Students' Perceptions For The Chemistry Laboratory Environment Improvement

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ABSTRACT

Chemistry students' perceptions of the chemistry laboratory learning environment were investigated in an Indonesian University. An already existing instrument *Chemistry Laboratory Environment Inventory* (CLEI) questionnaire was translated into Bahasa Indonesia and administered to 410 university students in three different years of chemistry study. Data analyses supported the validity and reliability of the instrument when used in this context and there were no statistically significant differences in mean scores for gender and programme of study. However, the mean differences in students' perceptions of their laboratory environment were statistically significant by year level. These differences were further validated by the interview data. Qualitative data were obtained from laboratory observations and interviews with the students. Furthermore, both quantitative and qualitative data confirmed that students wished for an improved laboratory learning environment in terms of more opportunities to explore their own interests and to work with better laboratory equipment. The chemistry department staff could use the information from this study to guide them in making changes for improving the learning process in the laboratory.

Key Words: Chemistry laboratory, Chemistry Laboratory Environment Inventory (CLEI), Gender, Year level, Higher education, Indonesia

1. INTRODUCTION

Learning environment is an important aspect in education which not only has the positive correlation with the students' outcomes, motivation, and attitudes, but also teachers' motivation (Fraser, 2002). Moreover, students' and teacher perceptions of the learning environment give valuable information to improve the quality of learning environment (Fraser, 1998). Furthermore, chemistry laboratory learning environment needs to be explored and is an integral part of chemistry teaching which influences the student learning outcomes and student attitudes toward chemistry. Therefore, it is important for the teachers to assess the effectiveness of chemistry laboratory through the Chemistry Laboratory Environment Inventory (CLEI) instrument. Moreover, since the study of learning environment in Indonesia needs to be developed, this study is one of the very few implementation of learning environment questionnaire which is translated in Indonesian language. This study investigated students' perceptions on their chemistry laboratory learning environment in one of universities in Indonesia using quantitative (CLEI questionnaire), and qualitative (observation, and interview) methods.

2. LEARNING ENVIRONMENT

Learning environment plays important role to help students engage with their learning process. Therefore, it is important for teacher to create the constructive learning environments which could help students to achieve best performances and meaningful learning experiences. According to Brown & Campione (1996), Wilson (1995) as cited in Jarvela (1998, p.439), "a learning environment should be managed so that students are encouraged to set personal goals, actively gather meaningful information, monitor and evaluate their own learning and reflect personal learning experiences in different authentic environments and social contexts". Furthermore, the positive classroom climate can motivate both students and teacher to learn and teach effectively. Teacher who creates the positive classroom climate such as having a good relationship with students will help students to achieve their learning outcomes (McGonigal, 1999; Friser, Rickards, Fraser, 1996). For example, the teacher knows the way to attract students' attention such as using varied and interesting teaching strategies, and positive reinforcements. As a result, the students will enjoy their learning and express their ideas and opinions (Jarvela, 1998). Therefore, most studies in learning environment show that the learning environment influences the student outcomes (Fraser, 2001). According to Entwistle (1991) as cited in Könings, Gruwel, and Merriënboer (2005),"students' perceptions of a learning environment will determine how much they will learn and how effective a learning environment will be"(p.465). Furthermore, it also promotes the appropriate classroom behaviour. As a result, it is important for the teachers to develop their knowledge and skills to create the positive learning environment (Yarrow, Millwater, & Fraser, 1997).

Furthermore, in Indonesia, learning environments research first started within the decades of 1970s and 1980s, but was not well developed until 2000 (Margianti, 2002). Several research studies on learning environments have been conducted in Indonesia which were the study of learning of modern culture (Piage, 1979 as cited in Margianti 2002); students' Perceptions of classroom psychosocial environment (Fraser, Pearse, & Azmi, 1982); computer learning environment and students outcomes (Margianti, 2001; Soeryaningsih & Fraser, 2000 as cited in Margianti 2002). Furthermore, the learning environments instruments which were adapted in Indonesia are What Is Happening In this Class? (WIHIC), College University Classroom Environment Inventory (CUCEI), Test of Computer Related Attitudes (TOCRA) , and Test of Science Related Attitudes (TOSRA) (Margianti, 2002). Therefore, based on my exploration on the importance of learning environments in education and the limitation of learning environments research in Indonesia, it is important to investigate the learning environment research and develop the instruments, especially in laboratory teaching.

3. CHEMISTRY LABORATORY LEARNING ENVIRONMENT

Laboratory experiment is an important part of science teaching and has a unique learning environment (Fraser, McRobbie, Giddings, 1992). Moreover, according to Novak (1988) as cited in Bradley (2006), the science laboratory learning plays important role in science curriculum which is different from the practical works for science which are done by scientists. Many studies show that experiments in laboratory influence students to have better attitudes toward science and learning outcomes (Yager, 1991; Stohr-Hunt, 1996; Thompson and Soyibo, 2002 as cited in Parkinson, 2004). Furthermore, laboratory experiments can help students to understand abstract concepts in science. Practical work is also fun and interesting for the students. In short, laboratory activities could enhance students' meaningful learning, conceptual understanding, and understanding the nature of science (Kipnis & Hofstein, 2007). As a result, they are motivated to explore the material which relates to the topics in the

classroom (Borrows, 1999 as cited in Parkinson, 2004). The positive learning environments in the laboratory will help teacher and students to achieve the best performances in learning process. Therefore, it is important to evaluate the learning environments in laboratory. It is not only to assess students' perceptions, but also investigate the impact of laboratory classes on student outcomes (Fraser, McRobbie, Giddings, 1992). Furthermore, this information could help teacher to imply several improvement on the laboratory learning environment. However, there are only few research studies on laboratory learning environments compared to other fields of learning environments such as teacher-students relationship. Therefore, exploring this field of learning environments will be useful, especially for science educators.

One example of science laboratory learning environment instrument is SLEI (Science Laboratory Environment Inventory) was developed to assess students' perceptions on learning environments in the laboratory classes (Fraser, McRobbie, Giddings 1992). Furthermore, SLEI was successfully modified by changing 'science' to 'chemistry' and renamed as the Chemistry Laboratory Environment Inventory (CLEI) in Singapore (Wong & Fraser, 1996; Wong, Young, & Fraser, 1997). Some minor modifications of items were made to suit local students' level of understanding and language usage. This CLEI instrument has been used to investigate chemistry laboratory classroom environment, teacher–student interactions and student attitudes towards chemistry among 497 gifted and non-gifted secondary-school students in Singapore (Lang,,Wong, & Fraser, 2005).This instrument is appropriate for the secondary and tertiary education which contains 35 items and five scales which are Student Cohesiveness (SC), Open-Endedness (OE), Integration (I), Rule Clarity (RC), and Material Environment (ME). According to Henderson, Fisher, & Fraser (2000), "the use of these scales provides coverage of the three dimensions identified by Moo's work (1974) for conceptualizing all human environments",(p.29). CLEI data is collected on five point likert scale with a response of Almost Never, Seldom, Sometimes, Often, and Very Often with scores of 1,2,3, 4, and 5, respectively for positive items and revised scores for the negative items. Furthermore, this instrument is designed with economical cost which is only one page and easy for teacher to hand scoring.

Table 2.
The Summary of CLEI Insrument

Aim	Assessment students' perceptions of their chemistry laboratory learning environment
Level Education	Upper Secondary & Higher Education
Number of Item	35
Scale	Five: Student Cohesiveness (SC), Open-Endedness (OE), Integration (I), Rule Charity (RC), Material Assessment (ME)
Form	Actual & Preferred Form
Scoring	(+) : 1,2,3,4,5 (Almost never, Seldom, Sometimes, Often, Very Often) (-) : 5,4,3,2,1 (Almost never, Seldom, Sometimes, Often, Very Often)

Table 3.
Descriptive Information Sample Item for Each Scale of the CLEI

Scale Name	Description	Sample Item
Student Cohesiveness	Extent to which students know, help are supportive of one another	I get along well with students in this chemistry laboratory (+)
Open-Endedness	Extent to which the laboratory activities emphasize open-Endedness.	In my chemistry laboratory sessions, the teacher decides the best way for me to carry out the laboratory experiments (-)
Integration	Extent to which the laboratory activities are integrated with non-laboratory and theory classes	I use the theory from our regular class sessions during chemistry laboratory activities (+)
Rule Clarity	Extent to which behaviour is guided by formal rules	There is a recognized way of doing things safety in this chemistry laboratory
Material Environment	Extent to which the laboratory equipment and materials are adequate	The chemistry laboratory that laboratory is crowded when I am doing experiments (-)

The CLEI instrument uses the actual and preferred form with clear instructions for the students to give their perceptions on their actual laboratory and their preferred laboratory learning environment (Fraser, McRobbie, Giddings, 1992). Moreover, The actual and preferred form as a personal version of students will give "meaningful and sensitive investigations of the environments existing within a class for different subgroups of students" (Fraser, McRobbie, Giddings 1992, p.7). Students choose the actual and the preferred learning environments in their laboratory. The result could be different or similar, but the teacher could have valuable information of their students' perceptions on actual and the preferred. The difference between the actual and the preferred learning environment could be used as information for teachers to choose the appropriate strategies to minimize the differences. Therefore, CLEI could be used for school-based professional development and guiding to improve the effectiveness of science laboratory teaching (Fraser, McRobbie, Giddings, 1992).

Finally, the use of CLEI instrument in the secondary and tertiary education will help teachers to evaluate their learning environments in science laboratory in order to improve their education process. Furthermore, the information from the CLEI could be useful as a guide to enhance the effectiveness of science laboratory. The effectiveness in science laboratory is very important because the practical work is high cost and time consuming. Therefore, evaluation of the science laboratory teaching is important.

4. METHODOLOGY

The study is conducted to assess students' perceptions on their chemistry laboratory learning environments in higher education in Indonesia. Through the CLEI questionnaire, observation, and interview, this study will answer these questions:

1. How do students' perceptions on their actual and preferred of their chemistry laboratory learning environment differ?

2. To what extent are learners' perceptions on their actual and preferred of their science laboratory learning environment affected by gender, program, and year level?
3. To what extent is the each scale on CLEI represented in the chemistry laboratory teaching?

The information on students' perception on their actual and preferred of their chemistry laboratory learning environment in the university is important for improving the effectiveness of teaching laboratory. Moreover, lecturers could use this information to improve their pedagogical practices. It also provides information for the university on the learning process in chemistry laboratory and using the information for university development.

This study used both quantitative and qualitative methods. Quantitative data was collected from a sample of 410 university students enrolled in university from year 2002-2007, which consist of 309 female students and 101 male students. CLEI instrument was used to assess students' perceptions on their actual and preferred chemistry laboratory learning environments. The responses were on a 5 point Likert scale. This instrument contains 35 items and five scales which are Student Cohesiveness (SC), Open-Endedness (OE), Integration (I), Rule Clarity (RC), and Material Environment (ME). The data was analyzed using the SPSS software to determine the reliability of the scales, the correlations between the scales of the questionnaire, the differences on students' perception which is affected by gender, program, and year level. Laboratory observations, followed by interviews with eight students from different academic program and year level provided qualitative data. The data are analysed and presented in the narrative writing style.

5. RESULTS

5.1 Quantitative Analysis of Students' Perceptions of Science Laboratory Learning Environment

5.1.1 The Reliability of Instrument

Compared to SLEI instrument which has been confirmed in Australia, the United State of America, Canada, England, Israel, and Nigeria (Henderson, Fisher, & Fraser, 2000), CLEI instrument has been confirmed only in Singapore and Brunei Darussalam. Table 3. presents the reliability, scores for the CLEI in the present study. Also presented are the mean and standard deviation scores for the actual and preferred version of the CLEI.

Reliability could be estimated by internal consistency based on the correlation among the variables by using Cronbach's alpha reliability coefficient (Brown, 2007; Newby & Fisher, 1997). The table 3 shows that the actual version of CLEI, the alpha reliability figures ranged from 0.67 to 0.69. All the alpha reliability of preferred version are lower that the actual version. However, the results show that the instrument is reliable which all alpha reliabilities above 0.50. Moreover, the four scales (Students' Cohesiveness and Integration) indicates the high usage in the classroom which is shown by the mean >3.50. On the other hand, the Open-Endedness, Rule Clarity and Material Environment is low usage which is implied by the mean score <3.50.

Table 4.
Scale Internal Consistency (Cronbach Alpha Reliability, Means and Standard Deviations for the CLEI

Scale	Alpha Reliability	Mean		Standard Deviation	
	Actual	*Actual*	*Preferred*	*Actual*	*Preferred*
Student	.69	3.55	3.91	.41	.46
Open-endedness	.69	2.61	3.41	.35	.55
Integration	.67	3.56	4.15	.50	.60
Rule Clarity	.67	3.43	3.72	.42	.52
Material Environment	.69	2.84	4.08	.49	.72

Number of students who answers the questionnaires (N) = 410

5.1.2 Correlations between Scales

The Pearson's correlation is used to find a correlation between at least two continuous variables (Brown, 2007). The interpretation of correlation could be done by examine the significant value (p) which less than 0.05 (Coakes & Steed, 2007). Furthermore, the correlation coefficient can range from -1.00-+1.00, the value of negative shows the negative correlation while the positive value shows the positive correlation (Statsoft, 2003).

Table 5.
Inter-scale Correlations for the CLEI

	Actual Student Cohesiveness	Actual Open Endedness	Actual Integration	Actual Rule Clarity	Actual Material Environment
Actual Student Cohesiveness	1	.057	.273(**)	.198(**)	.142(**)
Actual Open Endedness		1	.052	.055	.054
Actual Integration			1	.433(**)	.274(**)
Actual RuleClarity				1	.422(**)
Actual Material Environment					1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

The results on this study shows that most of the scale had positive correlation except for actual Student Cohesiveness, actual Open Endedness, and actual Material Environment with other scales which has negative values. Moreover, most the inter-scale correction are significantly correlated, except for actual Open-Endedness, preferred Integration, Rule Clarity, and actual Material Environment which have the value of $p>0.05$.

5.1.3 The Differences between Actual and Preferred Laboratory Learning Environment

Through the analysis in the table 6 which show t-value, df, and two-tail significance, the sample from the same of different group could be determined which show the degree of significant differences (Coakes & Steed, 2007). Moreover, "mean differences between the 'actual' and the 'preferred' individual responses, together with the results of paired samples t-tests for each scale [show] significantly different for every scale [if] $p<0.001$-$p<0.05$" (Bradley, 2006, p.8)

Table 6

Item Mean and Standard Deviation for Actual and Preferred in Students' Perceptions of Chemistry Laboratory Environment as Measured by the CLEI Scales

Scale	**Mean**		**Mean Differences**	t
	Actual	*Preferred*		
Student Cohesiveness	3.55	3.91	-.35	-12.16
Open Endedness	2.61	3.41	-.80	-26.26
Integration	3.56	4.15	-.58	-16.84
Rule Clarity	3.43	3.72	-.29	-9.5
Material Environment	2.84	4.08	-1.23	-29.37

The values of mean differences show that all the scale paired have the means of preferred version were higher that the means of actual version which show the negative values. This data indicates that the students seem to recognise the importance of all the scale in the instrument and prefer a more positive learning environment than they perceived at the present. Moreover, all the scale has significant correlation each other.

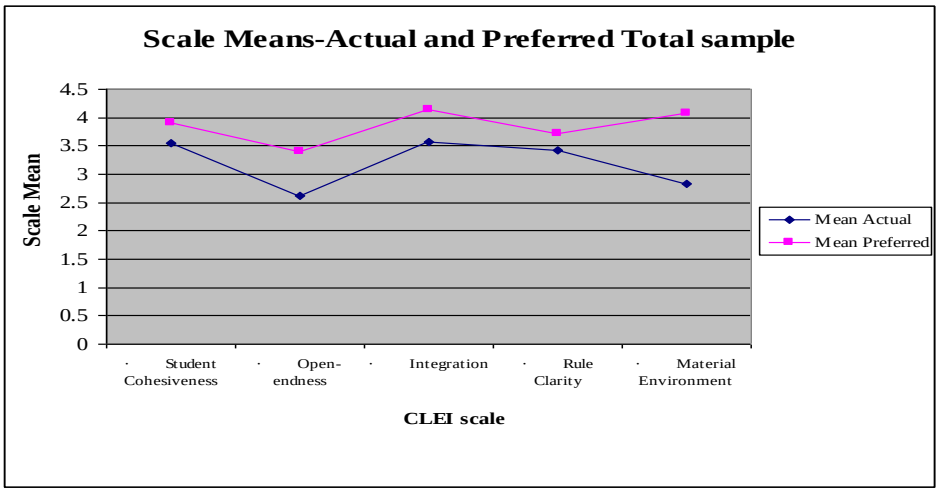

Figure 1. Scale Means-Actual and Preferred Total Sample

5.1.4 Comparison of the Students' Actual and Preferred Perceptions of Learning Environment by Gender

The results from the table 6 shows that there are no statistically significant differences between the female and male students on their actual and preferred science laboratory learning environment which confirms by the means and standard deviation which only slightly differences. However, it seems that females seem to have slightly positive perceptions on their laboratory learning environment from the actual version than do males. Even though from the research study on inquiry, Wolf and Fraser (2007), found that "classroom environment perceptions and attitudes were more positive for males in the inquiry group, but were more positive for females in the non-inquiry group". Furthermore, many studies also show that females less succeed in science subject such as physics than males (Parker, 1992). However, this study shows that females' perceptions on their science laboratory are more positive than males.

Table 7.

Item Mean and Standard Deviation for Gender Differences in Students' Perceptions of Chemistry Laboratory Environment Measured by the CLEI Scales

CLEI Scale	Gender	Mean		Std. Deviation	
		AC	PR	AC	PR
Student Cohesiveness	male	3.48	3.96	.45	.49
	female	3.58	3.89	.39	.45
Open Endedness	male	2.65	3.46	.35	.57
	female	2.59	3.39	.34	.55
Integration	male	3.52	4.08	.49	.67
	female	3.57	4.17	.50	.57
Rule Clarity	male	3.47	3.77	.42	.59
	female	3.42	3.71	.42	.49
Material Environment	male	2.81	4.13	.51	.72
	female	2.85	4.06	.49	.72

Number Of: Female: 309, Male: 101
AC: Actual, PR: Preferred

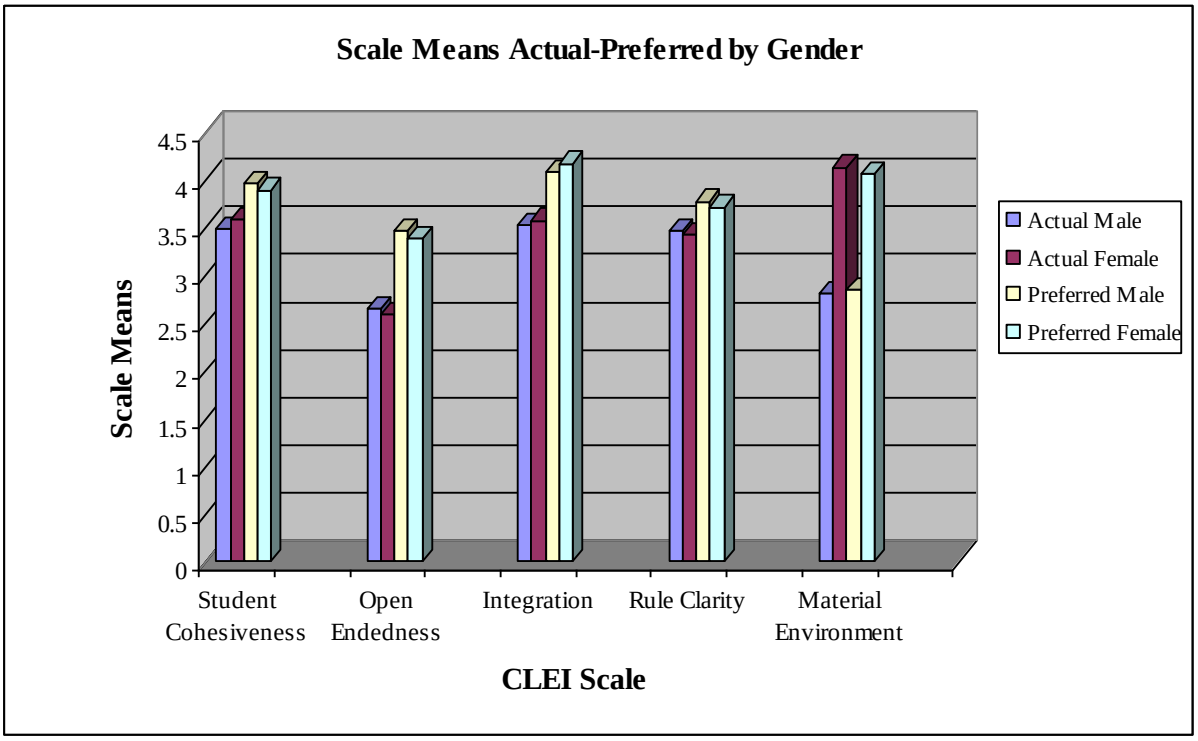

Figure 2. Scale Means-Actual and Preferred by Gender

From the figures also can be seen that both female and male give almost similar perceptions on their learning environment. As a result, it could be concluded that, the gender doesn't affect the students' perceptions on their laboratory learning environment.

5.1.5 Comparison of the Students' Actual and Preferred Perceptions of Learning Environment by Program and Year Level

The chemistry department in the university has two programs which are chemistry and chemistry education. The chemistry education course is designed for pre-service chemistry teachers and chemistry program for chemists. The department provides equal facilities between these two programs. Therefore, the result from the statistics has been shown that students' perception on these two programs were less different. However, on the year level, the statistical analysis show that the fresh year students had more positive perceptions on their laboratory learning environment which is supported by the actual condition which the laboratory chemistry facilities are better than the previous year.

Table 8.

The Comparison of mean scores of Students' Perceptions by Program and Year Level about their Chemistry Laboratory Environment as measures by CLEI

CLEI Scale	Program		Year Level	
	Chemistry Education	Chemistry	2002-2005	2006-2007
Student Cohesiveness	3.56	3.51	3.58	3.95
Open Endedness	2.60	2.61	2.62	3.41
Integration	3.59	3.45	3.62	4.31
Rule Clarity	3.42	3.44	3.48	3.86
Material Environment	2.83	2.85	2.87	3.95

N= By program : Chemistry Education (304), Chemistry (106)
By Year Level : 2002-2005 (242), 2006-2007 (168)

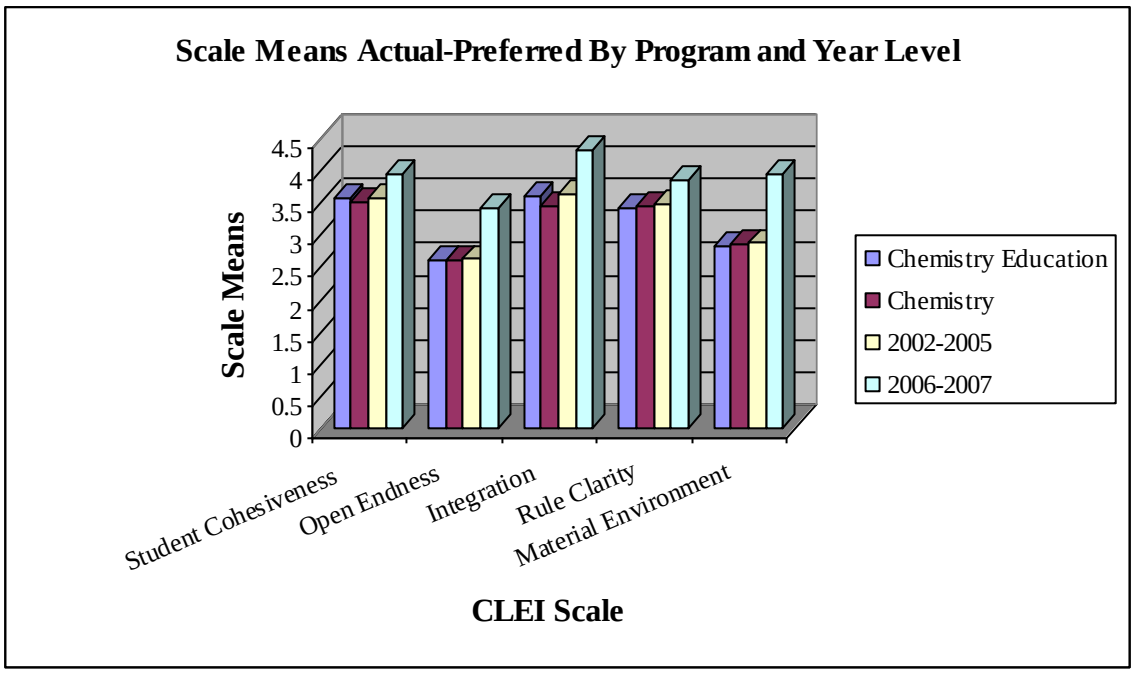

Figure 3. Scale Means-Actual-Preferred by Program and Year Level

5.2. Qualitative Analysis of Laboratory Observation and Interview

The qualitative data is gained from conducting observations in chemistry laboratory for one week. This data was further enhanced by interviewing eight students. The University has four chemistry laboratories namely *Basic and Inorganic Chemistry Laboratory, Physic Chemistry, Organic Chemistry and Biochemistry, and Analytical Chemistry.* Interviews with students and laboratory assistants from different program and year level provided in-depth information about their perceptions. Furthermore, both the observations and interviews provided meaningful insights into the features of chemistry learning environment scales which are also having positive significant correlation with each scale of CLEI.

5.2.1. Findings on Observations

I arrived at the University at 7.40am after a long struggle with the traffic jam in Jakarta. I could visualize the degree of difficulty students would have to undertake in this crowded city. I walked from the bus stop to the Mathematics and Science Faculty Which has a freshly painted new big board. I entered the main entrance, walked through several buildings towards main faculty building behind which science laboratories' building is located. Entrance to the laboratories is only through the faculty building. It took me nearly ten minutes to find laboratory building purple in colour with the big trees all around it. I passed through the faculty building and I noticed the green park between the faculty building and laboratory. Later, I knew that the Biology students are maintaining the park. I entered the laboratory building and found many students bringing the laboratory apparatus. The laboratory had three levels for Biology, Physics, and Chemistry. The chemistry laboratory was on the third floor and I went upstairs to get into the chemistry laboratory.

I was told laboratory staff that the concerned lecturer was absent. In absence of lecturer, I enquired about the topic from laboratory assistant that would be experimented by students. I saw that the students were ready in front of the laboratory door. The assistant reminded the students about the laboratory rules and asked the students to enter the laboratory. This laboratory is not big enough to accommodate 36 students and was crowded. The laboratory is divided into three sections, first main big section, where students conducted experiments, second section for laboratory equipment, and third small section for lecturer. The main big section is furnished with four long tables and a couple of wood chairs. In the middle of the table, there are several chemicals which are used for practicum during the semester.

Students were working in groups of two or three and four groups were working on each table. It was difficult for students to move around freely. The two laboratory assistants asked students to work on test which consisted of several questions relating to the Acid-Base Titration. After 15 minutes, all students finished the test, and then they are required to borrow the laboratory equipment such as burette, pipette, beaker glass, flask, and conical flask to the laboratory staff. I saw that four students prepared the acid and base solutions as standard and titrate which will be used on that Acid-Base Titration. After the students borrowed the laboratory equipment, they worked on the experiment. I looked at the lecturer's room; the assistants were busy assessing students' test and experiment reports. I couldn't imagine they had to observe students' experiment while they also had to assess students' working such as test and experiment report. Sometimes, I also noticed students asked several questions which related to basic concepts of the acid-base reactions to the assistants that requires depth explanation. Students worked on the acid-base titration by following the practicum book. I saw one group, one member of the group worked on the experiment, the other just wrote down the result. I also saw, within the same group they worked on different experiment (one topic consists several experiments). As a result, sometimes, the other could not understand others' experiment. It was because the students have to finish many experiments on one day. The laboratory activities were ended at 4pm and the students had to give the result to the assistants and returned the laboratory equipment to the laboratory staff. Four students who prepared the chemical substances also cleaned up the laboratory. It was the typical learning process in the laboratory.

5.2.2. Findings on Interviews

The data was collected through the semi-structured interview. Several questions guide the researcher to investigate the students' perceptions on their chemistry learning environments and the questions are extended depends on the response of the participants. There are several students' perceptions on their chemistry laboratory which will be explored in the findings.

In general, most of the students agreed that the laboratory activities were related to the theory in the classroom. However, they felt stressful and difficult to understand the concepts because of the overload of doing the experiments and writing of report on the same day.

> *"Since I attend the analytical chemistry practicum, I found that this practicum spend so much time and energy. I have to work in the laboratory all day, start 8am to 4pm. Moreover, the practicum reports that I have to finish within one week make me stressful to manage the time. For example, the practicum of anion and cation reaction identification which not only spends much time than others but also makes me confuse to understand the concepts"*

Moreover, most of students wanted the improvement on material environment, such as laboratory equipment and chemical substances which are scarce, and laboratory rooms which are small.

> *"I found several limitations such as the apparatus and chemical substances are limited, and the safety is inappropriate. It will be convenient if there some improvement of contextual learning, completed the apparatus and increasing the management of safety"*

There are other students' suggestions on material environment within their laboratory, such as: the fume room is not working well, laboratory instruments are not used optimally, and safety equipments are needed. I found that most students gave negative perceptions on their material environment in the laboratory. Moreover, students have less opportunity to work on their own interest, because all of them worked on the same experiments. Therefore, they felt the laboratory activities are just following the laboratory procedures as "cooked book" which caused meaningless learning experiences.

> *"I realized that if I didn't try to understand the concepts, I would be confused because I just followed the procedures without understanding what I did. As the result, I spent much time on practical work and waste the chemical substances because I didn't understand the concepts."*

Furthermore, most of them require availability of lecturer to help them understand the laboratory experiments. Because, they found that sometimes, the assistants didn't understand or could not solve the problems that students found while conducting the experiments. Moreover, it also motivates them to work in the laboratory.

> *"The lecturers should be present in the laboratory when we do experiments to help and guide us, especially if we encounter some*

difficulties doing the experiments. The assistants sometimes can't attend to our needs because they, too, are confused like us.

Laboratory assistants also perceived for the availability of the lecturer in the laboratory and their training.

"I need the training which related to our responsibility, such as using the instruments, doing the experiments before the students worked on it. I need to be reminded also on the basic concepts of the experiments".

Therefore, the findings on the interviews gave ideas on students' perceptions through the CLEI questionnaire which both the results related each others.

5.2.3. Comments on Findings from Observations and Interviews

Laboratory learning activities are designed for the working student groups. As a result, students have more opportunity to know and help each other. For example, one group consists of 2-3 students, where students share the associated work like one student weighs the sample and the others prepare the equipment. Moreover, since it is a state university, the students for each year level are fewer than private university, which are around 40 students for each program. Therefore, they know each other very well which helps them to have good cooperation. While interviewing, the students pointed out that the time limitation and the laboratory experiments encourage them to work together. Moreover, some of them have opportunity from their lecturer to choose their own partner in the laboratory which gives them ease at work.

The program is designed for all the students to work in the same experiments, except for analytical chemistry where the students are divided into two large groups which worked in two different experiments thus giving students less opportunity for working on their interest. Moreover, it is also because the chemical substances and laboratory equipment is expensive which discourage the students to explore their own interest. Through the interview, the students pointed out that they tend to focus on finishing the experiments which are determined by the curriculum because of the time limitation and the requirement. Even though, they really wanted to have opportunity to explore their own interest, but it is very difficult due to limited resources.

Based on the observations, the laboratory experiments integrate with the theory in the classroom. For example, in Analytical Laboratory, the theory of chromatography will be applied in laboratory experiment. As a result, it will be easy for students to understand the concepts. However, based on the interview, students feel, they only understand the few concepts because they just follow the practicum procedures without understanding the concept. Therefore, they need to be guided by the lecturers to understand the concepts, which is also shown by the statistical analysis and students perceive for more integration between theory and experiments. The students pointed out that they need the lecturer's availability to attend the laboratory experiments, in addition to the laboratory assistant who at times was unable to fully assist them. In addition to the subject matter lecturer can maintain better discipline in the laboratory which is very important keeping in view the students safety.

The material environment seems becoming common problem for laboratory experiments in education institution in Indonesia, especially affordability of chemical substances and laboratory equipment. Students also pointed out the unusable equipment. Although chemical substances are available but at times can be adultrated. Statistical analysis of lower means for the scale of *Material Environment* favors these findings. Moreover, chemistry department and teachers could use this information to guide them create the changes for the better learning environment.

5. DISCUSSION

Learning Environment Questionnaires for use in Indonesia need to be developed. This study is one of the initial steps towards developing these questionnaires where CLEI was translated in Indonesian language. Even though the instrument is reliable, further studies need to be conducted, because the value of alpha reliability is lower than the English version of CLEI instruments. Moreover from the result, it seems that the Open-Endedness and Material Environment less applied in the laboratory compared to other scales such as Interaction which had highest score of mean. The mean data also show that the mean for the preferred version were higher than the actual, which means students preferred the more positive learning environment than at the present.

Moreover, the inter-scale correlation shows that most scale has positive correlation and significant correlated each other. However, only the scales of Open Ended, Integration, and Rule Clarity scale which have significant correlation. Students' cohesiveness related positively and significantly with all scales in CLEI both actual and preferred version. One possible interpretation is students find conducive and useful learning environment which encourage them to support each others. Moreover, most the inter-scale correction are significantly correlated, except for actual Open-Endedness, preferred Integration, Rule Clarity, and actual Material Environment which have the value of $p>0.05$. It is supported by the observation and interview that, all students do the same experiments and less opportunity to explore their own interests. Throughout the data, it seems that teacher should improve the implementation of Open-Endedness and Material Environment in the laboratory. Furthermore, correlation between actual and preferred for each scale correlated positively.

In addition to the correlation, the paired test show that the paired scales correlated positively .However, only the Open Endedness, Integration, and Rule Clarity scale which have significant correlation. However, students' perceptions on their laboratory learning environment both actual and preferred version are not affected by the gender and program. It is because both female and male or chemistry education and chemistry program have the same opportunities in the learning process. However, there are different perceptions on students within different year level, because the laboratory facilities are improved recently. As a result, the new students give perceptions that are more positive on their learning environment. In general, all data supported the perception that students preferred the more positive learning environment than at the present. Teacher could use this information to apply or change the strategies to improve the science laboratory learning environment, especially on Open-Endedness and Material Environment scale. Even through, students preferred the less Rule Clarity guide them in laboratory, I think it is better to have the formal rule clarity in science laboratory which is not only for effectiveness the laboratory, but also students' safety.

In summary, on students' cohesiveness scale, students have opportunities to work together and support each other in the laboratory. However, open-Endedness is not well applied in the laboratory, which also shown by the observation and interview with students. It is because the lecturer doesn't give the different tasks for the students which are common that in laboratory activities, all students work on the same practical work and less opportunities for individual to work on her/his interests. Even though, it seems that the higher education should provide the opportunities for students to explore their interests, but it depends on students' initiative and lecturer encouragement. Moreover, both quantitative and qualitative data show that the integration of theory and practice in laboratory (quantitative) and the integration of theory and learning experiences in the classroom (qualitative) are applied by the teacher. Moreover, the integration will motivate the students to engage with their learning process. Rule clarity is also applied in the laboratory and classroom. Rule clarity in laboratory is important not only for the effectiveness of teaching laboratory, but also students' safety. On the other hand, the qualitative data shows that the lecturers give the rule clarity in the laboratory to create the effective education process and the students also seems understand the rule. Furthermore, the material environments are less adequate which is not only shown by the lowest mean score, but also the observation and interview data. It is found that the laboratory equipment needs to be improved. Moreover, students need the safety equipment in the laboratory.

6. CONCLUSIONS

In conclusion, Chemistry Laboratory Environment Inventory (CLEI) instrument provides the information of students' perceptions on actual and preferred laboratory learning environments which could be used for improvement and effectiveness teaching in science laboratory. Moreover, the five scales in CLEI instrument support each others to create the effectiveness of learning environment both in the classroom and laboratory.

Throughout this study, it is found that students' cohesiveness, integration, and rule clarity are well applied in the laboratory. The problem on Open-Endedness scale, because the students work on the same experiments which provide less opportunities for students to explore their interest. Moreover, material environment also need o be improved because it is important for the effective learning process. The study found that students' perceptions on their laboratory learning environment are not affected by gender and program, but it is affected by the year level which related to the improvement of laboratory facilities recently. Finally, the CLEI instrument is appropriate to assess the students' perception on their science laboratory learning environment. Five scales in CLEI instrument are the important factors for the lecturer to apply in the science laboratory and classroom to create the meaningful learning environment.

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