The Relationships among Pre-Service Chemstry Teachers' Attitude-Towards-Chemistry, Chemistry Self-Efficacy, and Chemistry Learning Experiences at Tertiary Level

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Abstract

The Theory of Planned Behaviour (TPB) is an all-encompassing theory that maintains behaviour is determined by many influences including significant individuals in ones life. According to the TPB, an individual's behaviour is influenced by their attitude toward that particular behaviour, their associates' (e.g., peers, family, and mentors) attitude toward the behaviour, and the individual's perceived control over the behaviour. The purpose of this study was to investigate the association and the contribution of pre-service chemistry teachers' chemistry learning experiences on their attitude-towards-chemistry and chemistry self-efficacy at tertiary level. This was a non-experimental quantitative research and sample survey method was used to collect data. Samples were selected by using a cluster random sampling technique. The Chemistry Attitudes Experiences Questionnaire (CAEQ) was adopted to measure pre-service chemistry teachers' attitude-towards chemistry, chemistry self-efficacy, and their chemistry learning experiences at tertiary level. The attitude-towards-chemistry consists of five subscales: Attitude toward chemists, skills of chemists, attitude toward chemistry in society, leisure interest in chemistry, and career interest in chemistry. The chemistry self-efficacy scale consists of one scale with pre-service chemistry teachers not appearing to have different efficacious beliefs for the different tasks in chemistry. The chemistry learning experiences scale consists of four subscales: Lecture learning experiences, tutorial learning experiences, laboratory learning experiences, and demonstrator learning experiences. Pearson product-moment correlation and multiple regression analysis were used to test the stated null hypotheses at a predetermined significance level, alpha = .05. The research findingsl bring some meaningful implications to those who are involved directly or indirectly in the planning and implementation of tertiary chemistry education.

Keywords: Attitude-towards-chemistry, chemistry self-efficacy, chemistry learning experiences, tertiary chemistry education

1. Background of the Study

The Theory of Planned Behaviour (TPB) is an all-encompassing theory that maintains behaviour is determined by many influences including significant individuals in ones life. According to the TPB, an individual's behaviour is influenced by their attitude toward that particular behaviour, their associates' (e.g., peers, family, and mentors) attitude toward the behaviour, and the individual's perceived control over the behaviour.

2. The Study

2.1 Problem Statement

Research into student learning experiences of science, like studies of science self-efficacy, is limited. There is a considerable body of literature on the measurement of students' perceptions of their learning environment (Fraser, 1994), and the relationship between student attitude and self-efficacy, and their learning environment (e.g., Lorsbach, 1999). However, research into students' learning experiences is different from learning environment research, in that the former also incorporates experiences and work required outside structured classes.

There has been much less research into students' science self-efficacy: a student's self-efficacy being his or her perception of their ability to undertake a specific scientific task or tasks. Although there has been some recent interest in the measurement of science self-efficacy (Andrew, 1998; Baldwin, Elbert-May & Burns, 1999), much self-efficacy research has been concerned solely with mathematics students (e.g., Lent, Larkin & Brown, 1986).

In the Malaysian context, despite limited efforts in other educational levels, study of learning experiences in one crucial dimension of education in Malaysia, teacher education is not yet explored. Hence, pre-service chemistry teachers' perceptions of their chemistry learning experiences formed the subjects of this investigation. Due to the deficient understanding of pre-service chemistry teachers' perceptions of tertiary chemistry learning experiences, this proposed study aimed to investigate the relationships among pre-service chemistry teachers' perceptions of tertiary chemistry learning experiences, attitudes towards chemistry, and chemistry self-efficacy.

2.2 Objectives of the Study

This study attempts to achieve the following objectives:-

i) to provide validation data (discriminant and predictive validity) for the 'Chemistry Attitudes Experiences Questionnaire' (CAEQ) when used in Sabah context;
ii) to gauge pre-service chemistry teachers' learning experiences, attitudes towards chemistry, and chemistry self-efficacy;
iii) to investigate the relationships and contribution of pre-service chemistry teachers' chemistry learning experiences on their attitudes towards chemistry and chemistry self-efficacy.

2.3 Research Questions

This study attempts to answer the following questions:-

i) Is 'Chemistry Attitudes Experiences Questionnaire' (CAEQ) a reliable and valid instrument to measure pre-service chemistry teachers' chemistry learning experiences, attitudes towards chemistry, and chemistry self-efficacy in Sabah context?

ii) What are pre-service chemistry teachers' chemistry learning experiences, attitudes towards chemistry, and chemistry self-efficacy?
iii) What are the relationships among pre-service chemistry teachers' chemistry learning experiences, attitudes towards chemistry, and chemistry self-efficacy?
iv) Do chemistry learning experiences contribute to pre-service chemistry teachers' attitudes towards chemistry and chemistry self-efficacy?

2.4 Research Hypotheses

Two null hypotheses formed to be tested in this study are:

i) There is no significant relationship among pre-service chemistry teachers' chemistry learning experiences, attitudes towards chemistry, and chemistry self-efficacy?
ii) Pre-service chemistry teachers' chemistry learning experiences do not contribute to their attitudes towards chemistry and chemistry self-efficacy.

2.5 Definition of Terms

Some of the terms used in this study are defined as follows:

2.5.1 Attitude-towards-Chemistry

Chemistry is defined as the learned patterns for thinking, feeling and acting that are transmitted via the acquisition of chemistry theory, skills, and values. According to Allport's definition of attitude, attitude is 'a mental and neutral state of readiness, organized through experience, exerting a directive and dynamic influence upon the individuals' response to all objects and situations with which it is related' (Horowitz & Bordens, 1995, p.228). In the context of this study, the attitude-towards-chemistry consists of five subscales: Attitude toward chemists, skills of chemists, attitude toward chemistry in society, leisure interest in chemistry, and career interest in chemistry.

2.5.2 Chemistry Self-Efficacy

Bandura (1986) defined self-efficacy as 'people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performance' (p. 391). In the context of this study, the chemistry self-efficacy scale consists of one scale with pre-service chemistry teachers not appearing to have different efficacious beliefs for the different tasks in chemistry.

2.5.3 Chemistry Learning Experiences

Chemistry learning experiences were considered to be any experience resulting in a belief formation about chemistry (where that belief is attitudinal, knowledge, or skill based). The chemistry learning experiences scale consists of four subscales: Lecture learning experiences, tutorial learning experiences, laboratory learning experiences, and demonstrator learning experiences.

3. Methodology

3.1 Research Design

This was a non-experimental quantitative research. Non-experimental research is a systematic empirical inquiry in which the researcher does not have direct control of independent variables because their manifestations have already occurred or because they are inherently not manipulable. Hence, inferences about relations among variables are made, without direct intervention, from concomitant

variation of independent and dependent variables (Johnson & Christensen, 2000). In this study, sample survey method was used to collect data. The 'Chemistry Attitudes Experiences Questionnaire (CAEQ) developed by Coll *et al*. (2002) was used to gauge pre-service chemistry teachers' chemistry learning experiences, attitudes towards chemistry, and chemistry self-efficacy.

3.2 Research Samples and Sampling Method

A group of pre-service chemistry teachers were selected by cluster random sampling technique from the School of Education and Social Development, Universiti Malaysia Sabah. In relation to this, Universiti Malaysia Sabah is one of the public higher education institutions which is responsible for the training of pre-service secondary school chemistry teachers. These pre-service chemistry teachers were trained to teach in different school contexts as secondary school science teachers. The CAEQ instrument was administered to these selected pre-service chemistry teachers to gauge their chemistry learning experiences, attitudes towards chemistry, and chemistry self-efficacy.

3.3 Instrumentation

In this study, the 'Chemistry Attitudes and Experiences Questionnaire (CAEQ) was used to investigate what influence pre-service chemistry teaches' learning experiences might have upon their attitude towards chemistry and chemsitry self-efficacy. The final version of the CAEQ consists of three scales, each containing a number of subscales (refer to Appendix).The attitude-toward-chemistry scale contains a total of 22 questions, across five subscales: Attitude toward chemists (9 items), skills of chemists (4 items), attitude toward chemistry in society (2 items), career interest in chemistry (5 items), and leisure interest in chemistry (2 items). The chemistry self-efficacy scale, containing 20 questions, consists of one scale with pre-service chemistry teachers not appearing to have different efficacious beliefs for the different tasks in chemistry (Dalgety, Coll, & Jones, 2001). The chemistry learning experiences scale, consisting of 35 questions, has four subscales: Lecture learning experiences (10 items), tutorial learning experiences (10 items), laboratory learning experiences (10 items), and demonstrator learning experiences (relating to graduate assistants who supervise practical classes) (5 items). The item distribution of CAEQ according to its subscales is illustrated in Table 1 below:

Table 1: Item Distribution of CAEQ according to its Subscales

Subscales	Item No.	Nos. Item
Attitude-toward chemistry		
Attitude toward chemists	1,2,3,4,5,6,7,8,9,	9
Skills of chemists	10,11,12,13,	4
Attitude toward chemistry in society	14,15,	2
Career interest in chemistry	16,17,18,19,20	5
Leisure interest in chemistry	21,22,	2
Chemistry self-efficacy	1-20	20
Chemistry learning experiences		
Lecture learning experiences	1-10	10
Tutorial learning experiences	11-20	10
Laboratory learning experiences	21, 22, 24, 25, 27, 28, 30, 31, 33, 34,	10
Demonstrator learning experiences	23, 26, 29, 32, 35,	5
	Total	77

3.4 Data Collection Procedures

Before administering the CAEQ instrument, formal permission from the related authorities was sought and obtained. The 'Chemistry Attitudes Experiences Questionnaire' (CAEQ) was personally-administered by the researchers. Pre-service chemistry teachers were gathered in the lecture hall and the

instrument was administered to the pre-service chemistry teachers concurrently. Pre-service chemistry teachers were informed about the nature of the instrument and how the instrument should be answered. In relation to this, each respondent was asked to read a statement pertaining to the perceptions they have about chemistry and related topics (attitudes towards chemistry), the confidence they have in undertaking different tasks (chemistry self-efficacy), and all the chemistry learning experiences during their first year chemistry classes (chemistry learning experiences), and then indicate their responses with the statement, i.e. 'Totally Confident' to 'Not Confident' or 'Strongly Agree', 'Agree', 'Neutral', 'Disagree' or 'Strongly Disagree' respectively.

3.5 Data Analysis Procedures

Each item in the CAEQ instrument to measure pre-service chemistry teachers' attitudes towards chemistry was responded to on a 7-point semantic differential scale. Items to measure pre-service chemistry teachers' chemistry self-efficacy were responded to on a 5-point semantic differential scale: 'Totally Confident' (5) to 'Not Confident' (1). On the other hand, each item to measure pre-service chemistry teachers' perceptions of their chemistry learning experiences was responded to on a 5-point Likert scales: 'Strongly Agree' (5), 'Agree' (4), 'Neutral' (3), 'Disagree' (2), and 'Strongly Disagree' (1).

Descriptive statistics were used to describe pre-service chemistry teachers' perceptions of their attitudes towards chemistry, chemistry self-efficacy and chemistry learning experiences. Among the descriptive statistics used were percentages, mean, average item mean, standard deviation, and range. On the other hand, as an effort to ensure all the quantitative data were drawn from a normally distributed population, graphical measures such as histogram, stem-and-leaf plot, normal Q-Q plot, and detrended normal Q-Q plot were plotted for each of the variables studied. Furthermore, numerical measures such as skewness and kurtosis were used to identify any deviations from normal distributions (Hair, Anderson, Tatham, & Black, 1998; Miles & Shevlin, 2001). After the assumptions of using parametric techniques in analyzing quantitative data were met, independent sample *t*-test was used to test the stated null hypotheses at a predetermined significance level, alpha = .05.

3.5.1 Pearson Product-Moment Correlation

Correlation was used to identify any possible significant linear relationships among pre-service chemistry teachers' chemistry learning experiences, attitudes towards chemistry, and chemistry self-efficacy. Pearson's product-moment correlation coefficients (*r*) were calculated to show the strength of the linear relationships among the variables studied.

3.5.2 *Multiple Linear Regression Analysis*

Stepwise multiple linear regression analysis was used to ascertain whether pre-service chemistry teachers' chemistry learning experiences (Experiences) can make a significant prediction on their attitudes towards chemistry (Attitudes) and chemistry self-efficacy (Efficacy). Stepwise variables selection method was used in order to get a parsimonious model which can explain most of the variance in the dependent variable by using least number of independent variables. Assumptions namely normality, homoscedasticity, linearity, and independence were met prior to multiple linear regression analysis. On the other hand, distance statistics (leverage measure and Cook's distance) and influence statistics (DfBeta and DfFit) were used to identify any outliers and influential observations in the collected data. To detect multicollinearity among the independent variables used in this study, correlation matrices, Tolerance (T), and Variance Inflation Factor (VIF) were used (Hair *et al*., 1998).

4. Research Findings and Discussion

4.1 Reliability and Validity of the CAEQ

4.1.1 Reliability of the CAEQ

The data were analyzed to test the internal consistency of the CAEQ scales. It was found that the Cronbach's Alpha reliability for attitude-toward-chemistry scale ranged from .746 (attitude toward chemistry in society) to .903 (career interest in chemistry) except for the 'leisure interest in chemistry' which showed a low reliability of .491. The chemistry self-efficacy scale showed a high reliability of .903 whereas the Cronbach's Alpha reliability for chemistry learning experiences scale ranged from .780 (demonstrator learning experiences) to .868 (tutorial learning experiences). Overall, the Cronbach Alpha reliability of the CAEQ was found to be at a high of .949. (Table 2). Hence, these findings supported the cross-cultural validity of the CAEQ when used for the first time in Sabah context. Each scale in the CAEQ was found to display satisfactory internal consistency reliability.

Table 2: Cronbach's Alpha Reliability of the CAEQ

Subscales	Item No.	Cronbach's Alpha Reliability
Attitude toward chemists	1,2,3,4,5,6,7,8,9,	.854
Skills of chemists	10,11,12,13,	.866
Attitude toward chemistry in society	14,15,	.746
Career interest in chemistry	16,17,18,19,20	.903
Leisure interest in chemistry	21, 22	.491
Chemistry self-efficacy	1-20	.903
Lecture learning experiences	1-10	.824
Tutorial learning experiences	11-20	.868
Laboratory learning experiences	21, 22, 24, 25, 27, 28, 30, 31, 33, 34	.856
Demonstrator learning experiences	23, 26, 29, 32, 35,	.780
	Overall	.949

4.1.2 Validity of the CAEQ

i) Discriminant validity

The discriminant validity is described as the extent to which a scale measures a unique dimension not covered by the other scales in the instrument. Table 3 indicates that the mean correlations of the scales in the CAEQ ranged from .285 to .455. From the values, the CAEQ appears to measure distinct although somewhat overlapping aspects of chemistry learning experiences, attitudes towards chemistry, and chemistry self-efficacy , but maintaining distinctions between each scale in each of the dimensions of the instrument.

Table 3: Discriminant Validity of the CAEQ

	Attitude toward chemists	Skills of chemists	Attitude toward chemistry in society	Career interest in chemistry	Leisure interest in chemistry	Chemistry self-efficacy	Lecture learning experiences	Tutorial learning experiences	Laboratotry learning experiences	Demonstrator learning experiences	Mean Correlation
Attitude toward chemists	-	.653	.613	.633	.485	.443	.272	.410	.383	.203	.455
Skills of chemists	.653	-	.608	.698	.529	.356	.201	.107	.111	-012	.364
Attitude toward chemistry in society	.613	.608	-	.695	.764	.388	.163	.188	.097	.030	.394
Career interest in chemistry	.633	.698	.695	-	.643	.231	.238	.128	.099	.023	.376
Leisure interest in chemistry	.485	.529	.764	.643	-	.431	.124	.220	.167	.188	.394
Chemistry self-efficacy	.443	.356	.388	.231	.431	-	.298	.436	.414	.350	.372
Lecture learning experiences	.272	.201	.163	.238	.124	.298	-	.708	.529	.481	.334
Tutorial learning experiences	.410	.107	.188	.128	.220	.436	.708	-	.693	.602	.388
Laboratory learning experiences	.383	.111	.097	.099	.167	.414	.529	.693	-	.680	.353
Demonstrator learning experiences	.203	-.012	.030	.023	.188	.350	.481	.602	.680	-	.285

ii) Predictive Validity of the CAEQ

Predictive validity examines whether the instrument predicts something that is expected to predict. An instrument has predictive validity if it successfully predicts something it is expected to (Trochim, 1999). To determine predictive validity of the CAEQ, the learning experiences subscales were correlated with the attitude-toward-chemistry and chemistry self-efficacy using Pearson's product moment correlation (Table 4). According to the data obtained, pre-service chemistry teachers' attitudes towards chemistry and chemistry self-efficacy were influenced by their chemistry learning experiences. In other words, the CAEQ predicts a result that it was designed to do so, and hence it possesses predictive validity. Hence, the CAEQ possesses high contruct validity, as measured by predictive validity. This suggests that the conclusions drawn from the theoretical constructs of the subscales will be valid.

Table 4. Predictive Validity of the CAEQ

	Lecture learning experiences	Tutorial learning experiences	Laboratory learning experiences	Demonstrator learning experiences
Attitude toward chemists	.272*	.410**	.383**	.203
Skills of chemists	.201	.107	.111	-012
Attitude toward chemistry in society	.163	.188	.097	.030
Career interest in chemistry	.238*	.128	.099	.023
Leisure interest in chemistry	.124	.220*	.167	.188
Attitude-toward-chemistry	.266*	.287*	.234*	.108
Chemistry self-efficacy	.298	.436	.414	.350

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

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

Pre-Service Chemistry Teachers' Attitudes towards Chemistry

Table 5: Mean and Standard Deviation of Pre-Service Chemistry Teachers' Attitudes towards Chemistry according to its Subscales

Subscales	Nos. Items	*N*	*M*	Average Item Mean[a]	*SD*	Range
Attitude toward chemists	9	81	48.00	5.333	8.255	19-63
Skills of chemists	4	87	22.75	5.687	4.180	4-28
Attitude toward chemistry in society	2	86	10.48	5.240	2.781	2-14
Career interest in chemistry	5	86	28.65	5.730	5.244	8-35
Leisure interest in chemistry	2	87	10.57	5.285	2.356	2-14
Attitudes towards Chemistry	22	80	120.21	5.464	19.716	36-153

[a]Average item mean = Scale mean divided by the number of items in a scale

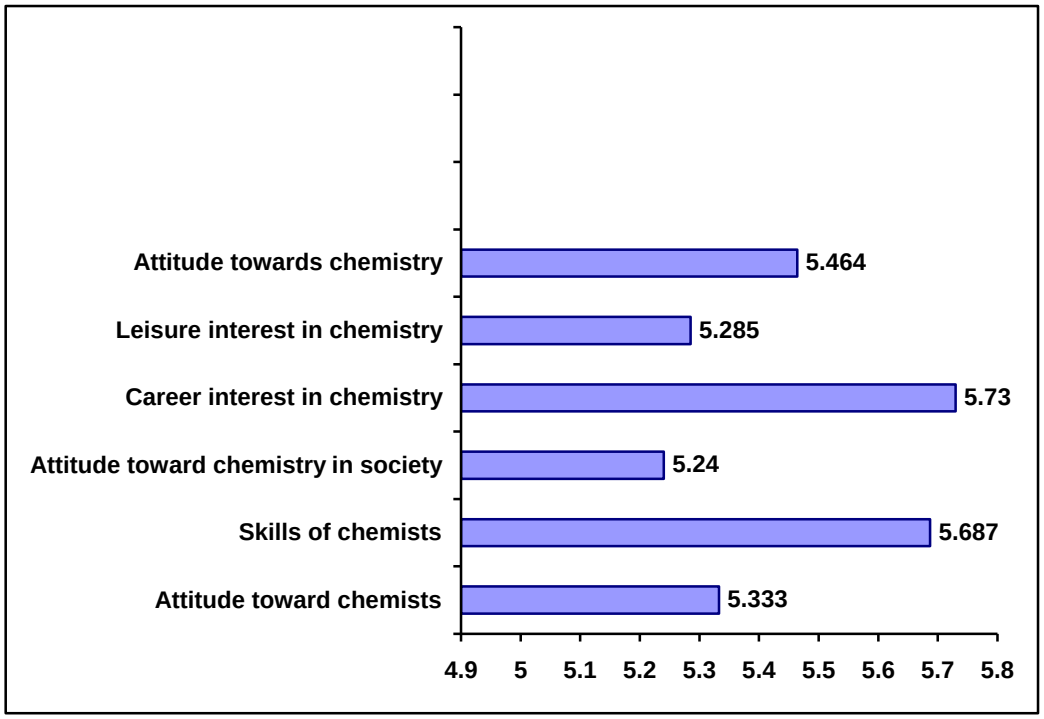

Figure 1: Pre-Service Chemistry Teachers' Attitudes towards Chemistry according to its Subscales

As shown in Table 5 and Figure 1, the overall average item mean of pre-service chemistry teacher's attitudes towards chemistry was 5.464 (*M* = 120.21, *SD* = 19.716). Pre-service chemistry teachers' attitudes towards chemistry in descending order were 'career interest in chemistry' (average item mean = 5.730, *M* = 28.65, *SD* = 5.244), 'skills of chemists' (average item mean = 5.687, *M* = 22.75, *SD* = 4.180), 'attitude toward chemists' (average item mean = 5.333, *M* = 48.00, *SD* = 8.255), 'leisure interest in chemistry' (average item mean = 5.285, *M* = 10.57, *SD* = 2.356), and 'attitude toward chemistry in society' (average item mean = 5.240, *M* = 10.48, *SD* = 2.781).

4.2 Pre-Service Chemistry Teachers' Chemistry Efficacy

Table 6: Mean and Standard Deviation of Pre-Service Chemistry Teachers' Chemistry Efficacy

Scale	Nos. Items	*N*	*M*	*SD*	Range
Chemistry Efficacy	20	87	69.39	9.578	47-91

As shown in Table 6, the overall mean of pre-service chemistry teacher's chemistry self-efficacy was 69.39 with a standard deviation of 9.578.

4.3 Pre-Service Chemistry Teachers' Perceptions of Chemistry Learning Experiences

Table 7 shows the mean and standard deviation of pre-service chemistry teachers' perceptions of tertiary chemistry learning experiences (overall and for each of the four subscales respectively).

Table 7: Mean and Standard Deviation of Pre-Service Chemistry Teachers' Perceptions of Chemistry Learning Experiences according to the CAEQ Subscales

Subscales	Nos. Items	*N*	*M*	Average Item Mean[a]	*SD*	Range
Lecture learning experiences	10	86	36.88	3.688	4.830	25-48
Tutorial learning experiences	10	86	36.90	3.690	5.168	26-48
Laboratory learning experiences	10	87	38.25	3.825	4.792	25-48
Demonstrator learning experiences	5	85	18.48	3.696	2.914	12-24
Chemistry learning experiences	35	83	130.39	3.725	15.169	93-166

[a]Average item mean = Scale mean divided by the number of items in a scale

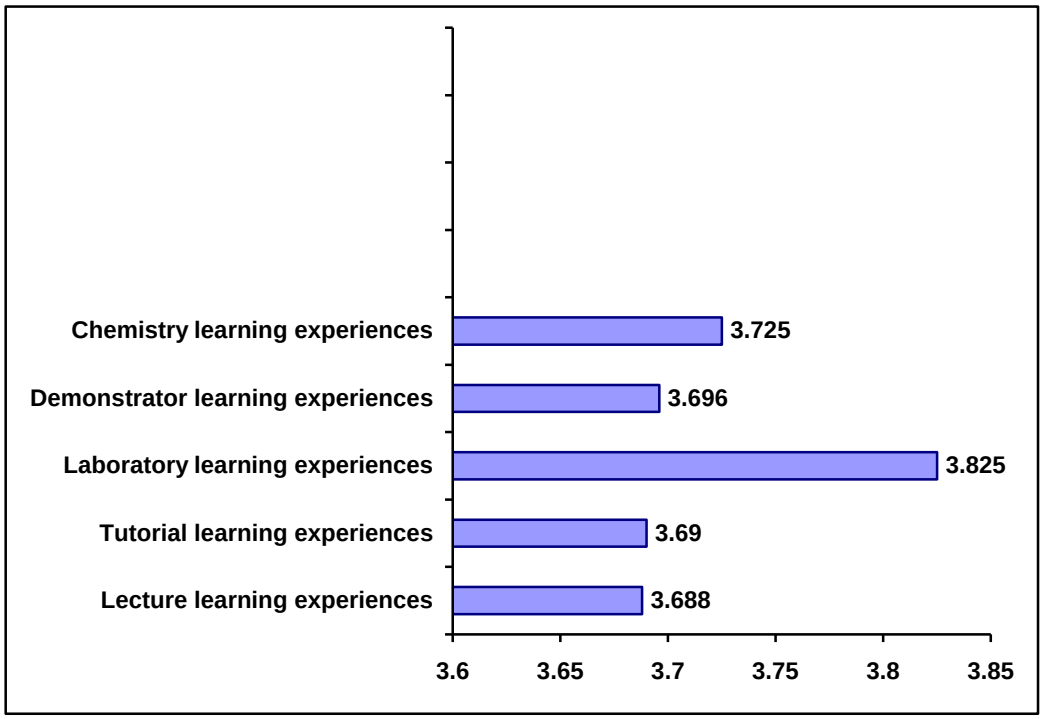

Figure 2: Pre-Service Chemistry Teachers' Perceptions of Chemistry Learning Experiences according to the CAEQ Subscales

As shown in Table 7 and Figure 2, the overall average item mean of pre-service chemistry teacher's chemistry learning experiences was 3.725 (M = 130.39, SD = 15.169). Pre-service chemistry teachers' chemistry learning experiences in descending order were 'laboratory learning experiences' (average item mean = 3.825, M = 38.25, SD = 4.792), 'demonstrator learning experiences' (average item mean = 3.696, M = 18.48, SD = 2.914), 'tutorial learning experiences' (average item mean = 3.690, M = 36.90, SD = 5.168), and 'lecture learning experiences' (average item mean = 3.688, M = 36.88, SD = 4.830).

4.4 The Relationships among Pre-Service Chemistry Teachers' Chemistry Learning Experiences, Attitudes towards Chemistry, and Chemistry Self-Efficacy

The first null hypothesis was tested by using the Pearson's product-moment correlation at a specified significance level, $p < .05$. Correlation analysis results showed that there were moderate, positive and significant correlations among pre-service chemistry teachers' chemistry learning experiences, attitudes towards chemistry, and chemistry self-efficacy. Pearson's product-moment correlation coefficients were found in the range of .390 to .482 (Table 8). Thus, this finding had successfully rejected the first null hypothesis.

Table 8: Pearson's Product-Moment Correlation Results

Variables	Experiences	Attitudes	Self-efficacy
Experiences	1.000		
Attitudes	.309** (p <.0005) n = 76	1.000	
Self-efficacy	.482** (p <.0005) n = 83	.430** (p <.0005) n = 80	1.000

** $p < .01$

4.5 The Influence of Pre-Service Chemistry Teachers' Perceptions of Chemistry Learning Experiences on their Attitudes towards Chemistry and Chemistry Self-Efficacy

The second null hypothesis was tested by using multiple linear regression analysis technique. Results (Table 9) showed that chemistry learning experiences significantly contributed to pre-service chemistry teachers' attitudes towards chemistry (F(1, 74) = 7.822, p = .007). Based on the R^2 value, this predictor variable explained 9.6% of the variance in pre-service chemistry teachers' attitudes towards chemistry. Hence, this finding had successfully rejected the second null hypothesis.

Table 9:
Simple Regression Results for Pre-Service Chemistry Teachers' Perceptions of Chemistry Learning Experiences on their Attitudes towards Chemistry (n = 82)

Predictor variables	B	SE	β	ΔR^2	t	p
Constant	72.259	17.790	-	-	4.062	< .0005
Experiences	.377	.135	.309	.096	2.797	.007

** $p < .01$;
Multiple R = .309
R^2 = .096
Adjusted R^2 = .083
SEE = 17.468
F (1, 74) = 7.822; p = .007

On the other hand, results in Table 10 showed that chemistry learning experiences significantly contributed to pre-service chemistry teachers' chemistry self-efficacy (F(1, 81) = 24.463, p < .0005).

Based on the R^2 value, this predictor variable explained 23.2% of the variance in pre-service chemistry teachers' chemistry self-efficacy. Hence, this finding had successfully rejected the second null hypothesis. Table 11 showed the associations between chemistry learning experiences, attitudes towards chemistry, and chemistry self-efficacy in terms of simple correlations, multiple correlation, and standardized regression coefficient.

Table 10:
Simple Regression Results for Pre-Service Chemistry Teachers' Perceptions of Chemistry Learning Experiences, on Chemistry Self-Efficacy (n = 83)

Predictor variables	*B*	*SE*	*β*	ΔR^2	*t*	*p*
Constant	31.478	7.833	-	-	4.019	< .0005
Experiences	.295	.060	.482	.232	4.946	< .0005

** $p < .01$;
Multiple R = .482
R^2 = .232
Adjusted R^2 = .222
SEE = 8.197
F (1, 81) = 24.463; p <.0005

Table 11: Associations between Chemistry Learning Experiences, Attitudes towards Chemistry, and Chemistry Self-Efficacy in terms of Simple Correlations, Multiple Correlation, and Standardized Regression Coefficient.

CAEQ scales	Attitudes towards Chemistry		Chemistry Self-Efficacy	
	r	Beta, *β*	*r*	Beta, *β*
Lecture experience	.278		.312	
Tutorial experience	.300	.300**	.478	.478**
Lab experience	.248		.447	
Demonstrator experience	.197		.399	
Multiple *R* Correlation		.300		.478
R^2		.090		.228

* $p < .05$

5. Conclusion

The results of this study have indicated that the CAEQ was a reliable and valid instrument to use and to gain a better picture of the chemistry learning experiences and the perceived learning needs of pre-service chemistry teachers at tertiary level in the state of Sabah, Malaysia. Correlation analysis results showed that there were moderate, positive and significant correlations among pre-service chemistry teachers' chemistry learning experiences, attitudes towards chemistry, and chemistry self-efficacy. Chemistry learning experiences were significant contributors to pre-service chemistry teachers' attitudes towards chemistry and chemistry self-efficacy. These research findings bring some meaningful implications to those who are involved directly or indirectly in the planning and implementation of tertiary chemistry education especially in the state of Sabah, Malaysia.

References

Andrew, S. (1998). Self-efficacy as a predictor of academic performance in science. *Journal of Advanced Nursing*, *27*, 596-603.

Baldwin, J.A., Elbert-May, D., & Burns, D.J. (1999). The development of a college biology self-efficacy instrument for non majors. *Science Education*, *83*(4), 397-408.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.

Coll, R.K., Dalgety, J., & Salter, D. (2002). The development of the Chemistry Attitudes and Experiences Questionnaire (CAEQ). *Chemistry Education Research and Practice in Europe*, *3*(1), 19-32.

Dalgety, J., Coll, R.K., & Jones, A. (2001). *An investigation of tertiary chemistry learning experiences, student attitude and self-efficacy: The development of the Chemistry Attitudes and Experiences Questionnaire (CAEQ)*. Paper presented at the 32nd annual conference of the Australasian Science Education Research Association Ltd. Sydney, Australia.

Fraser, B.J. (1994). Research on classroom and school climate. In D. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 493-541). New York: Macmillan.

Hair, J.F., Anderson, R.E., Tatham, R.L., & Black, W.C. (1998). *Multivariate data analysis*, 5th Ed. New Jersey: Prentice Hall Inc.

Horowitz, I.A., & Bordens, K.S. (1995). *Social psychology*. Mountain View, CA: Mayfield.

Johnson, B., & Christensen, L. (2000). *Educational research: Quantitative and qualitative approaches*. Allyn and Bacon.

Lent, R.W., Larkin, K.C., & Brown, S.D. (1986). Self-efficacy in the prediction of academic performance and perceived career options. *Journal of Counselling Psychology*, *33*(3), 265-269.

Lorsbach, A.W. (1999). Self-efficacy theory and learning environment research. *Learning Environment Research*, *2*, 157-167.

Miles, J., & Shevlin, M. (2001). *Applying regression and correlation. A guide for students and researchers*. London: Sage Publications.

Trochim, W.M. (1999). *The research methods knowledge base* (2nd ed). Cincinnati, OH: Atomic Dog.

APPENDIX

The Chemistry Attitudes And Experiences Questionnaire (CAEQ)

This part of the questionnaire investigates the perceptions you have about chemistry and related topics. For example, if you feel chemistry is mostly about the study of natural substances, and only a little bit about the study of synthetic material, you would answer the following questions as shown:

Chemistry Natural Substances __ _√_ __ __ __ __ __ __ Synthetic Material

	Please indicate what you think about the following								
	Chemists								
1	athletic								unfit
2	socially aware								socially unaware
3	environmentally aware								environmentally unaware
4	flexible in their ideas								fixed in their ideas
5	care about the effects of ther results								only care about their results
6	imaginative								unimaginative
7	friendly								unfriendly
8	inquisitive								indifferent
9	patience								impatient
	Chemistry research								
10	helps people								harms people
11	improve quality of life								decreases quality of life
12	solve problems								creates problems
13	advances society								causes society to decline
	Science documentaries								
14	enjoyable								boring
	Chemisry web sites								
15	interesting								boring
	Chemistry jobs								
16	challenging								easy
17	varied								repetitive
18	interesting								boring
19	satisfying								unsatisfying
20	exciting								tedious
	Talking to my friends about chemistry								
21	fascinating								dull
	Science fiction movies								
22	exciting								tedious

This part of the questionnaire investigates the confidence you have in undertaking different tasks. For example, if you feel very confident about talking to a scientist about chemistry, please indicate how confident you feel about talking to a scientist about chemistry

Totally confident __ _√_ __ __ __ __ __ Not confident

	Please indicate how confident you feel about							
1	talking to a scientist about chemistry	Totally Confident						Not Confident
2	achieving a passing grade in a chemical hazards course	Totally Confident						Not Confident
3	reading the procedures for an experiment and conducting the experiment without supervision	Totally Confident						Not Confident
4	designing and conducting a chemistry experiment	Totally Confident						Not Confident
5	tutoring another student in a first year chemistry course	Totally Confident						Not Confident
6	determining what answer is required from a written description of a chemistry problem	Totally Confident						Not Confident
7	ensuring that data obtained from an experiment is accurate	Totally Confident						Not Confident
8	proposing a meaningful question that could be answered experimentally	Totally Confident						Not Confident
9	explaining something that you learnt in this chemistry course to another person	Totally Confident						Not Confident
10	choosing an appropriate formula to solve a chemistry problem	Totally Confident						Not Confident
11	knowing how to convert the data obtained in a chemistry experiment into a result	Totally Confident						Not Confident
12	after reading an article about a chemistry experiment, writing a summary of the main points	Totally Confident						Not Confident
13	learning chemistry theory	Totally Confident						Not Confident
14	determining the appropriate units for a result determined using a formula	Totally Confident						Not Confident
15	writing up the experimental procedures in a laboratory report	Totally Confident						Not Confident
16	after watching a television documentary dealing with some aspect of chemistry, writing a summary of its main points	Totally Confident						Not Confident
17	achieving a passing grade in a Part Two chemistry course	Totally Confident						Not Confident
18	applying theory learnt in a lecture for a laboratory experiment	Totally Confident						Not Confident
19	writing up the results section in a laboratory report	Totally Confident						Not Confident
20	after listening to a public lecture regarding some chemistry topics, explaining its main ideas to another person	Totally Confident						Not Confident

This part of the questionnaire looks at your experiences during your first year chemistry classes. Please answer these questions considering ALL your experiences during your first year chemistry classes. For example, if you thought that three of four of your lectures encouraged you to enrol in the chemical hazards course, you would answer the following questions.

My lecturers encouraged me to enrol in chemical hazards course
SA A N D SD

	Please indicate these questions about your LECTURE classes					
1	The lecture material was relevant to the objectives of the course.	SA	A	N	D	SD
2	My lecturers were interested in my progress in chemistry.	SA	A	N	D	SD
3	The concepts introduced in the lecture material were explained clearly.	SA	A	N	D	SD
4	My lecturers encouraged me to take further chemistry papers.	SA	A	N	D	SD
5	The lecture notes were interesting.	SA	A	N	D	SD
6	The chemistry lecturers have made me feel that I have the ability to continue in science.	SA	A	N	D	SD
7	The lecture notes were clearly presented.	SA	A	N	D	SD
8	It was easy to find a lecturer to discuss a problem with.	SA	A	N	D	SD
9	The lecturers were presented in an interesting manner.	SA	A	N	D	SD
10	The lecturers explained problems clearly to me.	SA	A	N	D	SD
	Please answer these questions about your TUTORIAL classes					
11	The tutorial problems covered all parts of the course.	SA	A	N	D	SD
12	My tutors were interested in my progress in chemistry.	SA	A	N	D	SD
13	The problems in the tutorial sheets were relevant to the course.	SA	A	N	D	SD
14	My tutors encouraged me to take further chemistry papers.	SA	A	N	D	SD
15	The tutorial sheets helped me understand the lecture course.	SA	A	N	D	SD
16	The chemistry tutors have made me feel I have the ability to continue in science.	SA	A	N	D	SD
17	The material presented in tutorials was useful.	SA	A	N	D	SD
18	The material covered in tutorials was presented in an interesting manner.	SA	A	N	D	SD
19	It was easy to find a tutor to discuss a problem with.	SA	A	N	D	SD
20	The tutors explained problems clearly to me.	SA	A	N	D	SD
	Please indicate these questions about your LABORATORY classes					
21	The laboratory manual contained instructions that were easy to follow.	SA	A	N	D	SD
22	When writing up experiments in my laboratory book, the relationship between the data and the results was clear.	SA	A	N	D	SD
23	My demonstrators were interested in my progress in chemistry.	SA	A	N	D	SD
24	The practical experiments were related to lectures.	SA	A	N	D	SD
25	What is required in the write-up of an experiment is clear.	SA	A	N	D	SD
26	My demonstrators encouraged me to take further chemistry papers.	SA	A	N	D	SD
27	The theory behind the experiments was clearly presented.	SA	A	N	D	SD
28	The purpose of the calculations required for laboratory books write-up was clear.	SA	A	N	D	SD
29	The chemistry demonstrators have made me feel I have the ability to continue in science.	SA	A	N	D	SD
30	The laboratory manual, experimental techniques and write-up were all interlinked.	SA	A	N	D	SD
31	What was required in the questions when writing up the laboratory book was clear.	SA	A	N	D	SD
32	It was easy to find a demonstrator to discuss a problem with.	SA	A	N	D	SD
33	The experiments were interesting.	SA	A	N	D	SD
34	The amount of work required when writing up the laboratory book was appropriate for the amount of the assessment.	SA	A	N	D	SD
35	The demonstrators explained problems clearly to me.	SA	A	N	D	SD