# Assessing Students' Perceptions of their Chemistry Laboratory Classroom Learning Environments and their Science Attitudes in Upper Secondary School Classes in Thailand

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***Abstract:*** *Using the 35-item Chemistry Laboratory Environment Inventory (CLEI) which examines in five scales, namely; Student Cohesiveness, Open-Endedness, Integration, Rule Clarity and Material Environment scales. To investigate students' perceptions consisted of 58 students in 2 classes in Mahawichakul School at the 11th grade level in Thailand. Students' perceptions of their chemistry attitudes were assessed with the Test of Chemistry-Related Attitude (TOCRA). These actual and preferred perceptions of chemistry laboratory classroom environments and their attitudes toward chemistry were associated. It has found that students' perceptions of their actual and preferred chemistry classroom learning environments were also found, significantly. Research instruments with Cronbach's alpha reliability coefficients for the scales were reliable, while confirmatory. The efficiency predictive value ($R^2$) is significant for the CLEI and considered association with the TOCRA, and value indicates that 47% and 68% for the actual and preferred forms of the variance in students' attitudes are provided.*

***Keywords:*** *Actual and preferred forms, the Chemistry Classroom Learning Environments (CLEI), the Test of Chemistry–Related Attitude (TOCRA), and chemistry laboratory classes.*

## Introduction

In 1972, the Institute for the Promotion of Teaching Science and Technology is a Thai government agency (IPST, 2011). Its responsibilities include the development of national science and mathematics curricula, and sponsorship of science education, as well as the promotion of science in general. It is also Thailand's coordinator for the International Science Olympiads, was established in order to develop a national science and mathematics curriculum at the primary and secondary school level (Grade 1-12). Thailand had been using the 2000s versions of the science and mathematics curricular prior to that time in 2008 were reformed to the Basic Education Core Curriculum A. D. 2008 would undoubtedly provide all educational service area offices, local offices and basic education institutions under jurisdiction of various agencies with an appropriate framework and guidance for preparing the pertinent curriculum. The basic education to be provided to all Thai children and youths will be of higher quality in regard to acquisition of essential knowledge and skills required for learners' lives in the constantly changing society. Learners will also be able to acquire knowledge for continuous lifelong self-development (The Ministry of Education of Thailand, 2011). Upper secondary municipal schools were not able to choose teaching materials according to the preference of their teachers and the facilities available.

The purpose of this study is beyond the scope of this article to summarize the decades of research on this topic; however, a perusal of the school and classroom climate literature indicates that the stability and efficacy of elementary school children's social interactions influence their academic and social development. This study is to focus on given the paucity of strong empirical research conducted with Thai secondary school students at the Mahawichakul School at Grade 11th level in MahaSarakham Province for demonstrating the reliability and validity of the Chemistry Laboratory Environment Inventory (CLEI), before it could be recommended to school administration as a viable measure of school climate within the Test Of Chemistry-Related Attitude (TOCRA), the instruments need to be thoroughly analyzed psychometrically. The objective of this paper are: 1) to describe the validation procedures of the CLEI and the TOCRA; 2) to compare the students' responses with the actual and preferred chemistry laboratory classroom environments; 3) to associate between students' perceptions of their actual and preferred chemistry laboratory classroom environment and their attitudes toward chemistry.

**Literature Review**

Using students' and teachers' perceptions to study educational environments can be contrasted with the external observer's direct observation and systematic coding of classroom communication and events. Defining the classroom or school environment in terms of the shared perceptions of the students and teachers has the dual advantage of characterizing the setting through the eyes of the participants themselves and capturing data which the observer could miss or consider unimportant. Students are at a good vantage point to make judgments about classrooms because they have encountered many different learning environments and have enough time in a class to form accurate impressions. Also, even if teachers are inconsistent in their day-to-day behaviour, they usually project a consistent image of the long-standing attributes of classroom environment. Later in this chapter, discussion focuses on the merits of combining quantitative and qualitative methods when studying educational environments (Fraser & Tobin 1991). Because of the critical importance and uniqueness of laboratory settings in science education, an instrument specifically suited to assessing the environment of science laboratory classes at the senior high school or higher education levels was developed (Fraser, Giddings & McRobbie 1993). The *Science Laboratory Environment Inventory* (SLEI) was field tested and validated simultaneously with a sample of over 5,447 students in 269 classes in six different countries (the USA, Canada, England, Israel, Australia and Nigeria), and cross-validated with 1,594 Australian students in 92 classes (Fraser & McRobbie 1997), 489 senior high school biology students in Australia (Fisher, Henderson & Fraser, 1997) and 1,592 grade 10 chemistry students in Singapore (Quek, Wong, & Fraser, 2002). Santiboon and Fisher (2005) adapted version from the original of the SLEI to the PLEI (*Physics Laboratory Environment Inventory*) was assessed to upper secondary education level evidence of 4,576 students in 105 school classes throughout of Thailand. The aims of this research were to the strongest tradition in past classroom environment research has involved investigation of associations between students' cognitive and affective learning outcomes and their perceptions of psychosocial characteristics of their physics laboratory classrooms (Santiboon, 2012; Santiboon, Thongbu, & Saihong, 2016). In this research study, using the PLEI to assess students' perceptions of their physics laboratory classes, associations with students' cognitive and affective outcomes have been established for this sample group with their science attitudes and creative thinking abilities.

In the last decades, based on relevant studies and monitoring as well as evaluation of the curriculum in application during the past six years, strengths of the Basic Education Curriculum 2001 were identified. It facilitated decentralization of educational authority, enabling local communities and schools to participate and play important roles in preparing curriculums which met their real needs. Clear concepts and principles for promoting learners' holistic development were quite apparent. Nonetheless, the outcomes of these studies revealed several problems arising from lack of clarity. Shortcomings were found in provisions of the curriculum itself, its application and emerging unsatisfactory outcomes, resulting in confusion and uncertainty of practitioners at school level in preparing their own curriculums. Most schools were ambitious in prescribing the learning areas, leading to overcrowded curriculums. Excessively high expectations were also set. Measurement and evaluation did not correlate with the standards set which effected on preparation of certifying documents and transferring of learning outcomes.

Moreover, problems regarding learners' ability to acquire essential knowledge, skills, capacities and desired characteristics were quite disconcerting (Bureau of Academic Affairs and Educational Standards, 2008). Furthermore, the new curriculum; the Basic Core Curriculum B.E. 2551 (A.D. 2008) and the Basic Core Curriculum B.E. 2558 (A.D. 2015) (Draft) has prescribed a structure of minimum time to be allotted to each subject area for each grade level. Schools are given opportunities to increase learning time allotment, depending on their readiness and priorities. Improvement has been made to the process of measuring and evaluating learners' performance as well as criteria for graduation at each educational level. Adjustment has also been made for streamlining certification which correlates with learning standards, thus facilitating application of certifying documents. From the context of this basic core curriculum problem of learning management in science classroom in physics course is integrated. The problem of achievement of learning management at source has been achieved as low. The Institute the Promotion of Teaching Science and Technology (IPST) has been trying to solve the problems of learning management model with the integration of science education, this is just the beginning. Although there are eight centers, eight centers are located in different parts of the country (Ministry of Education, 2015).

The chemistry curriculum for upper secondary municipal level was divided and stand for understand processes of genetic transmission, variation, mutation, evolution of living things and factors affecting their survival in various environments; understand processes, importance and effects of biotechnology on human beings, and living things and the environment are standardized. Following the implementation of the new science curriculum in 2015, laboratory experimentation in chemistry has been incorporated within most of the teaching programs of upper secondary municipal school teachers in Thailand (IPST, 2015).

In the last four decades, there are too many researches on the classroom learning environment have spanned more than four decades with significant contributions to the field of education (Lian, Wong, and Der-Thang, 2006) who are the. Reviews of research (Fraser, 1986; Fraser, 1998; Fraser and Walberg, 1991; Fisher, Henderson, and Fraser, 1997) reported that most of the studies on classroom learning environments used the perceptual measures approach to investigate the nature of classroom learning environments. This approach involved the use of classroom environment instruments to measure teachers' and students' perceptions of their classroom environments for investigating the nature of the classroom learning environment. These studies had developed many well-validated and robust classroom environment instruments for use in many countries in different classroom contexts (Fraser, 1998).

The Science Laboratory Environment Inventory (SLEI) was developed to examine students' perspectives about their chemistry laboratory courses (Fraser, Giddings and McRobbie, 1993; Fraser and McRobbie, 1995). The SLEI examines five scales, namely: integration, rule clarity, student cohesiveness, open-endedness, and material environment. The CLEI consists of 7 items for each scale, yielding 35 total items which are answered through a 5-Point Likert scale. In this study, using the Chemistry Laboratory Environment Inventory (CLEI) was adapted version from the version of the Chemistry Laboratory Environment Inventory (CLEI) (Kijkosol, 2006) was to select on this research instrument to assess students' perceptions of their chemistry laboratory classroom environment inventory.

In Thailand, among researches on classroom learning environment, Kijkosol (2006) reported to provide validation information of three questionnaires that were modified and translated into Thai language, namely, the Questionnaire on Teacher Interaction (QTI), the Chemistry Laboratory Environment Inventory (CLEI), and the Attitude to Chemistry Class (ABC). Santiboon (2012) reported on the assessing science students' perceptions in learning activities achievements in physics laboratory classrooms in UdonThaniRajabhat University, using the 35-item Physics Laboratory Environment Inventory (PLEI), which is a modified from the original Science Laboratory Environment Inventory (CLEI) (Fraser, McRobbie, & Giddings, 1993). This questionnaire has an Actual Forms and a Preferred Form. Students' attitudes were assessed with the Test Of Physics-Related Attitude (TOPRA) modified from the Test of Science-Related Attitude (TOSRA) (Fraser, 1981). In this research study, the approach involved the use of classroom environment instrument to measure students' perceptions of their chemistry laboratory classroom environments for investigating the nature of the classroom learning.

**Methodology**

To investigate of associations between students' perceptions of their chemistry classroom environment and their attitudes toward chemistryforupper secondary educational students at the $11^{th}$ grade level in Mahawichakul School, MahaSarakham Province. This study modified the Test of Chemistry-Related Attitude (TOCRA) (Kijkosol, 2006) from the original short version of the Test of Science-Related Attitude (TOSRA) (Fraser, 1981; Kijkosol, 2006, Santiboon, 2012, 2013; Santiboon and Fisher, 2006) in Thai version was designed to measure eight distinct classroom-related attitudes amongupper secondary educational students at $11^{th}$ Grade level in Mahawichakul School classes, Maha Sarakham Province. The eight items are suitable for group administration and overall can be administered within the duration of a learning and chemistry classroom constructivist. Furthermore, TOCRA has been carefully developed and extensively field tested and has been shown to be highly reliable that it has been translated to Thai version in this study.

This research study describes the development of a new instrument for assessing student perceptions of psychosocial environment in chemistry laboratory classrooms, and reports comprehensive validation information for large samples of senior high school and university students from Mahawichakul School, MahaSarakham Province in Thailand. The work is distinctive because it extends classroom environment research in non-laboratory settings to chemistry laboratory classes, and provides one of the few classroom

environment studies conducted in Thailand during the last decade. The translation procedure was repeated twice before on tried out with other sample before the CLEI and the TOCRA ready for validation with the target of purposive random sample in Thailand.

**Sample**

The sample was selected with the purposive random sampling which a sample size consisted of 58 students in 2 classes in Mahawichakul School in Maha Sarakham Province in Thailand was considered the most suitable representatives of the population for this study.

**Instruments: The CLEI and the TOCRA**

The Chemistry Laboratory Environment Inventory (CLEI) was developed to examine students' perspectives about their chemistry laboratory courses (Fraser, McRobbie, and Giddings, (1993); Santiboon and Fisher (2005)). The CLEI is unique in that it comes in two parallel in Thai version forms, actual form which addresses the current class to assess the class as it actually is, and preferred form which addresses how they would prefer the class to be like – the idea situation (Santiboon and Fisher, 2005). The CLEI examines of five scales, namely; *Student Cohesiveness Integration, Rule Clarity, Open-Endedness, and Material Environment* (Fraser, McRobbie, and Giddings, (1993); Fisher, Henderson, and Fraser, (1997); Santiboon and Fisher, (2005).

Table 1 *Description of Scales and Sample Items for each Scale of the CLEI*

| Scale name | Moos category | Description | Sample item |
|---|---|---|---|
| Student Cohesiveness | R | Extent to which students know help and supportive of one another | I get along well student in this laboratory class. (+) |
| Open- Endedness | P | Extent to which the laboratory activities emphasize an open-ended, divergent approach to experimentation | In my laboratory sessions, the teacher decides the best way for me to carry out the laboratory experiments. (-) |
| Integration | P | Extent to which the laboratory activities are integrated with non-laboratory and theory classes. | I use the theory from my regular chemistry class sessions during laboratory activities. (+) |
| Rule Clarity | S | Extent to which behaviour in the laboratory is guided by formal rules. | There is a recognised way for me to do things safely in this laboratory. (+) |
| Material Environment | S | Extent to which the laboratory equipment and materials adequate. | I find that the laboratory is crowded when I am doing experiments. (-) |
| R: Relationship dimension; P: Personal Development dimension, S: System Maintenance and System Change dimension. Items designated (+) are scored 1,2,3,4 and 5 respectively for the responses Almost Never, Seldom, Sometimes, Often and Very Often. Items designated (-) are scored in the reverse manner. Omitted or invalid responses are scored 3. | | | |

In table 1, the CLEI consists of 7 items for each scale, yielding 35 total items which are answered through a 5-Point Likert scale, 'Almost never', 'Seldom', 'Sometime', 'Often', and 'Very often', indicating that the degree of agreement with each statement by student' respondents. Table 1 below gives an overview of the five scales and sample item for each scale of the CLEI. The student-actual and student-preferred forms were used to assess students' perceptions toward their actual and preferred Thai language classroom environment.

**Procedures of Data Collection**

The researcher team designed for administrating the CLEI to 115 Upper secondary educational students' personality. The period for data collection was in the second semester in the academic year 2015 (October 2015 – February 2016) for assessing students' perceptions in three times; In order to using the CLEI and the TOCRA were tried out for assessing the reliability and validation of the research instruments on Thai version in the first semester with a sample size of 35 students who were not the target sample group in the other classroom and analyzed the data analysis ($\forall$ = 0.76 for the CLEI and $\forall$ = 0.77 for the TOCRA). To administer of the target group, firstly; to assess students' perceptions of their preferred chemistry laboratory classroom environment inventory in November, 2015, secondly, using the student-actual-I form to assess students' perceptions of their actual chemistry laboratory classroom environment inventory in December, 2015, and thirdly, to assess students' perceptions of their attitudes toward chemistry with the TOCRA to ensure data collection process, the preparation for data collection was carried out comprehensively. At the end of data collection, all data were imported into SPSS statistical software to produce workable SPSS formatted data files for data analysis.

**Procedures of Statistical Analysis**

The student-actual and student-preferred forms of the CLEI were validated using the student sample stated below. The data was then stored in various SPSS files to perform all the statistical analyses on the internal consistency reliability, discriminant validity, the scale intercorelationto differentiate between students' perceptions in different classrooms and the factorial validity of the CLEI.

The Cronbach alpha reliability coefficient was calculated for each of the five scales as a measure of internal consistency reliability for each scale, using two units of analysis (the individual and the class mean). In addition, the discriminant validity for each CLEI scale was also obtained by computing the mean correlation of that scale with the other four scales of the CLEI using the individual student as the unit of analysis.

The ability of the CLEI scales (student-actual) to differentiate between perceptions of students in different classes was also examined using a series of one-way analyses of variance (ANOVA). For this ANOVA, class membership was used as the independent variable and the set of the five scales of the CLEI in the student-actual form was used as the dependent variable. The results of this analysis were presented in terms of the $eta^2$ statistic that is the ratio of *between* to *total* sums of squares.

**Research Questions**

The overall aim of this research study was to describe the determinants and effects of students' perceptions of chemistry classroom environments in Mahawichakul School classes in Thailand, in order to improve the performance of students in chemistry; therefore, the validation of the CLEI and the TOCRA forms the focus of the first and the second research questions.

*Research Question 1*: Is the Chemistry Laboratory Environment Inventory (CLEI) a valid and reliable for use in Mahawichakul School classes Thailand?

*Research Question 2*: Is the Test Of Chemistry-Related Attitude (TOCRA) a valid and reliable for use in the Mahawichakul School classes in Thailand?

As this was the first study procedure to measure classrooms students' perceptions in chemistry laboratory environment in Mahawichakul School classes in Thailand, a comparison between actual and preferred students' perceptions was thought important. This formed the focus of the next research question 3.

*Research Question 3*: Are there any differences between the students' perceptions of their actual and preferred classroom laboratory environments in chemistry classes in Mahawichakul School classes in Thailand?

It was also considered important to investigate associations between students' perceptions and learning environments with their attitudes to their chemistry laboratory classes. This formed the focus of research question 4.

*Research Question 4*: What associations are there between students' perceptions of their actual and preferred chemistry laboratory classroom environments and their attitudes toward chemistry in Mahawichakul School classes in Thailand?

## Results

### Validity and Reliability of Research Instrument

#### *A. Validation of the CLEI*

The actual and preferred perceptions of 72 students in 4 classes of their chemistry laboratory classroom environments were also measured using the CLEI. The CLEI data for the Mahawichakul School classeswere used to generate for each CLEI scales: The classes mean of students' actual and preferred scores, the standard deviations and the *t*-test results for statistical significance.

Table 2 *Scale Mean Scores, Means, Standard Deviations, and t-test for Actual and Preferred Forms of the CLEI*

| Scale | Form | Mean score | Mean | Standard Validation | t-test |
|---|---|---|---|---|---|
| Student Cohesiveness | Actual<br>Preferred | 24.80<br>27.93 | 3.54<br>3.99 | 0.71<br>0.37 | 3.07** |
| Opened-Endedness | Actual<br>Preferred | 24.87<br>26.23 | 3.55<br>3.75 | 0.66<br>0.60 | 1.32* |
| Integration | Actual<br>Preferred | 24.47<br>27.80 | 3.50<br>3.69 | 0.61<br>0.64 | 1.37* |
| Rule Clarity | Actual<br>Preferred | 24.43<br>27.87 | 3.49<br>3.70 | 0.57<br>0.57 | 1.21* |
| Material Environment | Actual<br>Preferred | 22.87<br>25.40 | 3.27<br>3.63 | 0.44<br>0.58 | 3.04** |

**Correlation is significant at the 0.05 level (2-tailed)*
*** Correlation is significant at the 0.01 level (2-tailed)*
**** Correlation is significant at the 0.001 level (2-tailed)*

In Table 2, the results show mean scores for each of the five CLEI scales, namely; *Student Cohesiveness Integration, Rule Clarity, Open-Endedness, and Material Environment* scales. As each scale has seven items, the scale means ranged from 22.87 to 24.80 on the Actual Form, and from 25.40 to 27.93 on the Preferred Form (maximum 35, minimum 7). Standard deviation for the Actual Form ranged from 3.27 to 3.55, and from 3.63 to 3.99 on the Preferred Form. Table 2 reveals that the differences between the Actual and Preferred Forms of the CLEI scales were statistically significant at the 0.05 level for all scale of the five scales.

Table 3 *Scale Internal Consistency (Cronbach alpha reliability), Discriminant Validity (Mean Correlation of a Scale with Other Scales) and Ability to Differentiate between Actual and Preferred Forms (ANOVA) for the CLEI*

| Scale | Form | Cronbach's alpha reliability | Discriminant validity | ANOVA Results *(eta²)* |
|---|---|---|---|---|
| Student Cohesiveness | Actual<br>Preferred | 0.75<br>0.81 | 0.69<br>0.73 | 0.62*** |
| Opened-Endedness | Actual<br>Preferred | 0.73<br>0.78 | 0.70<br>0.74 | 0.48** |
| Integration | Actual<br>Preferred | 0.76<br>0.78 | 0.71<br>0.75 | 0.41** |
| Rule Clarity | Actual<br>Preferred | 0.70<br>0.74 | 0.71<br>0.74 | 0.54** |
| Material Environment | Actual<br>Preferred | 0.60<br>0.65 | 0.73<br>0.78 | 0.47** |

**Correlation is significant at the 0.05 level (2-tailed)*
*** Correlation is significant at the 0.01 level (2-tailed)*
**** Correlation is significant at the 0.001 level (2-tailed)*

As reports in Table 3, the reliability coefficient for the different CLEI scales ranged from 0.60 to 0.75 when using the Actual Form and from 0.65 to 0.81 for the Preferred Form when using the individual student as unit of analysis. On the whole, these results are acceptable somewhat previously in the original validation sample (Fraser, McRobbie, and Giddings, 1993) and previously in validation sample in Thailand (Santiboon and Fisher, 2005). The 35-item CLEI also was subjected to a series of One-Way analysis of variance. As shown in Table 2, the $eta^2$statistic ranged from 0.20 to .24 for different scales. It was confirmed that each scale differentiated significantly ($\Delta<0.05$) between perceptions of students in different classrooms. The results given in Table 3 shows that on average item means for each of the five CLEI scales, that they contain five items, so that the minimum and maximum score possible on each of these scales is 7 and 35, respectively. Because of this difference in the number of items in the five scales, the average item mean for each scale was calculated so that there is a fair basis for comparison between different scales. These means were used as a basis for constructing the simplified plots of significant differences between forms of the CLEI. For the remaining five scales, namely; *Student Cohesiveness Integration, Rule Clarity, Open-Endedness, and Material Environment* scales. In terms of statistically significant of the internal consistency Cronbach alpha reliability and discriminant validity (mean correlation of a scale with other scales)using the unit of analysis, Table 3 shows the ability of each scale of the CLEI to differentiate between students' perceptions of their actual and preferred chemistry laboratory classroom environments by the *t*-test and $eta^2$statistic is also compared in Table 3.

The discriminant validity coefficients (the mean correlation of a scale with the other scale) of the chemistry laboratory classroom environment, these findings suggest that the scales of the CLEI measure district although somewhat overlapping aspects of the chemistry laboratory environment

Table 4 *Scale Intercorelations for the CLEI Using the Actual and Preferred Forms*

| Scale | Form | SC | OE | In | RC | ME |
|---|---|---|---|---|---|---|
| Student Cohesiveness | Actual<br>Preferred | | | | | |
| Opened-Endedness | Actual<br>Preferred | 0.80**<br>0.65** | | | | |
| Integration | Actual<br>Preferred | 0.78**<br>0.68** | 0.74**<br>0.66** | | | |
| Rule Clarity | Actual<br>Preferred | 0.76**<br>0.68** | 0.81**<br>0.76** | 0.68**<br>0.73** | | |
| Material Environment | Actual<br>Preferred | -0.07<br>0.62** | 0.01<br>0.66** | 0.33<br>0.74** | -0.12<br>0.56** | |

**Correlation is significant at the 0.05 level (2-tailed)*
*** Correlation is significant at the 0.01 level (2-tailed*
**** Correlation is significant at the 0.001 level (2-taile***)**

To investigate the circumplex of the CLEI, correlations between the scales were calculated. The result is presented in Table 4. As expected, the result shows that the correlation between a scale and scale next it generally, the circumplex nature of the CLEI has been confirmed.

### *B. Validation of the TOCRA*

To measure students' attitudes toward chemistry studies, this research study adapted the 8-item the *Test Of Chemistry-Related Attitude* (TOCRA) (Fraser, 1981; Santiboon& Fisher, 2005). Using internal consistency reliability the TOCRA had a value of 0.81 which was considered satisfactory for further use inMahawichakul School classes in Thailand in this study.

**Comparisons between Student's Perceptions of their Actual and Preferred Chemistry Classroom Learning Environment Classes**

Table 1 is comparing differences between the students' perceptions of their actual and preferred towards chemistry laboratory classroom learning environment for Upper secondary educationalstudents at the 9$^{th}$ grade level in Mahawichakul School classes. Figure 1 illustrates the differences between Actual and Preferred Forms and indicates that students would prefer more student cohesiveness, open-endedness, integration, rule clarity and an enhanced material environment in their laboratories. The results of this study also indicate that using the CLEI helps Upper secondary municipal teachers to gain a better picture of learning environment and the perceived learning needs of their students. It also provides support for the idea that teachers needs to take differences into consideration when planning and designing the chemistry curriculum for the students in chemistry laboratory environments.

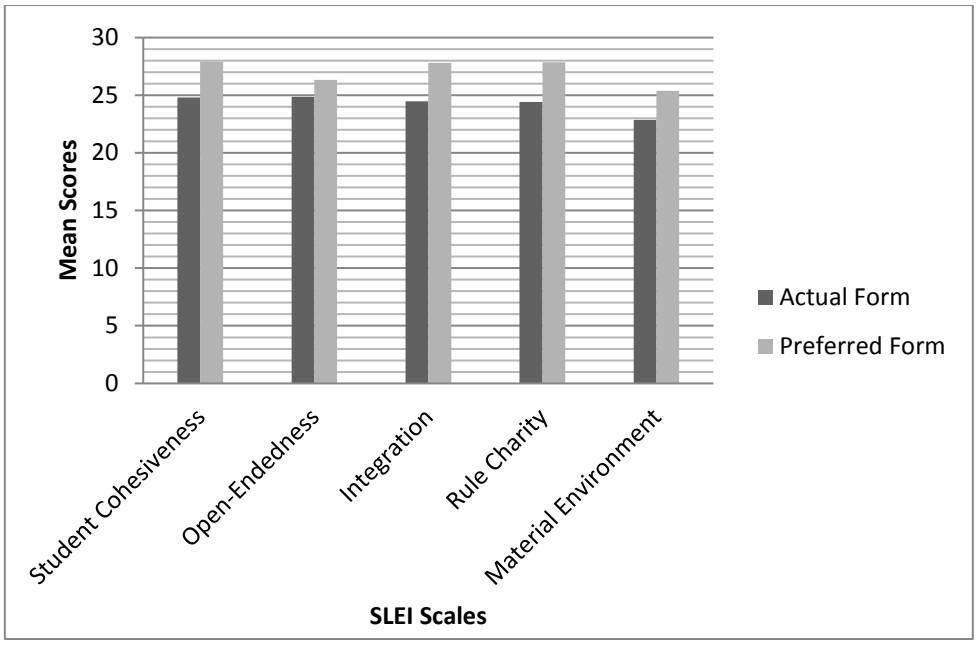


*Figure 1.* Significant differences between students' perceptions of their actual and preferred scores on the CLEI

**Associations between Students' Perceptions of their Actual and Preferred Chemistry Laboratory Classroom Learning Environments and their Attitudes toward Chemistry**

Focusing on the CLEI, the statistical procedures also involved the investigation of associations between students' perceptions of their actual and preferred chemistry laboratory classroom learning environments and their attitudes toward physics. The simple correlations values (r) are reported in Table 5 which shows significant correlations ($\Delta<0.05$) between students' attitudinal outcomes and chemistry classroom environment on all scales. These associations are all positive. In classes where the students perceived greater than open-endedness, integration, rule clarity, material environment, and satisfactory student cohesiveness there was a more favourable attitudes toward their actual and preferred chemistry classes.

Table 5 *Associations between CLEI Scale and Attitude Scale to seminar on chemistry education Class in Term of Simple and Multiple Correlations (R) and Standardized Regression Coefficient (β)*

| Scale | Preferred Form | | Actual Form | |
|---|---|---|---|---|
| | Simple Correlation Attitude (r) | Standard Regression Weight Attitude (β) | Simple Correlation Attitude (r) | Standard Regression Weight Attitude (β) |
| Student Cohesiveness | 0.34** | 0.63*** | 0.34** | 0.38** |
| Opened-Endedness | 0.31** | 0.54*** | 0.28** | 0.50*** |
| Integration | 0.33** | 0.53*** | 0.32** | 0.23** |
| Rule Clarity | 0.30** | 0.31** | 0.32** | 0.33** |
| Material Environment | 0.39** | 0.45*** | 0.30** | 0.30** |

| | | |
|---|---|---|
| Multiple Correlation (R) | 0.7533** | 0.6430** |
| R/2 | 0.5675** | 0.4135** |

**Correlation is significant at the 0.05 level (2-tailed)*
*** Correlation is significant at the 0.01 level (2-tailed)*
**** Correlation is significant at the 0.001 level (2-taile)*

Using the conservative standardized regression coefficient analyze, which measure the associations between students' perceptions on each scale of the CLEI and their attitudes towards chemistry when the effect of relationships between the scales is controlled for this research study.

The multiple correlation *R* is significant for the CLEI and shows that when the scales are considered together there are significant with the TOCRA. The $R^2$ values indicated that 41% and 57% of the variances in students' attitudes to their chemistry classes were attributable to their perceptions of their actual and preferred chemistry laboratory classroom environments, consequently. The beta weights (β) show that in classes where the students perceived greater open-endedness, integration, rule clarity, material environment, and satisfactory student cohesiveness scales in their chemistry laboratory lessons, students had a more fovourable attitude towards their chemistry classes. Overall, Thai temple municipal Upper secondary educational school students in the Municipality show relatively favourable perceptions of their actual and preferred laboratory environments' performances' relations, differently.

**Conclusions**

This study is significant for three reasons. First, it is too likely to provide information for explaining the students' low average mean scores on chemistry assessment from the PISA. It refers to the Programme for International Student Assessment, which is part of the Organization for Economic Co-operation and Development (OECD) in Paris. For the 2015 PISA test, Thailand scored 444 in science learning core - 50$^{th}$ among 65 participating countries.Second,itwill provide chemistry teachers with a strategy for using the CLEI in attempts to improve laboratory class environments in chemistry classes. Third, this study is likely to contribute to learning chemistry in the eighty two secondary office areas of Thailand. In this study, describes students' perceptions of chemistry laboratory environments in Mahawichakul School classes in Thailand, and considers how this can be used to improve the performance of students in Chemistry. This study has focused on the subject of chemistry, the chemistry laboratory classroom environments, and students' attitudes toward chemistry. Quantitative data were gathered with two instruments, namely; the Chemistry Laboratory Environment Inventory (CLEI) and the Test Of Chemistry-Related Attitude (TOCRA) were also used in this study. It was important to appropriate statistical procedures were used, in order to validate the questionnaires. The procedures included factor analysis, item analysis, Cronbach alpha, discriminant validity and one-way ANOVA. The results from these analyses confirmed the circumplex nature of the CLEI and taken with reliability of the classroom learning environments involved the CLEI and the TOCRA are valid and reliable for use in Mahawichakul School in Thailand. The results presented in this section have provided answers to Research Question 1 and 2. The actual and preferred perceptions of 72 chemistry laboratory classroom learning environment for Demonstration students in 4 classes at the 11$^{th}$ grade level in MahawichakulSchool were measured with the CLEI. The comparisons of the Actual Form with the Preferred Form indicated that students would prefer more student cohesivenessopen-endedness, integration, rule clarity, and material environment in their laboratories. In general, students' perceptions of their preferred classroom laboratory environment in chemistry classes tended to be greater than what they actually perceived to be provided. The results presented in this section have provided answers to Research Question 3. With regard to the CLEI, it was found that the five scales; student cohesivenessopen-endedness, integration, rule clarity, and material environment were positively associated with students' attitudes to actual and preferred chemistry classes in Mahawichakul School classes in Thailand.

**Implications For Further Research**

This study has implications for the Institute for Promotion of Teaching Chemistry and Technology (IPST), Office of the Basic Education Commission, the Primary Educational Service Office Areas, the Secondary Educational Service Office Areas, the University Demonstration School throughout of Thailand, chemistry teachers, educators, and educational researchers in the world. Two generally applicable instruments were used: the Chemistry Laboratory Classroom Environment Inventory (CLEI) and the Test Of Chemistry-Related Attitude (TOCRA) and were found valid and reliable for use in Mahawichakul School classes in Thailand. The availability of these instruments provides a means by which students' perceptions can be monitored by teachers to attempt their classroom teaching practice; they can be used by IPST staff to assist in the development of a chemistry curriculum at Upper and upper secondary municipal school levels, and to monitor reviews of the administration of systematic educational reforms in Thailand. Based on these findings, suggestions for improving the chemistry laboratory classroom environment are needed. The chemistry laboratory environment is characterized by moderate level of student cohesiveness and low levels of open-endedness, integration, rule charity and material environment. Teachers should provide laboratory activities related to what students learn in theory classes, preview and connect to future classes, make a clearly organized plan for teaching, give definitions for content in chemistry, and every the rate of delivery where appropriate. This study indicates that most dimensions of chemistry laboratory classroom environments were associated with students' attitudes toward chemistry. Positive associations were found between the scales of Student CohesivenessOpen-Endedness, Integration, Rule Clarity, and Material Environment with students' attitudes to chemistry classes. Chemistry teachers who have controlled of their class should be flexible enough to enable their students to be actively involved in classroom learning. It is suggested that classroom learning ideas and practical learning techniques could be incorporated into in-service and preservice courses for chemistry teachers in Thailand, especially for municipal chemistry teachers.

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