STUDENT PERCEPTIONS OF THE CHEMISTRY LABORATORY LEARNING ENVIRONMENTS AND STUDENT – INSTRUCTOR INTERACTIONS IN THE UNDERGRADUATE CHEMISTRY LABORATORY COURSES IN LEBANON

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Abstract

Laboratory work is a core component of university chemistry courses across the world in higher education. The importance of the classroom environment has been increasingly recognized over the past 50 years. This study investigates the chemistry laboratory environment, and it focuses on the actual chemistry laboratory learning environment and student-instructor interactions. The participants in this study are 152 undergraduate students at a private university in Beirut, Lebanon. The Actual Chemistry Laboratory Environment Inventory (ACLEI), and the Questionnaire on Teacher Interaction (QTI) were used to collect data. This study led to several findings: first, students perceived that their actual chemistry laboratory environment is relatively favourable; and second, students believed that teachers have a sense of leadership, understanding, and high standards but they are not very strict. Recommendations for improving chemistry laboratory learning environments.

Keywords: Chemistry Laboratory, Undergraduate Chemistry, Laboratory, Laboratory Environment, Student-Instructor interaction

1. Introduction

The introduction of practical work into university science courses started in Germany in the early 19th century and was spread to Scotland, America, and England by mid to late 19th century (Boud, Dunn & Hegarty-Hazel, 1986). Practical work is now well established, but there are considerable variations in the amount of practical work that contributes to different science programs throughout the higher education sector. Today, the aims may be different, in that many chemistry first degree graduates are not employed as bench chemists in the industry (Duckett et al., 1999; Statistics of Chemistry Education, 2007), and the needs of research have inevitably become much more specialized as chemical knowledge has expanded.

Carnduff and Reid (2003) outlined the need of the laboratory work in chemistry in higher education in terms of three broad areas: 1) *Practical skills* (including safety, hazards, risk assessment, procedures, instruments, observation of methods); 2) *Transferable skills* (including team working, organization, time management, communication, presentation, information retrieval, data processing, numeracy, designing strategies, problem-solving); and 3) *Intellectual stimulation* (connections with the 'real world', raising enthusiasm for chemistry).

Carnduff and Reid (2003) went on to provide a set of possible reasons for the inclusion of practical work in chemistry undergraduate courses: 1) illustrating key concepts; 2) seeing things for 'real'; 3) introducing equipment; 4) training in specific practical skills and safety; 5) teaching experimental design; 6) developing observational skills; 7) developing deduction and interpretation skills; 8) developing team working skills; 9) showing how theory arises from experimentation; 10) reporting, presenting, data analysis and discussion; 11) developing time management skills; 12) enhancing motivation and building confidence; and 13) developing problem-solving skills.

2. Chemistry Laboratory Learning Environment

The current field of learning environments has been shaped by several powerful figures over the years. In the past, the most common means of measuring the learning environment has been through the use of perceptions; that has led to insights into the learning environment through the eyes of the participants, rather than through the eyes of an external observer. There are numerous classroom environment instruments available that adequately assess

perceptions of classroom learning.

Chapaman and Tummer (1995) stated that perception is based on the premises that one's knowledge is developed from the senses. The public's perception is never uniform; individual's perceptions and attitudes are dependent on their subjective interpretation and evaluation of characteristics, and significance as influenced by factors such as culture, the media and social and educational experience. According to Chapman and Tummer, there are three components of the self-perception of academic ability construct: first, "perception of competence" which refers to beliefs or feelings regarding academic ability and proficiency in the content area; second, "perception of difficulties" which refers to beliefs that specific content area tasks are hard and which is also a part of each student's self-appraisal regarding the ability to achieve; and third, "attitudes" regarding specific content areas. Self-perceptions are a person's own beliefs or predictions concerning their abilities and performance. This may be different from an individual's actual performance. Both self-perceptions and actual competence have traditionally been divided into four smaller categories. These include academic, social, emotional, and behavioral (self-) perceptions.

The strongest tradition in past classroom environment research has involved investigation of the association between students' cognitive and affective learning outcomes and their perceptions of psychological characteristics of their classrooms (Fraser & Fisher, 1982; Haertel, Walberg & Haertel, 1981; McRobbie & Fraser, 1993). Numerous research programs have shown that student perceptions account for appreciable amounts of variance in learning outcomes, often beyond that attributable to background student characteristics. For example, Fraser's (1994) tabulation of 40 past studies in science education showed that associations between outcome measures and classroom environment perceptions had been replicated for a variety of cognitive and affective outcome measures, a variety of classroom environment instruments, and a variety of samples ranging across numerous countries and grade levels.

Lewin (1936) initiated the idea that personal behavior is a result of the interaction between the individual and his/her environment. Murray (1938) expanded upon this idea by considering additional effects within the system, namely, that an individual's behavior is affected internally by characteristics of personality and externally by the environment itself. The individual's interaction with the environment relates to the personal needs of the individual. Herbert Walberg and Rudolf Moos independently examined participant perceptions of various learning settings (Moos, 1974b, 1979; Walberg, 1979; Walberg & Anderson, 1968). Research and evaluation related to Harvard Project Physics led Walberg and Anderson (1968) to develop the Learning Environment Inventory (LEI).

Moos (1974a) developed a scheme for classifying human environments into three dimensions (relationship, personal development, and system maintenance and change) to enable the classification and sorting of various components of an environment. The three basic types of dimensions that assist in explaining characteristics of human behavior are described below: 1) The *Relationship Dimension* that assesses the nature and intensity of personal relationships within the environment and the extent to which people are involved in the environment and support one another; 2) The *Personal Development Dimension* that assesses the extent of personal growth and self-enhancement; and 3) The *System Maintenance and System Change Dimension* that assesses the responsiveness, orderliness, level of expectation and control of the environment.

Past research which investigated the determinants of classroom environment has revealed reliable differences in the perceptions of classroom environment held by students and their teachers (Fraser, 1984), and by male and female students (Fraser et al., 1995). In other studies, classroom environment was found to vary with class size (Anderson & Walberg, 1972), between students from different streams or tracks (Wong & Fraser, 1994) and between Catholic and governmental schools (Dorman et al., 1994).

In Australia, Fraser and his colleagues began programmatic research which first focused on student-centered classrooms and involved the use of the Individualized Classroom Environment Questionnaire (ICEQ) (Fraser 1980, 1990). Subsequently, other specific instruments were developed, validated and applied to a variety of research purposes around the world. In particular, these questionnaires include the Science Laboratory Environment Inventory (SLEI) (Fraser et al., 1995; Henderson et al., 2000; Wong & Fraser, 1996), Constructivist Learning Environment Survey (CLES) (Kim et al., 1999; Taylor et al. 1997), and the What Is Happening In this Class? (WIHIC) (Aldridge et al., 1999; Dorman, 2003; Fraser & Chionh, 2000).

Finally, the varied types of past research on educational learning environments include: (a) investigations of associations between student outcomes and classroom environment (McRobbie & Fraser, 1993; Wong, Young & Fraser, 1997); (b) evaluation of educational innovations and systemic reform; (c) investigation of differences between student and teacher perceptions of experienced and perceived learning environments; (d) studies of changes in learning environments during the transition from primary to high school; (e) teachers' practical attempts to improve their own classroom and school environments; and (f) incorporation of educational environment ideas into the work of school psychologists.

An essential characteristic of the effective chemistry education is to support theoretical explanations with actual practices in the laboratory. Therefore, laboratory activities had a unique and central role in chemistry

education. Science educators have proposed that many educational benefits accrue from engaging students in chemistry laboratory activities (Lunetta, 1998). When properly developed, laboratory activities have the potential to enhance students' achievement, conceptual understanding and understanding of the nature of science as well as their positive attitudes and cognitive growth (Hofstein, Nahum, & Shore, 2001; Lazarowitz & Tamir, 1994). Since the atmosphere of laboratory is less formal when compared to the classroom atmosphere and presents the opportunities for more interaction between students and teacher, students and their peers; it naturally has the potential to promote positive social interactions and thus create a constructive and positive learning environment (Hofstein et al., 2001; Lazarowitz, 1991).

2.1 Development, Validation and Use of Chemistry Laboratory Environment Inventory (CLEI)

The Science Laboratory Environment Inventory (SLEI) was devised to assess laboratory settings in science classrooms at the secondary school level or in higher education environments (Fraser, Giddings, & McRobbie, 1992). It assists in examining the effectiveness that laboratory work has on student learning and the enjoyment of science. The questionnaire is designed to obtain students' views of their laboratory class environment. The initial development of this new instrument was guided by five criteria (Fraser, McRobbie, & Giddings, 1993):

1. *Consistency with the literature on laboratory teaching.* A review of the literature identified dimensions considered important in the unique environment of the science laboratory class (Hofstein & Lunetta, 1982; Woolnough, 1991).
2. *Consistency with instruments for non-laboratory settings.* Guidance was obtained by examining all scales in existing classroom environment instruments for non-laboratory settings (Fraser, 1986).
3. *Coverage of Moos' general categories.* Scales provided coverage of the three general categories of dimensions identified by Moos (1974b) for conceptualizing all human environments. These are *Relationship Dimensions*, *Personal Development Dimensions*, and *System Maintenance and System Change Dimensions*. Since a complete picture of the environment includes Relationship Dimensions, Personal Development Dimensions, and System Maintenance and System Change Dimensions, the SLEI included scales in each of these categories.
4. *Salience to teachers and students.* Interviews with science teachers and students at the upper secondary and university levels showed that SLEI's dimensions and individual items were salient.
5. *Economy*. To achieve economy regarding the time needed for answering and scoring, the SLEI had a relatively small number of reliable scales, each containing a small number of items.

The above five criteria led to an instrument containing eight scales, but only five scales survived field-testing and item/factor analyses and appeared in the final version (Fraser, McRobbie, & Giddings, 1993):

Student Cohesiveness assesses the extent to which students know, help, and are supportive of one another.
Open-Endedness assesses the extent to which laboratory activities emphasize an open-ended, divergent approach to experimentation.
Integration assesses the extent to which laboratory activities are integrated with non-laboratory and theory classes.
Rule Clarity assesses the extent to which behavior in the laboratory is guided by formal rules.
Material Environment assesses the extent to which laboratory equipment and materials are adequate.

The Open-Endedness scale was included because, despite many calls for science laboratory classes to be more open-ended (for example, National Research Council, 1990), and various studies have revealed that most laboratory activities were close-ended (Lumpe, 1991).

Wong and Fraser (1995) modified the SLEI to form the Chemistry Learning Environment Inventory (CLEI) in a study in Singapore. It was found that the CLEI was a reliable and valid instrument for assessing secondary school students' perceptions of their chemistry laboratory environment. In the present study, actual and preferred forms of the CLEI were employed. The CLEI consisted of five scales: (1) student Cohesiveness; (2) open-endedness; (3) integration; (4) rule clarity; and (5) material environment.

The CLEI has a total of 35 items, with seven items in each scale. The response format of the CLEI is a five-point frequency rating scale consisting of Very Often, Often, Sometimes, Seldom and Never, which are scored 5, 4, 3, 2 and 1, respectively. There were no major changes made to the 35 items of the SLEI for the actual and preferred versions of the instrument except for the replacement of the word "science" with "chemistry." The 35 items were arranged in *cyclic order* (see Figure 1) in groups each comprising one item from each of the five dimensions: Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, and Material Environment.

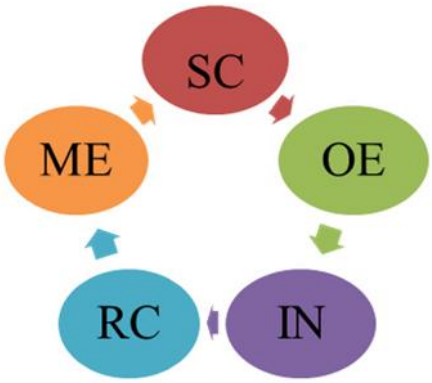

Figure 1: Cyclic arrangement of CLEI items

The wording of each item varies slightly between the actual and preferred forms. For example, in the actual version of CLEI, one item is "I get on well with students in this chemistry class." In the preferred version, the statement is modified to be "I prefer to get on well with students in this chemistry laboratory class." Based on the students' responses, scale scores are computed through the aggregation of scores for items belonging to that scale. The higher the scale score, the more of that particular dimension is perceived by a particular student to be present or preferred in the laboratory classroom environment.

2.2 Development, Validation and Use of Questionnaire on Teacher Interaction (QTI)

Leary (1957) believed that the way humans communicate is indicative of their personality. Along with other psychologists, he felt that the most important forces driving human behavior are the reduction of fear and the corresponding maintenance of self-esteem. Therefore, when people communicate consciously or unconsciously, they choose behaviors which avoid anxiety and allow them to feel good about themselves. These may differ for each person and depend on the personality of the communicating partner. One individual might choose an authoritarian style, whereas another prefers dependency to achieve the same end (Wubbels, Creton, Levy, & Hooymayers, 1993). They adapted the Leary model (Figure 2) and developed the Model for Interpersonal Teacher Behavior (Figure 3).

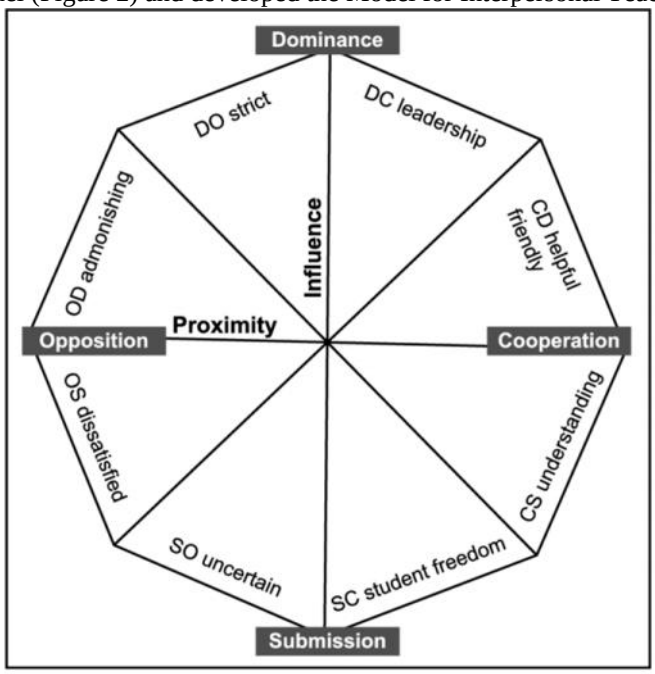

Figure 2: The Leary Model and Coordinate System

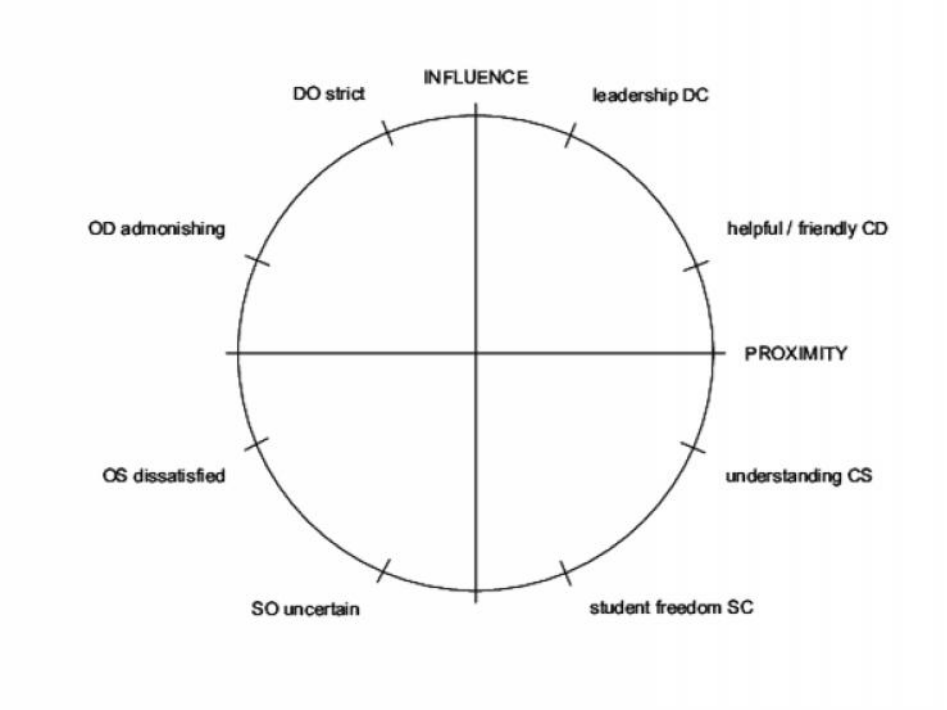

Figure 3: The Model for Interpersonal Teacher Behavior

Wubbels, Creton, Levy, and Hooymayers (1993) labeled the two dimensions of Leary's model Proximity (Cooperation-Opposition) and Influence (Dominance-Submission). The Proximity dimension designates the degree of cooperation or closeness between those who are communicating. The Influence dimension indicates who is directing or controlling the communication and how often. Leary used the term Dominance-Submission to describe the continuum of behaviors in the Influence dimension. Figure 2 depicts the Leary model and coordinate system. Figure 3 the model provides the examples of the different types of interpersonal behaviors displayed by teachers. The sections in the model for interpersonal behaviors are labeled as DC, CD, CS, SC, SO, OS, OD and DO according to their position in the coordinate system. For example, two sectors CS and SC are both considered to have elements of Cooperation and Submission. However, in the CS sector, the Cooperation aspect predominates over the Submission aspect. Also, Wubbels, Creton, and Hooymayers (1985) tried to use Leary's Interpersonal Adjective Checklist (ICL) in the education setting and found that not all 128 items appear on ICL apply to teachers. Based on this experience and the model for Interpersonal Teacher Behavior, they developed *the Questionnaire for Interactional Teacher Behavior* in the early 1980s.

Later they designed the Questionnaire on Teacher Interaction (QTI) (Wubbels & Levy, 1993). The original version of the QTI in the Dutch language consisted of 77 items, and it was designed to measure secondary students' and teachers' perceptions of teacher interpersonal behavior. After an extensive analysis, items found to be not correlated to the respective scales were deleted, and a 64 items version was developed and administered in the USA (Wubbels & Levy, 1991). Later, an Australian version of the QTI which contained eight scales was answered using a five-point response scale. The response provision in the QTI is a five-point Likert-type scale which is scored from 0 (Never) to 4 (Always) on the questionnaire itself. This method of giving a response to each question facilitates a faster completion of the questionnaire. In this way, the QTI can be administered easily and quickly in the class by the teacher. The items are arranged into eight scales corresponding to the eight interrelated sections of the model for interpersonal teacher behavior.

Since its development, the QTI has been used in Netherlands, USA, Australia, and some Asian countries (Brunei, Singapore, Korea, Indonesia, and Thailand) and was cross-validated in different contexts and cultures. All studies supported the view that the data obtained from the questionnaire provided useful information for the teacher about their learning environment.

3. Purpose of the Study and Research Questions

The effectiveness of the undergraduate chemistry laboratory has been the subject of research for several decades. This research explored the undergraduate chemistry learning environments and student-instructor interactions at the university level. In particular, this study aimed to:

Assess students' perception of the actual undergraduate chemistry laboratory learning environment

Assess students' interactions with their lab instructors

The research questions investigated in this study were:

What are the students' perceptions of their actual chemistry laboratory learning environment (ACLEI) in the Chemistry laboratory courses?

What are the students' perceptions of the interactions with their Chemistry lab instructors?

4. Research Methodology

4.1 Design, Participants and Setting

In this study, the researcher used Non-Experimental Quantitative Design. This study took place at a large private university in Beirut (Lebanon) during the Spring 2014 semester which is for four months in the Natural Sciences Department and covered a sample of six Chemistry laboratory courses (General Chemistry lab, Quantitative analysis, Organic Chemistry 1 Lab, Organic Chemistry 2 Lab, Physical Chemistry Laboratory, and Instrumental Analysis). These six Chemistry laboratory courses were the only courses offered during Spring 2014.

A total of 152 undergraduate students from ten sections enrolled in the six lab courses participated in this study. The students were informed that this study had no impact on their grades and all the names of the instructors and rooms were represented by pseudonyms. Most of the respondents came from urban areas in a percentage of 89.04%; whereas a small subset (10.96%) of the students enrolled in the practical chemistry courses were from rural areas. The highest percentage of responses (85.53%) that completed the questionnaires was in the age range of 18-20 years, and 65.56% were females. Ninety percent of the respondents have completed their high school at private academic institutions, and 76.97% of the students were Lebanese. Most of the respondents have finished one to two chemistry laboratory courses and one to three regular chemistry courses. The majority of the students were at the junior level (47.55%). The distribution of majors was as follow: Biology (45.03%), Nutrition (24.5%), Chemistry (11.92 %), Pharmacy (4.64%), and other fields or undecided (13.91%). Almost half of the students (51.02%) have a high GPA (between three and four); whereas only 3.4% of them have a GPA below two.

4.2 Instrumentations

For this study and to answer the two research questions, the researcher used two instruments to collect data. A quantitative component was involved in this study by administrating two questionnaires listed below:

Actual Chemistry Laboratory Environment Inventory (ACLEI): To assess students' perceptions of their actual learning environment (Appendix A)

Questionnaire of Teacher Interaction (QTI): To measure students' interactions with their Chemistry laboratory instructors (Appendix B)

4.3 Descriptive Information for the Instruments Used in this Study

4.3.1 Chemistry Laboratory Environment Inventory (CLEI) – ACLEI

Table 1 below has a common-sense description of each CLEI scale and the classification of the CLEI scales according to Moos' schema for conceptualizing psychosocial learning environments. Moos (1974a, 1974b, 1979) suggested three basic categories for describing and assessing human environments: relationship, personal development or growth, and system maintenance and system change. Instruments assessing classroom environments should cover these three general categories. Relationship dimension refers to the extent to which people are involved in the environment and support and help each other (refer to Student Cohesiveness scale). The personal development dimension refers to the direction along which personal growth and self-enhancement tend to take place (refer to the Open-Endedness and Integration scales). The third dimension of system maintenance and system change refers to the extent to which the environment is orderly, is in control and has clear expectations (refer to Rule Clarity and Material Environment scales).

One version of chemistry laboratory learning environment inventory (ACLEI) was used to collect data related to students' perception of the chemistry laboratory learning environment. The actual chemistry laboratory learning environment inventory (ACLEI) consists of 35 items, and it was used to assess students' perceptions of their actual learning environment. The questionnaire consists of five-scales and each scale containing seven items (see Table 1).

Table 1: Descriptive Information of CLEI

Scale Name- 5 scales	Description of Scale	Sample Items	Scales classified according to Moos' scheme	Items- 7 items/ scale
Student Cohesiveness [SC]	The degree to which students know, help and are supportive of one another.	I get on well with students in this chemistry laboratory class. (+)	R	1, 6, 11, 16, 21, 26, 31
Open-Endedness [OE]	The degree to which the laboratory activities emphasize on open-ended, divergent approach to experimentation.	There is the opportunity for me to pursue my chemistry interests in this chemistry laboratory class. (+)	P	2, 7, 12, 17, 22, 27, 32
Integration [IN]	The degree to which the laboratory activities are integrated with non-laboratory and theory classes.	What I do in our regular chemistry class is unrelated to my chemistry laboratory work. (-)	P	3, 8, 13, 18, 23, 28, 33
Rule Clarity [RC]	The degree to which behavior in the laboratory is guided by formal rules.	My chemistry laboratory class has clear rules to guide my activities. (+)	S	4, 9, 14, 19, 24, 29, 34
Material Environment [ME]	The degree to which the laboratory equipment and materials are adequate.	I find that the chemistry laboratory is crowded when I am doing experiments. (-)	S	5, 10, 15, 20, 25, 30, 35
Both versions of CLEI (ACLEI and PCLEI) have 35 items each, where 13 items of them are negatively keyed (Items#: 3, 5, 6, 8, 9, 15, 17, 20, 23, 24, 25, 26, and 33)				
R = Relationship Dimensions; P = Personal Development Dimensions; S = System Maintenance and Change Dimensions				
Format: five-point Likert (Almost never/ Very often)				

4.3.2 Questionnaire of Teacher Interaction (QTI)

The questionnaire of teacher interaction (QTI) consists of 48 items, and it was used to measure students' interactions with their Chemistry instructors. QTI consists of eight-scales and each scale containing six items (see Table 2).

Table 2: Descriptive Information of QTI

Scale Name- 8 scales	Description of Scale	Sample Items	Scales classified according to Moos' scheme	Items- 6 items/ Scale
Leadership [DC]	The extent to which teacher provides leadership to class and holds student attention.	This teacher acts confidently. [+]	S	1, 5, 9, 13, 17, 21

Helping/Friendly [CD]	The extent to which teacher is friendly and helpful towards students.	-This teacher helps us with our work. [+] -This teacher is friendly. [+]	R	25, 29, 33, 37, 41, 45
Understanding [CS]	The extent to which teacher shows understanding/concern/care to students.	If we do not agree with this teacher, we can talk about it. [+]	R	2, 6, 10, 14, 18, 22
Student Responsibility/Freedom [SC]	The extent to which students are given opportunities to assume responsibilities for their activities.	-We can influence this teacher. [-] -We can decide some things in this teacher's class. [+]	S	26, 30, 34, 38, 42, 46
Uncertain [SO]	The extent to which teacher exhibits her/his uncertainty.	This teacher is hesitant. [-]	S	3, 7, 11, 15, 19, 23
Dissatisfied [OS]	The extent to which teacher shows unhappiness/dissatisfaction with the student.	It is easy to make a fool out of this teacher. [-]	R	27, 31, 35, 39, 43, 47
Admonishing [OD]	The extent to which teacher shows anger/temper/impatient in class.	This teacher gets angry quickly/ unexpectedly. [-]	R	4, 8, 12, 16, 20, 24
Strict [DO]	The extent to which teacher is strict with and demanding of students.	We are afraid of this teacher. [-]	S	28, 32, 36, 40, 44, 48
QTI has 48 items, where 25 items of them are negatively keyed (Items#: 3, 4, 7, 8, 11, 15, 16, 19, 20, 23, 24, 27, 28, 30, 31, 34, 35, 36, 38, 39, 42, 43, 44, 47, and 48)				
R = Relationship Dimensions; S = System Maintenance and Change Dimensions				
Format: five-point Likert (Never/ Always)				

4.4 Data Analysis

The quantitative data were analyzed by using the SPSS20 software. Descriptive statistics (mean, mode, min, max, standard deviation, CV, etc.) were calculated for the two questionnaires related to the learning environment and student-instructor interactions.

5. Data Analysis and Results

5.1 What is the students' perception of their Actual Chemistry Laboratory Environment?

The data presented in Table 3 for the present sample of 152 students, and it reports the mean, standard deviation, minimum, maximum and coefficient of variation (CV) of the sample (Appendix A), taking into consideration the negative items were reversed (Items #: 3, 5, 6, 8, 9, 15, 17, 20, 23, 24, 25, 26, and 33).

Table 3: Descriptive Statistics of ACLEI

N= 152 students		Number of Items	Mean	Std. Deviation	Min	Max	CV
Student Cohesiveness		7	3.90	0.56	2.57	5.00	14.33%
1	Students in this laboratory class get along well as a group.						
6	Students have little chance to get to know each other in this laboratory class.						
11	Members of this laboratory class help one another.						
16	Students in this laboratory class get to know each other well.						
21	Students are allowed to beyond the regular laboratory exercise and do some experimenting of their own.						
26	It takes a long time to get to know everybody by his/her first name in this laboratory class.						
31	Students work co-operatively in laboratory sessions.						
Open-Endedness		7	3.14	0.63	1.71	4.86	20.21%
2	There is an opportunity for students to pursue their chemistry interests in this laboratory class.						
7	In this laboratory class, we are required to design our experiments to solve a given problem.						
12	In our laboratory sessions, different students collect different data for the same problem.						
17	Students are allowed to beyond the regular laboratory exercise and do some experimenting of their own.						
22	We use the theory from our regular chemistry Class sessions during laboratory activities.						
27	In our laboratory sessions, the teacher/instructor decides the best way to carry out the laboratory experiments.						
32	Students decide the best way to proceed during laboratory experiments.						
Integration		7	3.33	0.75	1.57	5.00	22.58%
3	What we do in our regular chemistry class is unrelated to our laboratory work.						
8	The laboratory work is unrelated to the topics that we are studying in our chemistry class.						
13	Our regular chemistry class work is integrated with laboratory activities.						
18	We use the theory from our regular chemistry Class sessions during laboratory activities.						
23	There is a recognized way of doing things safely in this laboratory.						
28	What we do in laboratory sessions helps us to understand the theory covered in regular chemistry classes.						
33	Laboratory work and regular chemistry class work are unrelated.						
Rule Clarity		7	3.88	0.54	2.29	5.00	13.83%
4	Our laboratory class has clear rules to guide student activities.						
9	This laboratory class is rather informal, and few rules are imposed.						
14	Students are required to follow certain rules in the laboratory.						
19	There is a recognized way of doing things safely in this laboratory.						
24	There are few fixed rules for students to follow in laboratory sessions.						
29	The instructor outlines safety precautions before laboratory sessions commence.						
34	This laboratory class is run under clearer rules than other classes.						
Material Environment		7	3.23	0.83	1.00	5.00	25.74%
5	The laboratory is crowded when we are doing experiments.						
10	The equipment and materials that students need for laboratory activities are readily available.						
15	Students are ashamed of the appearance of this laboratory.						
20	Laboratory equipment is in poor working order.						
25	The laboratory is hot and stuffy.						

30	A laboratory is an attractive place in which to work.
35	The laboratory has enough room for individual or group work.

According to Table 3, students perceived that their actual chemistry laboratory environment is relatively favourable, as implied by the range 3.14 to 3.90 (meaning that students perceived the events as described by the questionnaire with a frequency range of from "sometimes" to "often") for the average item mean for different ACLEI scales in Figure 4. The mean scores for the Student Cohesiveness (mean=3.90) and Rule Clarity (mean=3.88) scales were the highest of all scales (both scales means were near to 4.00 which correspond that they both are close to "often"), this implies that students perceive a relatively good level of cohesiveness and clear rules in the laboratory environment. The mean scores for Open-Endedness (mean=3.14), Integration (mean=3.33) and Material Environment (mean=3.23) scales were the lowest of all scales (their scales means were between 3.00 and 3.50 which correspond that they are very close to "sometimes"), this implies that the laboratory courses are normally carried out using "ready-made" procedures and results, the laboratory courses are not highly coordinated with theory classes, and the material and equipment were perceived to be inadequate.

The coefficient of variation (CV) that measures the dispersion of the values of each variable around the mean shows that the dispersion is low because all CV values vary from 14-26% (Table 3) which is less than 50%. But when we looked closer to each item in the ACLEI, we can see two exceptional items with high dispersion with CV greater than 50%, which are: Item #7 (In this laboratory class, we would be required to design our own experiments to solve a given problem) and Item #22 (In our laboratory session, different students would do different experiments). Both items belong to the same scale "Open-Endedness."

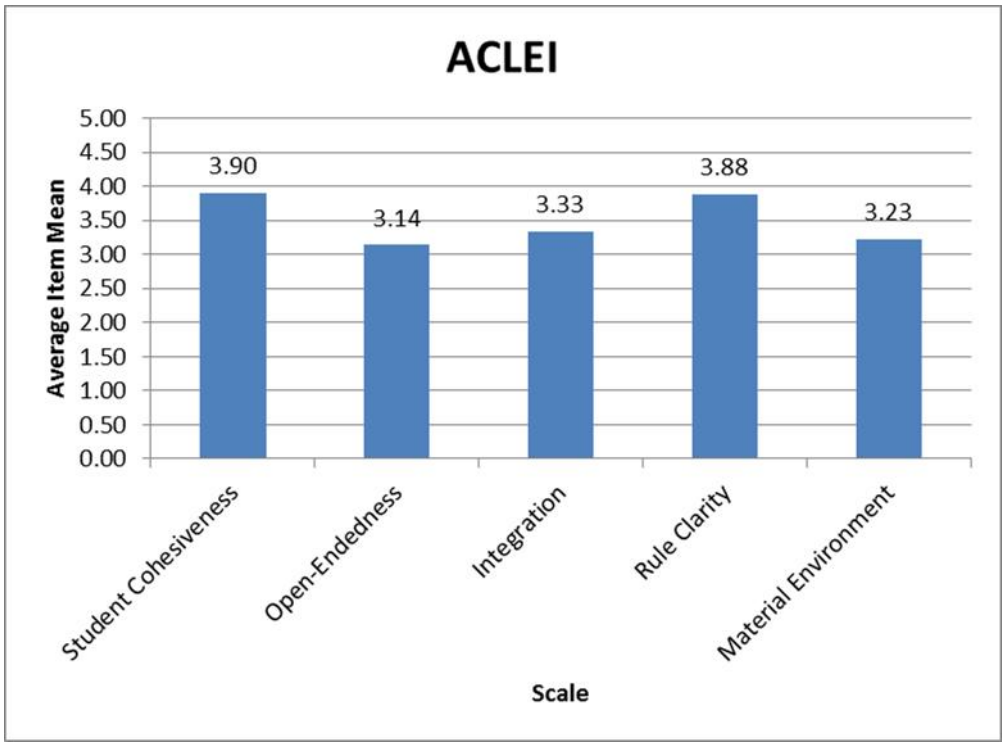

Figure: Simplified Plot of ACLEI

5.2 What is the students' perception of their Chemistry instructors' interpersonal behavior?

The Questionnaire of Teacher Interaction (QTI) was used in this study to measure students' interactions with their Chemistry laboratory instructors (Appendix B). In this questionnaire, eight characteristics of effective instructors were defined: leadership, helping or friendly, understanding, personality, uncertainty, dissatisfaction, admonishing, and strictness. The survey instrument used by the students' evaluations of the Chemistry instructors' interpersonal behavior inventory was Likert five-point scale questionnaire (QTI). Participants graded their contentment from "Never=0" to "Always=4". The data are presented in Table 4 for the present sample of 152 students, and it reports the mean, standard deviation, minimum,

maximum and coefficient of variation (CV) of the sample, knowing that the negative items were reversed (Items#: 3, 4, 7, 8, 11, 15, 16, 19, 20, 23, 24, 27, 28, 30, 31, 34, 35, 36, 38, 39, 42, 43, 44, 47, and 48). According to Table 4, students' perceptions of their Chemistry instructors' interpersonal behavior are characterized by relatively high scores, as implied by the range 2.57 to 3.47. This means that students perceived the events as described by the questionnaire with a frequency range closer to "Always" for the average item means for different QTI scales in Figure 5. The mean scores for the Leadership (mean=3.47), Understanding (mean=3.47), and Uncertain (mean=3.47) scales were the highest sectors of the model of all scales. These scales means were near to 4.00 which correspond that they are close to "Always." This implies that students perceive that teachers have a good level of leadership, explain clearly, act confidently, trust the students, patient, allow them to tell him/her what to do but on the other hand, some teachers seem uncertain. The Responsibility/Freedom (mean=2.74) and Strict (mean=2.57) scales were the lowest two scales as perceived by the students, which implies that the students have less freedom in the laboratory courses, the teachers are less strict with them even when correcting exams, the exams are somehow hard, and the instructors' standards are high. We are left with three scales that go in between of the highest and lowest scales which are Helping/Friendly (mean=3.23), Dissatisfied (mean=3.37), and Admonishing (mean=3.37).

The coefficient of variation (CV) that measures the dispersion of the values of each variable around the mean shows that the dispersion is low because all CV values vary from 17-25% (Table 4) which is less than of 50%, but with four exceptional items with high dispersion with CV greater than 50%, which are: Item #26 (We can decide some things in this instructor's class), Item #28 (The instructor is strict), Item #36 (The instructor tests are hard), and Item #44 (The instructor is severe when marking papers). Item #26 belongs to the "Student Responsibility/Freedom" scale, and other three items (#28, 36 and 44) belongs to the "Strict" scale.

Table 4: Descriptive Statistics of QTI

N= 152 students		Number of Items	Mean	Std. Deviation	Min	Max	CV
Leadership		6	3.47	0.68	0.00	4.00	19.71%
1	This instructor talks enthusiastically about her/his subject.						
5	This instructor explains clearly.						
9	This instructor holds our attention.						
13	This instructor knows everything that goes on the classroom.						
17	This instructor is a good leader.						
21	This instructor acts confidently.						
Helping/Friendly		6	3.23	0.61	0.67	4.00	19.04%
25	This instructor helps us with our work.						
29	This instructor is friendly.						
33	This instructor is someone we can depend on.						
37	This instructor has a sense of humor.						
41	This instructor can take a joke.						
45	This instructor's class is pleasant.						
Understanding		6	3.47	0.65	0.00	4.00	18.84%
2	This instructor trusts us.						
6	If we don't agree with this instructor, we can talk about it.						
10	This instructor is willing to explain things again.						
14	If we have something to say, this instructor will listen.						
18	This instructor realizes when we don't understand.						
22	This instructor is patient.						
Student responsibility/ Freedom		6	2.74	0.48	1.50	3.83	17.44%
26	We can decide some things in this instructor's class.						

30	We can influence this instructor.					
34	This instructor lets us fool around in class.					
38	This instructor lets us get away with a lot in class.					
42	This instructor gives us a lot of free time in class.					
46	This instructor is lenient.					
Uncertain		6	3.47	0.70	0.67	4.00	20.16%
3	This instructor seems uncertain.					
7	This instructor is hesitant.					
11	This instructor acts as if she/he does not know what to do.					
15	This instructor lets us boss her/him around.					
19	This instructor is not sure what to do when we fool around.					
23	It is easy to make a fool out of this instructor.					
Dissatisfied		6	3.37	0.81	0.33	4.00	24.12%
27	This instructor thinks that we cheat.					
31	This instructor thinks that we don't know anything.					
35	This instructor puts us down.					
39	This instructor thinks that we can't do things well.					
43	This instructor seems dissatisfied.					
47	This instructor is distrustful.					
Admonishing		6	3.37	0.71	0.67	4.00	21.15%
4	This instructor gets angry unexpectedly.					
8	This instructor gets angry quickly.					
12	This instructor is too quick to correct us when we break the rule.					
16	This instructor is impatient.					
20	It is easy to pick a fight with this instructor.					
24	This instructor is disrespectful.					
Strict		6	2.57	0.55	0.83	3.83	21.30%
28	This instructor is strict.					
32	We have to be silent in this instructor class.					
36	This instructor's tests are hard.					
40	This instructor's standards are very high.					
44	This instructor is severe when marking papers.					
48	We are afraid of this instructor.					

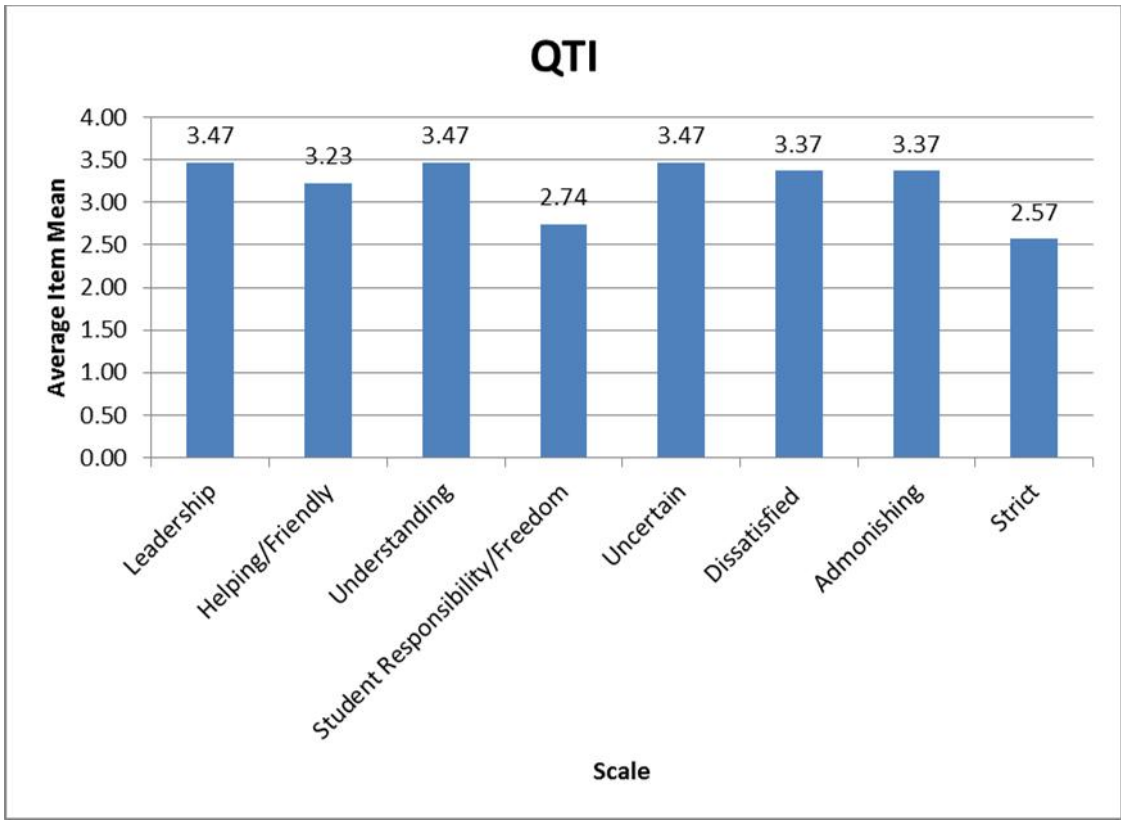

Figure 5: Simplified Plot of QTI

In summary, the results showed that students perceived instructors as having a good level of leadership, understanding, and standards, but they are not very strict. On the other hand, the students see that they have fewer responsibilities and freedom in the laboratory courses.

6. Discussion of the Results and Findings

Universities have in the recent years faced new challenges as the new generations of students enter the old institutions. Many of the incomers belong to the so-called digital natives who use various digital applications and mobile devices as integrated parts in their everyday lives, their knowledge seeking and knowledge sharing activities are different from previous generations (Sandstrom, Ketonen, & Lonka, 2014). Research finding state that chemistry students can provide us with important insights also into how higher educational facilities and curricula could be better organized to support the new generation of learners and emerging knowledge practices (Sandstron, Ketonen, & Lonka, 2014).

It is well known that the learning environment is an important aspect of the education process. It influences both the students' outcomes and teacher performances. Using CLEI and QTI instruments at the higher education level helps instructors to evaluate their learning environments in the chemistry laboratory to improve their education process and performance. Furthermore, the information from CLEI and QTI could be useful as a guide to enhance the effectiveness of chemistry laboratory. These instruments provide the information of students' perceptions of actual and preferred laboratory learning environments, in addition to the instructor interpersonal behavior. The effectiveness in chemistry laboratory is very important because the practical work is high cost and time-consuming. Therefore, evaluation of the chemistry laboratory teaching is important for improving and developing students' learning achievement successfully.

Responses on items of Open-Endedness factor based on using the ACLEI were interesting in this study. Students made it clear that they almost never get a chance to design their experiment, decide the best way to proceed during laboratory experiments, or allow to go beyond the regular laboratory exercise and to do some experimenting of their own; this finding agrees with the chemistry laboratory manuals' evaluation.

The findings from both the ACLEI and QTI showed that we need to be more aware of dynamic student-instructor interactions taking place in the classroom. According to Doll et al. (2010), students will be more committed to learning when they perceive a more positive environment and feel valued and respected by their

teacher.

Furthermore, instructors must facilitate activities that promote a positive learning environment and creating activities that allow students more freedom to explore their interests, while still accomplishing the same learning goals. To create activities that allow an extension of thinking, but are not entirely open-ended, instructors may try directing the focus of students by offering potential areas to explore, or experiments to perform, but giving students the freedom to choose within the guidelines. By doing this, there is an element of open-endedness, but not too much that students may develop less favorable attitudes toward the classroom.

7. Recommendations of the Study

According to findings of the study and previous researches related to the chemistry laboratory learning environment the following suggestions can be made: First, based on students' perceptions, the findings related to the chemistry laboratory learning environment and student-instructor interactions are particularly useful to the administrators and instructors and could help instructors to reflect on the various aspects of the chemistry laboratory and their interactions with students. Second, the findings of associations between chemistry laboratory learning environment and instructor-student interactions suggest that it would be desirable for educators to consider creating a more *Student-Cohesiveness* (degree to which students know, help and are supportive of one another), *Integration* (degree to which the laboratory activities are integrated with theory classes), *Rule clarity* (degree to which behavior in the laboratory in guided by formal rules) and *Material Environment* (degree to which the laboratory equipment and materials are adequate) learning environment for the teaching and learning of chemistry in universities. Third, chemistry classroom learning environment is an important predictor to understand students' attitude toward chemistry and their motivational beliefs. For this reason, classroom environments should be developed according to students' need and their interest. Therefore, instructors should try to find and form classroom learning environments which students will prefer. Fourth, because the CLEI and QTI each account for variance in student attitudes that is independent of that accounted for by the other instrument, it is useful to include both the CLEI and QTI in future studies involving associations between learning environment and students' affective outcomes: attitudes and anxiety. Fifth, instructors and administrators in the science department must pay particular attention to the low score in the Open-Endedness (the degree to which the laboratory activities emphasize an open-ended divergent approach to experimentation) and Material Environment (degree to which the laboratory equipment and materials are adequate) dimensions of the laboratory learning environment. This indicates areas where improvement can be made in the teaching and learning of chemistry. Sixth, the Open-endedness learning environment could be beneficial in establishing a unique and enjoyable learning environment for the students. The practical implication of this finding is that teachers might attempt to adopt more open-ended approaches in their teaching and improve the quality of the material environment in the chemistry. Seventh, the Chemistry Learning Environment Inventory could be used by instructors as one part of action research intended to examine the effects of a new laboratory teaching approach or strategy and as a part of improving instruction. Even researchers can also use this instrument for more summative type studies in which they examine effects of different kinds of teaching in the laboratory on students' perceptions of the learning environment. Eighth, seminars, workshops, and conferences should be organized occasionally for chemistry instructors. This will help the instructors to refresh their knowledge especially on modern strategies of teaching and learning which could enhance the teaching and learning of chemistry and to improve the chemistry laboratory learning environment. Finally, we must redesign our chemistry curriculum by customizing instruction to meet the learning needs of learners, incorporating more lively and practical approaches and infusing scientific inquiry, creative and critical thinking skills into both the theoretical and the laboratory work.

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Appendix A: Actual Chemistry Laboratory Environment Inventory (ACLEI)

This questionnaire contains statements about practices which could take place in this laboratory class.
You will be asked how often each practice actually takes place.

Items #		Almost Never	Seldom	Sometimes	Often	Very Often
		1	2	3	4	5
1	Students in this laboratory class get along well as a group.					
2	There is opportunity for students to pursue their own chemistry interests in this laboratory class.					
3	What we do in our regular chemistry class is unrelated to our laboratory work.					

4	Our laboratory class has clear rules to guide student activities.					
5	The laboratory is crowded when we are doing experiments.					
6	Students have little chance to get to know each other in this laboratory class.					
7	In this laboratory class, we are required to design our own experiments to solve a given problem.					
8	The laboratory work is unrelated to the topics that we are studying in our chemistry class.					
9	This laboratory class is rather informal and few rules are imposed.					
10	The equipment and materials that students need for laboratory activities are readily available.					
11	Members of this laboratory class help one another.					
12	In our laboratory sessions, different students collect different data for the same problem.					
13	Our regular chemistry class work is integrated with laboratory activities.					
14	Students are required to follow certain rules in the laboratory.					
15	Students are ashamed of the appearance of this laboratory.					
16	Students in this laboratory class get to know each other well.					
17	Students are allowed to go beyond the regular laboratory exercise and do some experimenting of their own.					
18	We use the theory from our regular chemistry class sessions during laboratory activities.					
19	There is a recognized way of doing things safely in this laboratory.					
20	Laboratory equipment is in poor working order.					
21	Students are able to depend on each other for help during laboratory classes.					
22	In our laboratory sessions, different students do different experiments.					
23	The topics covered in regular chemistry class work are quite different from topics dealt with in laboratory sessions.					
24	There are few fixed rules for students to follow in laboratory sessions.					
25	The laboratory is hot and stuffy.					
26	It takes a long time to get to know everybody by his/her first name in this laboratory class.					
27	In our laboratory sessions, the teacher/instructor decides the best way to carry out the laboratory experiments.					
28	What we do in laboratory sessions helps us to understand the theory covered in regular chemistry classes.					
29	The instructor outlines safety precautions before laboratory sessions commence.					
30	The laboratory is an attractive place in which to work.					
31	Students work co-operatively in laboratory sessions.					
32	Students decide the best way to proceed during laboratory experiments.					
33	Laboratory work and regular chemistry class work are unrelated.					
34	This laboratory class is run under clearer rules than other classes.					
35	The laboratory has enough room for individual or group work.					

Appendix B: Questionnaire of Teacher Interaction (QTI)

This questionnaire asks you to describe the behavior of your instructor.
This is NOT a test. Your opinion is what is wanted.

Instructor's Name _____ University _____
Course _____ Academic Year _____

Item #		Never				Always
1	This instructor talks enthusiastically about her/his subject.	0	1	2	3	4
2	This instructor trusts us.	0	1	2	3	4
3	This instructor seems uncertain.	0	1	2	3	4
4	This instructor gets angry unexpectedly.	0	1	2	3	4
5	This instructor explains clearly.	0	1	2	3	4
6	If we don't agree with this instructor, we can talk about it.	0	1	2	3	4
7	This instructor is hesitant.	0	1	2	3	4
8	This instructor gets angry quickly.	0	1	2	3	4
9	This instructor holds our attention.	0	1	2	3	4
10	This instructor is willing to explain things again.	0	1	2	3	4
11	This instructor acts as if she/he does not know what to do.	0	1	2	3	4
12	This instructor is too quick to correct us when we break the rule.	0	1	2	3	4
13	This instructor knows everything that goes on the classroom.	0	1	2	3	4
14	If we have something to say, this instructor will listen.	0	1	2	3	4
15	This instructor lets us boss her/him around.	0	1	2	3	4
16	This instructor is impatient.	0	1	2	3	4
17	This instructor is a good leader.	0	1	2	3	4
18	This instructor realizes when we don't understand.	0	1	2	3	4
19	This instructor is not sure what to do when we fool around.	0	1	2	3	4
20	It is easy to pick a fight with this instructor.	0	1	2	3	4
21	This instructor acts confidently.	0	1	2	3	4
22	This instructor is patient.	0	1	2	3	4
23	It is easy to make a fool out of this instructor.	0	1	2	3	4
24	This instructor is disrespectful.	0	1	2	3	4
25	This instructor helps us with our work.	0	1	2	3	4
26	We can decide some things in this instructor's class.	0	1	2	3	4
27	This instructor thinks that we cheat.	0	1	2	3	4
28	This instructor is strict.	0	1	2	3	4
29	This instructor is friendly.	0	1	2	3	4
30	We can influence this instructor.	0	1	2	3	4
31	This instructor thinks that we don't know anything.	0	1	2	3	4
32	We have to be silent in this instructor class.	0	1	2	3	4
33	This instructor is someone we can depend on.	0	1	2	3	4
34	This instructor lets us fool around in class.	0	1	2	3	4
35	This instructor puts us down.	0	1	2	3	4
36	This instructor's tests are hard.	0	1	2	3	4
37	This instructor has a sense of humor.	0	1	2	3	4
38	This instructor lets us get away with a lot in class.	0	1	2	3	4
39	This instructor thinks that we can't do things well.	0	1	2	3	4
40	This instructor's standards are very high.	0	1	2	3	4
41	This instructor can take a joke.	0	1	2	3	4
42	This instructor gives us a lot of free time in class.	0	1	2	3	4
43	This instructor seems dissatisfied.	0	1	2	3	4
44	This instructor is severe when marking papers.	0	1	2	3	4
45	This instructor's class is pleasant.	0	1	2	3	4
46	This instructor is lenient.	0	1	2	3	4
47	This instructor is distrustful.	0	1	2	3	4
48	We are afraid of this instructor.	0	1	2	3	4