limited number of questions were analyzed on the basis of RBT and PCFs, further limited in only one subject, therefore, an extensive study is needed to be conducted on various subjects and multi-graders level so that it can be generalized in length and breadth of the country, as TIMSS (Trends in International Mathematics and Science Study).

References

Akhtar, D., & Shagufta. (2009). *A study of relationship of cognitive styles with gender, social class and students academic achievement at elementary level* (Unpublished doctoral dissertation). Allama Iqbal Open University, Islamabad.

Aly, A. (2006). Reflections on Bloom's revised taxonomy. *Electronic Journal of Research in Educational Psychology*, *8*(4), 213–230.

Amer, A. (2006). Reflections on Bloom's revised taxonomy. *Electronic Journal of Research in Educational Psychology*, *4*(1), 213–230.

Anderson, I. K. (2006). *The relevance of science education: As seen by pupils in Ghanaian junior secondary schools* (Unpublished doctoral dissertation). Unpublished Doctoral Thesis, University of the Western Cape.

Andre, T. (1979). Does answering higher-level questions while reading facilitate productive learning? *Review of Educational Research*, *49*(2), 280–318.

Barbara, B., & Tambra, P. (2008). Developmental psychology: Incorporating Piaget's and Vygotsky's theories in classrooms. *Journal of Cross-Disciplinary Perspectives in Education*, *1*(1), 59–67.

Bird, L. (2010). Logical reasoning ability and student performance in general chemistry. *Journal of Chemical Education*, *87*(5), 541–546.

Bischoff, P. J., & Anderson, O. R. (2001). Development of knowledge frameworks and higher order cognitive operations among secondary school students who studied a unit on ecology. *Journal of Biological Education*, *35*(2), 81–88.

Bush, H. M., Daddysman, J., & Charnigo, R. (2014). Improving outcomes with Bloom's taxonomy: From statistics education to research partnerships. *Journal of Biometrics & Biostatistics*, *5*(4), 1–30.

Campbell, R. L. (2006). *Jean Piaget's genetic epistemology: Appreciation and critique*. Summer Seminar, Charlottesville. Retrieved from `http://hubcap.clemson.edu/~campber/piaget.html`

Crowe, A., Dirks, C., & Wenderoth, M. P. (2008). Biology in bloom: Implementing Bloom's taxonomy to enhance student learning in biology. *CBE-Life Sciences Education*, *7*(4), 368–381.

DeAvila, E., & Pulos, S. (1979). Group assessment of cognitive level by pictorial Piagetian tasks. *Journal of Educational Measurement*, *16*(3), 167–175.

De Lisi, R. (1979). *The educational implications of Piaget's theory and assessment techniques.* Eric, New Jersey.

Eber, P. A., & Parker, T. S. (2007). Assessing student learning: Applying Bloom's taxonomy. *Human Service Education*, *27*(1), 45–53.

Egan, K., & Judson, G. (2009). Of whales and wonder. *Engaging the Whole Child: Reflections on Best Practices in Learning, Teaching, and Leadership*, *65*(6), 20–25.

Elsa, E. (2011). Cognitive and psycholinguistic skills of adults who are functionally illiterate: Current state of research and implications for adult education. *Applied Cognitive Psychology*, *25*(5), 753–762.

Forehand, M. (2005). Bloom's taxonomy: Original and Revised. In M. Orey (Ed.), emerging perspectives on the learning, teaching, and technology. Retrieved from http://eit.tamu.edu/JJ/DE

Fraser, B. J., & Butts, W. L. (1982). *Test of science-related attitudes handbook.* Australian Council for Educational Research, Hawthorn, Victoria.

Gray, W. M. (1978). A comparison of Piagetian theory and criterion-referenced measurement. *Review of Educational Research*, *48*(2), 223–249.

Gwendolyn, D. G. (2010). Education in Pakistan: The key issues, problems and the new challenges. *UNEVOC Canada & ICELP International conference unlocking the human potential to learn. ABLA Community Scholars Project Chicago, Illinois USA*.

Hartford, F., & Good, R. (1976). Assessment of cognitive requirements of instructional materials. *School Science and Mathematics*, *76*(3), 231–237.

Hudson, P. (2007). High-impact teaching for science. *Teaching Science: The Journal of the Australian Science Teachers Association*, *53*(4), 18–22.

Huitt, W. (2009). Bloom et al.'s taxonomy of the cognitive domain. *Educational Psychology Interactive*, *22*. Retrieved from http://www.edpsycinteractive.org/question/cogsys/.

Husna, U., Azizan, & Faridah, I. (2012). Identifying pupil's cognitive level in fractions using Bloom's taxonomy. *International Journal of Business and Social Science*, *3*(9), 283–293.

Iverach, M. R., & Fisher, D. L. (2008). An interdisciplinary investigation of high school students' approaches to learning science: The relations amongst achevement goals, consrictivist pedagogical dimensions, motivational belefs and self-regulated learning. *Science Mathematics and Technology Education: Beyond Cultural Boundaries*, 233-255.

Kelvin, S. (2001). *Conceptual frameworks and the education of young children. Handbook of research on the education of young children.* Erlbaum, New Jersey.

Khan, S. A. (2008). *An experimental study to evaluate the effectiveness of cooperative learning versus traditional learning method* (Unpublished doctoral dissertation). International Islamic University, Islamabad.

Kousar, P. (2009). *Comparative effectiveness of expository strategy and problem solving approach of teaching mathematics at secondary level* (Doctoral dissertation, PMAS-Arid Agriculture University, Rawalpindi). Retrieved from http://www.eprints.hec.gov.pk/cgi/search

Mahmoud, A. (2014). An analysis of the tenth grade english language textbooks questions in Jordan based on the revised edition of Bloom's taxonomy. *Journal of Education and Practice*, *5*(18), 139–151.

Matusov, E. (2001). The theory of developmental learning activity in education: Dialectics of the learning content. *Culture & Psychology*, *7*(2), 231–240.

Melehat, Gezer, M., Oner Sunkur, & Sahin, I. F. (2014). An evaluation of the exam questions of social studies course according to revized Bloom's taxonomy. *Education Sciences & Psychology*, *28*(2), 3–17.

Memon, G. R. (2007). Education in Pakistan: The key issues, problems and the new challenges. *Journal of Management and Social Sciences*, *3*(1), 47–55.

Nasr, A. R., & Kono, A. (2011). Attitude towards biology and its effects on student's achievement. *International Journal of Biology*, *3*(4), 100–104.

Oliveira, A. W. (2010). Improving teacher questioning in science inquiry discussions through professional development. *Journal of Research in Science Teaching*, *47*(4), 422–453.

Parker, S. K., Wall, T. D., & Cordery, J. L. (2001). Future work design research and practice: Towards an elaborated model of work design. *Journal of Occupational and Organizational Psychology*, *74*(4), 413–440.

Parveen, Q. (2010). A comparison of the effectiveness of use of transmitter of knowledge and inductive inquiry models on students academic achievement. *Unpublished PhD dissertation, Department of Education, Faculty of Social Sciences International Islamic University, Islamabad.*. Retrieved from `http://prr.hec.gov.pk/ThesisS`

Piaget, J. (1970). Science of education and the psychology of the child. Revolution in the teaching of intelligence.

Polk, M., B Frank, & Goldstein. (1980). The lancet: Randomised clinical trial of perioperative cefazolin in preventing infection after hysterectomy. *The Lancet*, *315*(8166), 437–441.

Rader, J. R. (1975). Piagetian assessment of conservation skills in the gifted first grader. *Gifted Child Quarterly*, *19*(3), 226–229.

Radmehr, F. (2010). A study on the performance of studentsmathematical problem solving based on cognitive process of revised bloom taxonomy. *Journal of the Korea Society of Mathematical Education Series D*, *14*(4), 381–403.

Reeves, M. F. (1990). An application of Bloom's taxonomy to the teaching of business ethics. *Journal of Business Ethics*, *9*(7), 609–616.

Rima, K. (2014). *Evaluating textbook questions and classroom instructional questionsfor grade 6 science in a private school in Dubai based on the revised Bloom's taxonomy* (Unpublished doctoral dissertation). Dissertation submitted in partial fulfillment of the requirements for the degree of M.Ed. in International Management and Policy Faculty of Education Dubai.

Romiro, B. G. (2015). The impact of cognitive and metacognitive learning strategies in desktop teaching. *Journal of the Association for Anglo-American Studies*, *1*(2), 135–143.

Ron, S. (2008). Investigating the relationship between cognitive ability and academic achievement in elementary reading and mathematics. *University of Nebraska - Lincoln Digital Commons University of Nebraska - Lincoln*.

Saad, R., & Saouma, B. (2012). The relationship between teachers' knowledge and beliefs about science and inquiry and their classroom practices. *Eurasia Journal of Mathematics, Science & Technology Education*, *8*(2), 113–128.

Shah. (2010). Analysis of cognitive difficulty of the concepts taught in science in eighth graders, Piagetian developmental levels of students and their attitude toward the learning of science. *Doctoral thesis, Punjab University, Lahore, 2010*. Retrieved from `http://www.eprints.hec.gov.pk/cgi/search`

Tahir, M. (2007). *Impact of formative evaluation and fixed internal schedule reinforcement on academic achievements of secondary school students* (Doctoral dissertation, National University of Modern Languages, Islamabad). Retrieved from `http://www.eprints.hec.gov.pk/cgi/search`

Talat, E., Abro, A., & Jamali, Y. (2013). Analysis of PCFs of learners at concrete operational stage in Pakistan. *Interdisciplinary Journal of Contemporary Research in Business*, *5*(3), 139–151.

Toyin, T., Jamie, E., & Stuart, H. (2013). Best practice strategies for effective use of questions as a teaching tool. *American Journal of Pharmaceutical Education*, *77*(7), 1–9.

Tschopp, J. K., & Kurdek, L. A. (1981). An assessment of the relation between traditional and paper-and-pencil formal operations tasks. *Journal of Research in Science Teaching*, *18*(1), 87–91.

Usha, V., & Murthy, S. (2011). Raising students' cognitive skills, extending level of textbook questions: Can we do both. *Proceedings of episteme 4, India*, 189–193.

Winne, P. H. (1979). Experiments relating teachers' use of higher cognitive questions to student achievement. *Review of Educational Research*, *49*(1), 13–49.

Yusuf, Y. H., Avsar, L., Yavuz, O. C., Uygun, H., & Ozdil, Y. (2013). Evaluation of the mathematics questions in the last twelve years of the public boarding and bursary examination for the fifth grade students according to the bloom taxonomy. *European Journal of Educational Studies*, *5*(3), 52–62.