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Chemistry Laboratory Teaching-Learning Environment – Developing an Inventory for Survey

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***Abstract*: This paper deals with the development of a new instrument to conduct a survey research on chemistry laboratory teaching-learning environment at intermediate level. The sample size was consisted of 360 male students of grade 12 doing their F.Sc. with chemistry as one of the science subject from 12 public sector colleges of Lahore. The syntax of all the statements was set on class form with the response pattern on 5-point Liker scale. The dimensionality of items was identified by factor analysis. The cumulative percentage of variance with three scales was obtained 62 %. The three dimensions were defined: teaching tactics, communing climate, and learning ambiance with items 9, 7 and 5 respectively. Teaching tactics scale deals with the teaching strategies facilitating learners in their learning improvements. Communing climate scale deals with the helping and sharing attitude of individuals at workplace. Learning ambiance scale deals with the atmosphere available to students where their learning is enhanced. Cronbach alpha reliability for overall instrument was obtained 0.79. Descriptive statistics,score distribution and characteristics of the curve were discussed on overall perception as well as on three scales.**

***Keywords*: Teaching learning environment, students' perception, chemistry laboratory, teaching tactics, communing climate, learning ambiance.**

1. INTRODUCTION

Is it newest to contemplate the worth of laboratory activities in science subjects? Kirschner and Meester (1988) argue that it is enormously rare for anybody to question the necessity of laboratory work. Hofstein (2004) accentuates that the science cannot be meaningful to students without worthwhile practical experiences in the laboratory. Waldrip (1994) draws attention that practical work was first the part of university education, however, soon after its significance was also acknowledged at secondary education.

Holbrook (2005) focuses his mind towards the role of teacher as they need to know what their pupils are thinking and learning in laboratory and classroom. Learning is contingent upon what teachers and pupils do in classrooms, teachers manage complicated and demanding situations, channeling the personal, emotional, and social pressures of students to help in learning and make better learners in the future (Black & William, 1998). According to Altaf (n.d.), these are the teaching strategies of the teachers that are worthwhile to know students' performance in lab by means of formative assessment and to do diagnostic measures. In the nut shell, teaching and learning are undivided, unifying force of conjunction, rather than yoking together of discrete elements of classroom environment as emphasized by Fry, Ketteridge and Marshall (2009, p. 301)

The classroom activities can be measured by means of perceptions of students and teachers (Fraser, 1986). These perceptions provide an important perspective on educational settings (Moos 1979, as cited in Baek& Choi, 2002). This technique has been given considerable attention since1960s. Fraser, Treagust, Fisher, Quek, Wong, Waldrip, Aldridge, and many others are well known leaning environment researchers who have conducted their studies on classroom environment through perceptions of students and teachers for all levels of education. It has been written in National Curriculum of Pakistan (2006) for chemistry grades XI – XII that students watch their teachers and notice so many things about them. Highlighting another benefit Waldrip (1994) mentions that the perceptions are obtained from many lessons based on students' perceived experience rather than on observed behavior.

For survey research on science laboratory classroom environment at school level, an instrument Science Laboratory Environment Inventory (SLEI) is found in the literature (Hofstein, 2004; Fraser & Griffiths, 1992; Chin & Wong, n.d.; Rickards, 1998). Chin and Wong argue that SLEI is the only instrument that is used in the study of science laboratory classroom environment at secondary level. Rickards views that this instrument was specially designed for senior secondary and tertiary level science laboratories. SLEI was consisted of eight scales in its initial version but the field testing and item/factor analysis changed it into five scales. According to Fraser and Griffiths the initial version was made up of 72 items with equal distribution in eight scales; however, the modified version was composed of 35 items.

Henderson, Fisher, and Fraser (1995); Lee and Fraser (2001); and Fraser (2007, p. 107) indicate that the preliminary version of SLEI was field tested in many countries such as Australia, Canada, England, Israel, Nigeria and USA with a sample of 5447 students in 269 classes. Quek, Wong, and Fraser (2001); Kalu (2004); and Wong and Fraser (1994) have described its various forms: Class form (actual or preferred) and Personal form (actual or preferred). Wong and Fraser conducted a study based on SLEI in which the questionnaires were also filled by teachers with the students and given new titles as: teacher actual form, teacher preferred form, student actual form, and student preferred form. The format, number of items and scales were same in all these four forms except the wording. According to Wong and Fraser, the statements were reworded for teacher version for getting their perceptions rather than student.

Although, SLEI has also been used for chemistry laboratory; however, Quek, Wong and Fraser (2002, 2005) developed a particular Chemistry Laboratory Environment Inventory (CLEI) parallel to SLEI with five dimensions: student cohesiveness, open-endedness, integration, rule clarity, and material environment. Kijkosol (2005) has provided the definitions of these variables. According to him student cohesiveness is "an extent to which students know, help and are friendly towards each other". Open-endedness is "an extent to which laboratory activities emphasize an open-ended, divergent approach to experimentation". Integration is "an extent to which laboratory activities are integrated with non-laboratory and theory classes". Rule clarity deals with the "emphasis on clear rules, on knowing the consequences for rules-breaking, and on the teacher dealing consistently with students who break rules". Material environment is "an extent to which books, equipments, material, space, and lighting are adequate". These five dimensions are not unique for SLEI and CLEI but also constitute many other inventories related to classroom environment, shown in table 1.

Table 1: Description of Five Scales of SLEI/CLEI and the Use in Various Inventories

Scale	Inventory (Reference)
Student Cohesiveness:	LEI: Learning Environment Inventory (Fraser, Anderson, &Walberg, 1982); MCI: My Class Inventory (Fraser, Anderson, & Walberg); CUCEI: The College and University Classroom Environment Inventory (Treagust, &Fraser, 1986); SLEI (Abudhim, Yunanxiang, &Mutahar, 2008); WIHIC: What Is Happening In this Class (Dorman, &Adam, 2004); TROFLEI: Technology-Rich Outcomes-Focused Learning Environment Inventory (Aldridge, Dorman, &Fraser, 2004; Dorman, Aldridge, & Fraser, 2006); MSCI: My Science Class Inventory (Chin, & Wong, n.d.); CLEI (Quek, Wong, &Fraser, 2002, 2005).
Open-Endedness:	SLEI, MSCI, CLEI
Integration:	SLEI, MSCI, CLEI
Rule Clarity:	CES: Classroom Environment Scale (Fisher, 1986); SLEI, MSCI, CLEI
Material Environment:	LEI, SLEI, MSCI, CLEI

CLEI has widely been used in various studies. Wong and Fraser are prominent figures who have conducted many research studies in Singapore and their collaboration is significant that they have a lot of research related with chemistry laboratory learning environment (Wong, Young, & Fraser 1997; Wong,& Fraser 1994; Quek, Wong,& Fraser 2002).

Other than CLEI, the literature shows a list of 13 questions on 5-point Likert scale which were used in another survey with first year Scottish undergraduate students on looking their reactions to chemistry laboratory experiences (Reid, 2011, pp. 23-24). Reid mentions further that later on the same questions were used by Shah, Riffat, and Reid (2007) in their survey study with various postgraduate groups in Pakistan.

In another study, Domin (2007) has reported a questionnaire with 7 statements, which he used with seventeen students at the end of the second semester regarding their perceptions of the different chemistry laboratory instructional environments, i.e., traditional lab style or problem-based style. In the past, Welberg and Moos are the eminent pioneers who worked on classroom events in terms of individual's perceptions in late 1960s (Fraser 1986, p.16). Since then number of new instruments have been developed related to investigation on classroom environment.

2. METHOD

The learning environment instrumentin its development follow the familiar pattern of three core stages: (1) identification of salient dimensions and items related to the field of study and covering social climate dimensions identified by Moos, (2) reviewing of tentative items by experts, (3) field testing and data analysis for studying the internal consistency of each scale (Clayton 2007., Aldridge, Dorman & Fraser 2004., and Treagust& Fraser 1986). Chemistry laboratory teaching-learning environment inventory (CLTLEI) adhered to this pattern in its developmental stages. Initially, detailed notes prepared on students activities in chemistry laboratory from three male colleges of public sector and discussed with class teachers. Subsequently, a preliminary draft of questionnaire was sketched out with 34 items on Likert five-point scale as: undecided (0), strongly disagree (1), disagree (2), agree (3), strongly agree (4). The items were brought out to give a format of 'class and actual forms' and secondly to make a relevancy with Moos's dimensions. Rudolf Moos developed his social climate scale in 1974, which had three basic dimensions: relationship, personal development, and system maintenance and system change (Fraser 1986, p.16; Cuyjet, Howard-Hamilton, & Cooper 2011, p.57). Tentative statements made better on content validity by three experts having their experiences teaching chemistry laboratory classes for many years. Cronbach Alpha reliability coefficient was adjusted to a suitable intensity by pilot testing for two times. The items with low or negative correlations were deleted and the statements of many items were restated. Finally, the instrument was adjusted at 21 items for field testing.

3. FACTOR ANALYSIS

The dimensionality of 21 items was identified by using maximum likelihood factor analysis. With three scales, the Total Variance Explained reported cumulative percentage of variance by 62 % and was equal to the variance of unrotated factors. The variance of first three factors reported were 37.13 %, 12.81 % and 12.00 %. Table 2 shows the factor loading of 21 items.

Table 2: Factor Loading on CLTLEI

Item No.	Factor Loading	Item Statement
Factor 1		
1	.92	Students do their practical work in groups in our chemistry laboratory.
2	.86	All the details of chemistry experiments are present in laboratory manual and there is no need to design experiments by ourselves.
3	.87	Our teacher first demonstrates experiment then we do that.

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4	.81	For more awareness, internet, other books or science magazines are consulted for chemistry practical work.
8	.89	Students write down their experimental work on their note books during practical period.
9	.94	Students finish their experimental work in the time provided.
13	.91	Chemistry practical work is not made easy and interesting for us.
18	.89	In our chemistry lab. the experimental results are almost same of all students.
21	.92	Teacher writes suggestions on practical notebooks for the improvement of students' learning.
Factor 2		
5	.80	Students' performance in chemistry lab. skills is supervised and is supported by teacher's guidance.
6	.53	Students' performance in following chemistry lab. safety rules is supervised and is supported by teacher's guidance.
7	.79	Students can discuss chemistry practical work with their teacher.
10	.62	Those students, who create problem and destroy disciplines are controlled in a better way.
15	.54	Teacher provides special guidance to those students who are weak in chemistry practical work.
17	.58	Each student is encouraged to do experimental work by himself.
20	.57	Minimum, students' practical note books are examined once each after two weeks.
Factor 3		
11	.70	We feel a big difference between theory and chemistry practical work.
12	.59	There is no relation between chemistry experiments and our daily life.
14	.53	There is no interaction for the interest of students in the environment of our chemistry laboratory.
16	.68	Students' performance is assessed only on the basis of calculations and results they produce after experimental work while experimental and scientific skills are ignored.
19	.70	Students' understanding and following chemistry laboratory safety rules is ignored while assessment.

N = 50 students all male, grade 12, from one of the public sector colleges of Lahore, selected conveniently, doing F.Sc (Faculty of Science: Intermediate level of Pakistan grade 11, 12)

The dimensionality of 21 items was adjusted into three constructs, teaching tactics (factor 1), communing climate (factor 2), and learning ambiance (factor3). Thereafter, the scales were defined as in table 3.

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Table 3: CLTLEI Dimensions and Definitions

Dimensions	Moos Category	Definitions
Teaching Tactics	P	A degree that defines teaching strategies facilitating learners in their learning improvements.
Communing Climate	R	A degree that defines helping and sharing attitude of individuals at workplace.
Learning Ambiance	S	A degree that defines an atmosphere available to students where their learning is enhanced.

P, R, S stand for personal growth, relationships, and systems, maintenance and change.

4. RESULTS

Descriptive Information:

Table 4 provides descriptive information of CLTLEI. Students have depicted their perception somewhat less in favor of learning ambiance. This dimension dealt with the statements to investigate the friendly atmosphere of chemistry laboratory providing opportunities for learning fortification. The mean 54 % revealed that the lab contribution was less passable on learning ambiance. Communing climate dimension was designed to investigate teacher's encouragement and support for learners during laboratory teaching. With 71 % of its mean, this feature is relatively better in the view of students.The third dimension teaching tactics is not less than to a certain level of its acceptance by having mean at 63 %.

Figure 1 show another view of the responses, where, the percentages at agreeing (A+SA) are high in all categories. This has revealed less disfavored perception of students with respect to chemistry laboratory teaching-learning environment (A+SA = 64 %).

Table 4: Descriptive Information & Reliability Index of CLTLEI and its Scales

Scales*	No of Items	TotalScore		
(Range)	Mean	Alpha Reliability		
TT	9	36 (4 – 34)	22.71 (63%)	.62
CC	7	28 (0 – 28)	20.00 (71%)	.75
LA	5	20 (0 – 19)	10.83 (54%)	.65
CLTLEI	21	84 (8 – 74)	53.54 (64%)	.79

* N=360 in all categories (male students studying chemistry at grade 12 of F.Sc. from all 12 public sector colleges of Lah ore.)

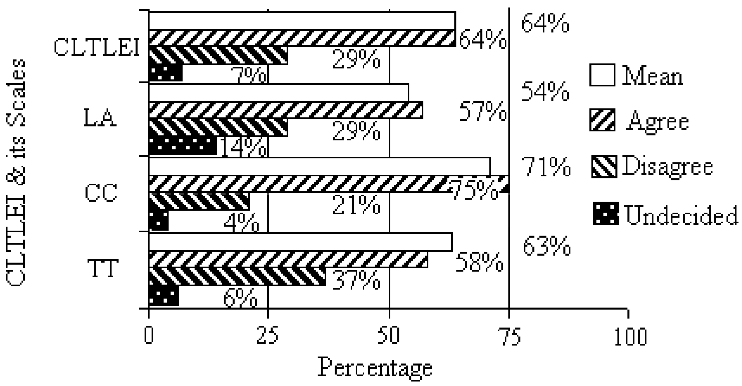

Figure 1. Relative strengths of responses on Likert scale and means.

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Score Distribution:

Table 5 shows data distribution; has elaborated more clearly in figure 2. The distribution is around standard deviation -1.68 to 2.29 on z-score; and on T score it is around 33.20 to 72.90 for three scales collectively. The score distribution of overall instrument is within -2.00 to +2.00 standard deviation; i.e., 30 to 68 on T score.

Table 5: Score Distribution on z and T Score

Scales	**Colleges**	**Range of Mean**	**T Score Transformation****		
	N	SD	Actual	z-Score*	
TT	12	1.98	19.37 – 25.57	-1.68 – 1.44	33.20 – 64.40
CC	12	2.17	17.67 – 24.97	-1.07 – 2.29	39.30 – 72.90
LA	12	1.70	6.70 – 13.00	-2.43 – 1.28	25.70 – 62.80
CLTLEI	12	4.93	43.73 – 62.43	-1.99 – 1.80	30.10 – 68.00

*All means at z-score are 0.00; ** T = 10 × z + 50

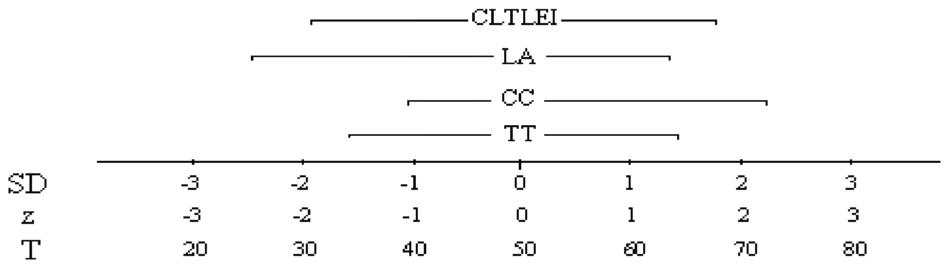

Figure 2: Obtained scores of CLTLEI around normal distributions.

Characteristics of the Curve:

Table 6 explains the shapes of curves. The peaks of all the curves are sharp and showing positive kurtosis, i.e., leptokurtic; in other words, higher to normal kurtosis (zero). Leptokurtosis of learning ambiance is very close to normal, while CLTLEI is showing excessive high peak. All the curves are negatively skewed and are not much beyond to the normal skewness (-1 to +1).

Table 6: Kurtosis and Skewness of the Curves

Scales	N	Kurtosis	Skewness	Type of Mode	Order of Central Tendencies
TT	360	2.55	-1.10	Unimodal	Mean < Median < Mode 22.71 23 25
CC	360	1.92	-0.79	Unimodal	Mean = Median < Mode 20 20 21
LA	360	0.15	-0.56	Unimodal	Mean < Median < Mode 10.8 11 13
CLTLEI	360	4.14	-1.37	Unimodal	Mean < Median < Mode 53.54 55 58

5. DISCUSSION

Gupta-Bhowon, Jhaumeer-Laulloo, Wah and Ramasami (2009, p. 365) argue that students interact closely with teachers and peers in a well-designed laboratory and thus learning can be enhanced, monitored, and assessed effectively. In CLTLEI, the teaching tactics scale covered the questions relating to how teacher managed to make his teaching effective. For example, managing students' working in groups or individual; involving students to imitating the steps as demonstrated by the teacher or help them in discovery; involving the students to get more awareness by the use of other resources such as internet etc or just follow the laboratory manual; managing that the results of almost all students should be same or the results vary student to student or group to group; managing the strategy so that students finish their experimental work and writing practical notebook within the specified practical period; and engaging the teacher himself on writing the suggestions on students' laboratory notebooks for learning improvements.

Communing climate covered the questions relating to investigating how teacher was encouraged and helping for students. For example, students' performance in laboratory is supervised and supported by teacher's guidance or this component is missing; creating an environment where students feel free to discuss with teacher on practical work whenever they need it or students feel hesitation; creating an environment for such situations where special guidance is required for students when they feel they are weak on a particular experiment or teacher does not like to give special time/guidance to handle such serious matters of learning situations; creating an environment where students feel that their written work of experiments is examined by the teacher regularly and can get feedback; further, disciplinary control of the laboratory is well managed or not.

Learning ambiance covered the questions relating to the available atmosphere of the chemistry laboratory which provided opportunities for learning enhancement. For example, laboratory activities provide an atmosphere where students feel that they are doing experimental work to support an understanding of the scientific concept which they study in theory class, or a burden is created in the mind that along with theory classes they have to attend laboratory classes as an additional workload; an attractive outlook of lab to attract student to spend time there, so it may cause development of interest among students towards lab work or they feel what a boring place where they have to do some academic work; an atmosphere where students' assessment is bona fide or students feel that they just have to show their experimental results to the teacher and what they do during experimental activities is never assessed.

CLTLEI is a short form questionnaire developed in Pakistani perspective with the help of field notes and guidance from chemistry teachers. According to Waldrip (1994), the technique of research involving measurement of perceptions is more economical compared to cost and time involved in training an outside observer. Baek and Choi (2002) argue that suppose outsiders are more 'objective' to obtain some information about the classroom, but it is difficult for them to know the real setting without actually participating in it. Students are obviously the participants of the research study that spend a considerable amount of time (Waldrip; Baek& Choi) to form accurate, durable impressions of the social milieu of an educational setting (Baek& Choi). Acquiring acceptablyfine reliability, the attributes of the instrument are securing not much beyond to the normal curve. The three scales of the instrument cover three important features of classroom environment: teaching strategy, communing climate, and learning ambiance. Shah and Nasir (2011) state that:

"Promotion of learning science among students at all levels of education has been the prime focuses of the educational policy 2009-10 of (Pakistan); so, there is a need to explore different factors that possibly have any effect on science learning especially at school level."

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