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Chemical literacy levels of engineering students in Northeastern Thailand

Rungrat Thummathong [1], Kongsak Thathong [*]

Faculty of Education, Khon Kaen University, Khon Kaen 40002, Thailand

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ABSTRACT

The objective of this study was to investigate the chemical literacy levels of undergraduate engineering students in Faculties of Engineering in Northeastern Thailand. The subjects were 391 undergraduate engineering students who were enrolled in a basic chemistry course in the 2nd semester of the 2012 academic year in the Faculty of Engineering at the North-Eastern University and at the Rajamangala University of Technology Isan in Khon-Kaen province. The instruments were a chemical literacy test (CLT) and semi-structured interviews. The CLT had 3 assessment formats: 1) multiple-choice CLT, 2) written CLT, and 3) test of chemistry related attitudes. The holistic results of the CLT responses of the engineering students showed that the mean of percentage scores was 43.58 and about three-fifths (61.90%) of the engineering students' level of chemical literacy was categorized at the “low level”. In addition, the results of semi-structured interview responses of the engineering students (n = 40) showed that more than half (57.5%) of the engineering students’ chemical literacy level was also categorized at the “low level”. The overall chemical literacy of the engineering students was categorized at the “low level”. Hence, it is necessary for educational institutions to develop learning activities for engineering students to achieve higher chemical literacy and to avoid any impact caused by chemical usage applied with a lack of knowledge and understanding and social responsibility.

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Introduction

A changing world has resulted in the need for human society to be involved in the production of scientific knowledge and the understanding of technology. The influence of science and technology on modern society has been so extensive that the print and electronic media often announce the latest advancements in science and technology in the fields of genetic engineering (for example, human genome project, gene transplant, and cloning) and artificial intelligence as well as regarding space stations (Yrez & Cakir, 2006). Moreover, the impact of science on a nation and its citizens can be seen from the production of the basic human need for social, political, educational, technological, and economic advancement (Oludipe & Awokoy, 2010). Thus, understanding scientific information and the relationship between science, technology, and society is extremely useful. We need to prepare people with sufficient knowledge and ability when encountering changes to have competence to solve real-world problems. This calls for scientific literacy (Bond, 1989). Scientific literacy is a target in major reforms in the teaching of science today and is conceptualized as the main goal of science education (American Association for the Advancement of Science [AAAS], 1993; DeBoer, 2000; Institute for the Promotion of Teaching Science and Technology [IPST],

* Corresponding author.
E-mail addresses: thummathong2516@gmail.com (R. Thummathong), kongsaktha@gmail.com (K. Thathong).
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[1] Co-first author.

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2003; National Research Council [NRC], 1996). Scientific understanding is a goal for a scientifically literate society. Scientific understanding deals with the ability to use the conceptual knowledge of science and the ability to differentiate between scientific data and data from other disciplines (Barlia, 2016). Scientific literacy, which is the gateway to achieving scientific and technological advancement and economic survival, is achievable through science education (Oludipe & Awokoy, 2010). Scientific literacy is for everyone because it enlightens and enables each individual to make informed choices and to make rational decisions where issues of science and technology are concerned. Therefore, all of us need to develop scientific literacy with the ability to understand how science works, to make informed decisions, to apply knowledge rationally, creatively and ethically, and to use our science-related skills to improve ourselves and to develop the country.

At present, scientific literacy is an important issue affecting human decisions. It is evident at the international level in various perspectives of science education. Coll and Taylor (2009) conducted a survey of the perspectives of scientific literacy at the international level and found that scientific literacy played an important role in science education worldwide. The view of scientific literacy has spread in education at all levels from children to the general population. Scientific literacy can be developed in children and adults and scientific literacy is an indication that individuals have participated in the life-long sciences (Liu, 2009). Science scholars have suggested that the definition of scientific literacy should consist of components of the knowledge of science, the understanding and application of science, higher-order cognitive skills, the ability to use scientific knowledge to solve problems, understanding the nature of science, ethics that guide the work of scientists, and its relation to culture, society, and technology. Scientifically literate individuals will also be able to use science concepts, processes, and terms accurately and appropriately (Chin, 2005; Duschl, Schweingruber, & Shouse, 2007; Holbrook & Rannikmae, 2009; NRC, 2007; Norris & Philip, 2003; Preczewski, Mittler, & Tillotson, 2009; Rutherford & Ahlgren, 1990).

Chemistry is one of the most important branches of science. It enables learners to understand what happens around them (Sirhan, 2007). Chemistry topics generally involve studying about matter and understanding the properties of matter that are important in many disciplines such as health sciences, geography, physics, environmental science, and economics (Brown, LeMay, & Bursten, 2000). Moreover, in recent years it has been shown that the use of chemicals can play a vital role in our daily lives as consumers both directly and indirectly. It can also affect human decision making in areas such as health, information on dietary intake (starch, carbohydrates, fats, vitamins), and food choices that affect the metabolism of the human diet. Therefore, it is necessary to prepare the population to be knowledge able about chemicals in everyday life. Learning chemistry is not just about learning the content available only in textbooks or the requirements of the curriculum. For the learning to be effective, those taught must be able to put that knowledge into practice in everyday life, get involved in activities concerning chemical issues, and make rational and informed decisions regarding their own experiences.

Chemical literacy is a part of scientific literacy (Mozeika & Bilbokaite, 2010). It characterizes the activation of knowledge, skills, acquirements, and other elements retained. There is solidarity with adequate educational aims (Holman & Hunt, 2002; Roberts, 2007, pp. 9–17). There is also a world community because today's competitive economic growth has challenged the issue of science. Therefore, there is a strong push for more science education. This can be seen from a comparison study of international science students. In 2011, the results of assessment in the Trends in International Mathematics and Science Study (TIMSS) with 6,124 students in 172 schools from 45 countries and 14 states reported that Thai students had a mean science score of 472, which ranked them 29th and they were assessed as being at a low level (Institute for the Promotion of Teaching Science and Technology [IPST], 2011). In addition, the results of scientific literacy for 15-year-old students assessed under the Program for International Student Assessment (PISA) illustrated that a mean score of 425 for Thai students in scientific literacy was statistically significantly below the Organization for Economic Co-operation and Development (OECD) average of 500, with Thai students ranked 49th from 65 countries (IPST, 2011).

These international assessment results are warning signs that we should be looking at the development of the scientific literacy of the country's population. Perhaps the most vital ingredient needed to achieve this type of collaboration is science education—not just of the knowledge, but the process of scientific investigation and the values it holds, such as honesty, objectivity, respect for the facts and their implications, communication, openness to opposing evidence, and a healthy distrust of authority. For study involving the assessment of scientific literacy has expanded to a wider circle of science education, which is not limited just to students, it is assessed in adults as well. However, according to statistical data in the 2008 Science and Engineering Indicators (National Science Board, 2008 as cited in Liu, 2009), the percentage of adults in selected countries answering correctly questions related to basic science concepts and principles, such as on lasers and genetic heredity, was quite low (<40% for most questions). Although the percentages of adults understanding fundamental science concepts and principles vary greatly from country to country and from topic to topic, no consistent evidence suggests that there is a high level of scientific literacy among adults.

Combined, these studies show the importance of the level of scientific literacy for people at all levels including the general population, because scientific literacy is necessary to build social foundations and for the nation to be strengthened further. Therefore, the researcher was interested in investigating directly the chemical literacy levels of college students studying chemistry and in particular, engineering students, who are considered an important work force in bringing their knowledge of chemistry to be applied in future.

Objective

This study aimed to investigate the chemical literacy levels of undergraduate students of the Faculty of Engineering in the Northeast of Thailand.

Definition

Chemical literacy refers to a person's ability to comprehend and apply the knowledge of chemistry in everyday life in terms of understanding three major aspects of knowledge, awareness, and the application of chemistry in daily life appropriately and effectively. This chemical literacy test consisted of six components: knowledge and understanding of chemistry contents; knowledge and understanding of the relationship between chemistry, technology, and society; application of analytical thinking; application of reasoning; moral awareness and a sense of responsibility; and attitude towards chemistry.

Methods

Population and Sample

The population was 5,108 first-year engineering students who were enrolled in a basic chemistry course in the 2nd semester of the 2012 academic year in the Faculty of Engineering at the North-Eastern University and the Rajamangala University of Technology Isan in Khon Kaen province.

A stratified sampling technique was used to select a sample of 200 students from the Faculty of Engineering at the North-Eastern University and 191 students from the Rajamangala University of Technology Isan with a total of 391 (310 male and 81 female students). Ninety four (24.04%) of the students had High School Certificates and 297 (75.96%) of the students had Vocational Certificates. Simple random sampling was used to select 10 percent (40) of the 391 students for semi-structured interviews.

Research Instruments

Chemical Literacy Test

The chemical literacy test (CLT) was developed by the researcher and consisted of three assessment formats: 1) multiple-choice test; 2) essay or written test; and 3) a five-point Likert scale. The CLT was administered to 400 students studying in the Faculty of Engineering at the Rajamangala University of Technology Isan in Khon Kaen, Kalasin, and Nakhon Ratchasima provinces in order to investigate the quality of the test items.

1) Multiple-choice test. The multiple-choice CLT refers to the 60-item multiple-choice test of chemical literacy with an item stem and four options with only one correct answer for assessing representative concepts of chemistry in 11 topics of fundamental chemistry and 7 topics of general chemistry. The 11 topics related to the fundamentals of chemistry were: 1) theory of atoms, 2) atoms, elements, and the periodic table, 3) chemical bonds, 4) mole and volume per mole, 5) stoichiometry, 6) gases, 7) chemical equilibrium, 8) acids-bases, 9) electrochemical reactions,10) thermodynamics, and 11) chemical kinetics. The seven topics of general chemistry were: 1) oil, 2) pollution, 3) food additives, 4) cancer, 5) polymers, 6) detergents, and 7) medicine. The quality of the multiple-choice test was reported in terms of internal consistency reliability (K-R 20) with a value of 0.72 and ranges of the IOC, item difficulty index and discrimination index being 0.67–1.00, 0.20–0.61, and 0.20–0.68, respectively.

2) Essay or written test. The written CLT refers to 22-items for 18 situation-based questions as constructed response or essay test items on chemical literacy which consisted of four parts to assess the four components of chemical literacy: 1) knowledge and understanding of the relationship between chemistry, technology and society, 2) application of analytical thinking, 3) application of reasoning, and 4) moral awareness and a sense of responsibility. Most of the questions were based on a given context in chemistry presented in the form of a story, newspaper article, or scenario. The quality of written CLT was reported in terms of internal consistency reliability (K-R 20) with a value of 0.80 and ranges in the IOC, item difficulty index, and discrimination index of 0.67–1.00, 0.20–0.69, and 0.51–0.86, respectively.

3) Five-point Likert scale. The test of chemistry related attitude (TOCRA) used a five-point Likert scale. A 70-item, self-report instrument was designed to obtain information about each respondent's attitude toward chemistry. There were seven aspects of attitude components: the social implication of chemistry, normality of chemistry, attitude to inquiry, adoption of chemical attitude, enjoinment of chemistry, leisure interest in chemistry, and career interest in chemistry. Each aspect had 10 items making a total of 70 items. The test of chemistry related attitudes was reported in terms of internal consistency reliability (Cronbach's alpha) with a value of 0.88. In scoring the instrument, numerical values of 1–5 were assigned to each level of opinions: 1 = strongly disagree, 2 = disagree, 3 = uncertain, 4 = agree, and 5 = strongly agree.

Semi-structured Interview

The semi-structured interview consisted of 14 questions to assess the six components of chemical literacy. When the interviewing was completed, each participant's interview responses were transcribed and scored according to a scoring rubric constructed by the researcher. The scoring rubric was constructed as a model of the responses used to score and evaluate students' views from the semi-structured interview. Each question in the semi-structured interview was scored 1–5 according to the answer: low (1), somewhat low (2), moderate (3), somewhat high (4), and high (5) as indicated in Table 1. The scoring rubric had three main categories of chemical

Table 1
Scoring rubric for categorizing responses of semi-structured interviews

Category	Criteria in categorizing of responses or model of answers
Low (1)	Student knowledge of chemistry is low. As a group, students are unable to tell/identify and explain the answer pertinently to the posed question, and give no reason or apply irrelevant reasoning
Somewhat low (2)	Student knowledge of chemistry is somewhat low. As a group, students can tell and identify the possible answer to the point a little but are unable to explain the details of the answer.
Moderate (3)	Student knowledge of chemistry is moderate. As a group, students are able to identify and elaborate on answers to some points, but it is lacking some evidence-based information for an explanation, or showing a limited ability to give reason.
Somewhat high (4)	Students knowledge of chemistry is somewhat high. As a group, students are able to identify and explain the details pertinent to the question by giving an example/illustration/more information but it does not cover the whole answer.
High (5)	Student knowledge of chemistry is high. As a group, students are able to identify and explain the details of the most pertinent illustration by giving an example of information that covers all the answer according to comprehensive content matter and theories, or by showing reasoning ability and understanding.

literacy: low level, moderate level, and high level. For each question, a “low level” response scored 1–2, while a response that demonstrated a more accurate concept of chemistry, or a “high level” was rated 4–5. The middle score of 3 represented a “moderate level” of chemical literacy.

Data Collection

*Quantitative data***:** The CLT was administered to 391 students during August–September, 2012.

Qualitative data: The 40 students were interviewed two weeks after finishing the CLT using a semi-structured interview method during October–November, 2012.

Data Analysis

Data were analyzed both quantitatively and qualitatively with an emphasis on quantitative analysis. Descriptive statistics were reported in terms of the percentage, frequency, and the mean and standard deviation for the percentage of obtained scores regarding the CLT and the semi-structured interview. Then, the criterion-scoring rubric in Table 2 was used to evaluate the level of students' responses and scores were summed in terms of the percentage of the total score.

Table 2
Percentage of criterion score in classification of chemical literacy level of students

Percentage with score ≤49	Percentage with score ≤69	Percentage with score ≥70
Low level	Moderate level	High level

Results

The results are shown in two categories as follows.

Chemical Literacy Levels

Chemical Literacy Test according to 3 Aspects and 6 Components of the CLT

Table 3 indicates that total percentages of most students' chemical literacy scores in each category of levels of chemical literacy were at the “low level”, “moderate level”, and “high level” with values of 61.9 percent, 33.5 percent, and 4.6 percent, respectively. The mean ($\overline{X}$) of the total percentage score was 43.58 which was categorized at the “low level” of chemical literacy as indicated in Table 4. The results of the CLT responses of engineering students showed that about three-fifths (61.90%) of the engineering students' chemical literacy level was at the “low level”. For more detailed analysis, students' scores for each aspect of chemical literacy were categorized into levels of chemical literacy. Most engineering students' percentage scores for the CLT were categorized according to three aspects of chemical literacy: knowledge and understanding, the application of chemistry in daily life, and awareness and were at the “low level” (50.90%), “low level” (85.7%), and “high level” (40.9%), respectively. Most of the engineering students' percentages scores for the CLT were categorized according to six components of chemical literacy: knowledge and understanding of chemistry content; knowledge and understanding of the relationship between chemistry, technology, and society; application of analytical thinking; application of reasoning; moral awareness and a sense of responsibility; and attitude towards chemistry and were at the “low level” (85.2%), “high level” (53.20%), “low level” (84.90%), “low level” (85.40%), “high level” (38.90%), and “moderate level” (84.70%), respectively (Table 3).

In addition, percentage scores for each aspect and component of the CLT were reported in terms of means and standard deviations as indicated in Table 4.

Results of Chemical Literacy from Semi-structured Interviews

After the CLT was administered to the 391 engineering students, purposive selection of 40 participants or 10 percent of students who had completed the CLT was undertaken for interviewing. The follow-up, semi-structured interview was used to allow students to elaborate on their responses to semi-structured interview items. An audio tape recorder and note taking were used during the interview sessions. When the interview was completed, the participant's interview responses were transcribed and scored according to the scoring rubric (Table 1) as well as being categorized according to the criteria in Table 2. The results of the semi-structured interviews are reported in Table 5. The researcher scored the transcribed interview of one student twice two weeks apart to ensure consistency of rating.

Table 3
Students' level of chemical literacy according to six components and three aspects of the chemical literacy test

(n = 391)

Aspect of chemical literacy	Component of chemical literacy	Students' levels of chemical literacy		
		Low level (% score≤ 49) Number of people (%)	Moderate level (% score≤ 69) Number of people (%)	High level (% score≥70) Number of people (%)
Knowledge and understanding	Knowledge and understanding of chemistry content	**333(85.20%)**	58 (14.80%)	0 (0.00%)
	Knowledge and understanding of the relationship between chemistry, technology and society	87 (22.30%)	96 (24.60%)	**208(53.20%)**
	Sub-total	**199 (50.90%)**	162 (41.40%)	30 (7.70%)
Application of chemistry in daily life	Application of analytical thinking	**332(84.90%)**	33 (8.40%)	26 (6.60%)
	Application of reasoning	**334(85.40%)**	35 (9.00%)	22 (5.60%)
	Sub-total	**335 (85.70%)**	51 (13.0%)	5 (1.3%)
Awareness	Moral awareness and a sense of responsibility	128 (32.70%)	111 (28.40%)	**152(38.90%)**
	Attitude towards chemistry	1 (0.30%)	**331(84.70%)**	59 (15.10%)
	Sub-total	124 (31.7%)	107 (27.4%)	**160 (40.9%)**
Total		**242**	131	18
Percentage		**61.9**	33.5	4.6

Note: Bold indicates the highest percentage for each response

Table 5 shows that of the semi-structured interview responses of engineering students (n = 40), more than half (57.5%) had a chemical literacy level at the "low level". When the students' scores for each aspect of chemical literacy were categorized into levels of chemical literacy, most percentages from the semi-structured interview were categorized according to the three aspects of chemical literacy: knowledge and understanding, the application of chemistry in daily life, and awareness at the "moderate level" (52.5%), "low level" (60%), and "moderate level" (52.5%); respectively. Based on the six components of chemical literacy; knowledge and understanding of chemistry content; knowledge and understanding of the relationship between chemistry, technology, and society; application of analytical thinking; application of reasoning; awareness of moral in the aspects of responsibility; and attitude towards chemistry, the engineering students' percentage responses in the semi-structured interviews were categorized at the "low level" (72.5%); "moderate level" (75%), "low level" (55%), "low level" (65%), "moderate level" (52.5%), and "moderate level" (45%), respectively. Table 6 illustrates some of the students' semi-structured interview responses with regard to the levels of chemical literacy using assumed names for students.

Discussion

The results of the investigation of engineering students in Khon Kaen province using the CLT and semi-structured interviews to explore their chemical literacy showed that students' chemical literacy was different and could be classified into three levels of "low", "moderate", and "high".

The results of the holistic CLT responses of engineering students (n = 391) had a mean of the percentage scores of 43.58 with a standard deviation of 15.10 and about three-fifths (61.90%) of engineering students' level of chemical literacy was categorized at the "low level" of chemical literacy. The mean percentage scores of engineering students (n = 391) ranged from the "low level" to the "moderate level". The low levels of the three components of chemical literacy of students' responses were for knowledge and understanding of chemistry content ($\overline{X}$= 33.88, SD = 12.43), application of analytical thinking ($\overline{X}$= 17.03, SD = 22.56), and application of reasoning ($\overline{X}$= 28.54,

Table 4
Mean and standard deviation of percentage scores of students according to aspects and components of the chemical literacy test

(n = 391)

Aspect of chemical literacy	Component of chemical literacy	$\overline{X}$	SD	Chemical literacy level
Knowledge and understanding	Knowledge and understanding of chemistry content	33.88	12.43	Low
	Knowledge and understanding of the relationship between chemistry, technology and society	62.76	26.95	Moderate
	Sub-total	48.31	15.98	Low
Application of chemistry in daily life	Application of analytical thinking	17.03	22.56	Low
	Application of reasoning	28.54	22.59	Low
	Sub-total	22.79	19.26	Low
Awareness	Moral awareness and a sense of responsibility	55.20	36.94	Moderate
	Attitude towards chemistry	64.06	5.91	Moderate
	Sub-total	59.63	19.12	Moderate
Total		43.58	15.10	Low

Table 5
Percentage of students' level of chemical literacy using semi-structured interviews

(n = 40)

Aspect of chemical literacy	Component of chemical literacy	Students' levels of chemical literacy		
		Low level (% score≤ 49) Number of People (%)	Moderate level (% score≤ 69) Number of people (%)	High level (% score≥70) Number of people (%)
Knowledge and understanding	Knowledge and understanding of chemistry content	**29(72.50%)**	11 (27.50%)	0 (0.00%)
	Knowledge and understanding of the relationship between chemistry, technology and society	4 (10%)	**30(75%)**	6 (15%)
	Sub-total	19 (47.50%)	**21 (52.50%)**	0 (0%)
Application of chemistry in daily life	Application of analytical thinking	**22(55%)**	16 (40%)	2 (5%)
	Application of reasoning	**26(65%)**	13 (32.5%)	1 (2.5%)
	Sub-total	**24(60%)**	16 (40%)	0 (0%)
Awareness	Moral awareness and a sense of responsibility	10 (25%)	**21(52.50%)**	9 (23.50%)
	Attitude towards chemistry	17 (42.50%)	**18(45%)**	5 (12.5%)
	Sub-total	14 (35%)	**21 (52.5%)**	5 (12.5%)
Total		**23**	17	0
Percentage		**57.50**	42.50	0

Note: Bold indicates the highest percentage for each response

SD = 22.59). The moderate levels of the three components of chemical literacy of students' responses were knowledge and understanding of the relationship between chemistry, technology and society ($\overline{X}$= 62.76, SD = 26.95); moral awareness and a sense of responsibility ($\overline{X}$= 55.20, SD = 36.94); and attitude towards chemistry ($\overline{X}$ = 64.06, SD = 5.91).

In the sample of 40 students interviewed using semi-structured interview questions, the responses to 14 questions showed that for various issues of chemical literacy, the majority of engineering students ranged from the "low level" to the "moderate level". The lower levels of the three components of chemical literacy were knowledge and understanding of chemistry content (72.5%), application of analytical thinking (55%), and application of reasoning (65%). The moderate levels of the three components of chemical literacy of students' responses were knowledge and understanding of the relationship between chemistry, technology and society (75%), moral awareness and a sense of responsibility (52.5%), and attitude towards chemistry (45%).

These results of the quantitative data analysis (in terms of the mean percentage score) and the qualitative data analysis were congruent in categorizing the levels of chemical literacy of engineering students. The overall students' level of chemical literacy was rated at the "low level" suggesting that most students have only a low degree of knowledge of chemistry. This may have been caused by many factors such as differences in educational background because the majority (n = 297 or 75.96%)of the students studying for their first year in the Faculty of Engineering had finished their vocational education where the emphasis was mainly on vocational knowledge and not general education, especially science. This may result in the students having a lack of fundamental science knowledge. Moreover, the students had misconceptions and thought that chemistry was not necessary for learning in engineering because they were unable to see the linkage between chemistry and engineering. In fact, chemistry is the basis of science and is necessary because there of the importance of content related to the nature of the substance, which is linked to the knowledge of many subjects of engineering such as materials engineering, thermo dynamics, and physics. The students have to apply chemistry in studying for and applying a creative career in engineering for the safety of the community.

The results reflect that we should be encouraging students to learn chemistry as a component of their knowledge and understanding so they study at a higher level and use the knowledge daily and effectively later. Furthermore, the students also lacked high order thinking skills in analytical thinking and reasoning to apply knowledge and to solve the problem under the different circumstances both as a part of everyday life and in solving problems related to the chemical, so it is important to improve the teaching and learning activities that can help encourage and support students to achieve chemical literacy in aspects of the application of chemistry in daily life. As Sadler (2004) noted, the scientific literacy of a person in negotiating socio-scientific issues has focused on the application of the moral and ethics of the person, which is considered an important feature of engineers to provide a higher quality than in others. It must be a key component in any practice that will be used to develop the country's prosperity and sustainability. In addition, Huang (2010) found that 15-year-old Canadian students' interest in learning science was significantly related to their scientific literacy and learning achievement in science subjects. Therefore, if students have a good attitude toward chemistry then they will be paying attention and giving importance to learning in this course. They will also pay their attention in participating in activities related to chemistry that will make them want to seek knowledge and find out about chemistry to make their learning more efficient.

The results indicating a low level of holistic chemical literacy in the engineering students was consistent with

Table 6
Examples of semi-structured interview and students' levels of chemical literacy

Aspect of CL	Component of CL	Item	Students' levels of chemical literacy		
			Low	Moderate	High
Know-ledge and understanding	Know-ledge and understanding of chemistry content	1. What chemistry studies about?		Mr.Ceewan: Chemistry is the study about gas, compounds, and solution.	Mr. Daeng: Chemistry is the study about atom, mass, liquid, solution, solid, gas, thermodynamics, kinetics, base and acid, electrochemical, measurement of substance, elements, and compounds as well as symbolic writing, chemical formula, principles and basic theory.
		3. What are an atom, element, and compound?	Mr. An-nop: Atom is various molecules in daily life	Mr. Daeng: Atom is the smallest particle. Element is natural substance, and compound is a chemical that is not 100% pure	Mr. Ngien: Atom is the smallest part of an element consists of protons, neutrons, electrons, and nuclei that can react chemical. Element refers to a pure homogeneous substance, single atom that cannot be separated. Compound is substance consisting of two elements or more.
	Knowledge and understanding of the relationship between chemistry, technology and society	4. How are chemicals associated with daily use?	Mr. Banjob: Refers to things that use to facilitate our convenience	Mr. Kenny: In consuming things because we need to understand the personal consuming needs.	Mr. Shawn: Chemicals are associated with outcomes, and production of chemicals during chemical reaction. Measuring, reading number from tools or equipment in daily use of each discipline, such as reading number from the thermometer, measuring cylinder, scale in different unit of measurement, such as meter, kilogram, ampere, Kelvin, etc.
The application of chemistry in daily life	Application of analytical thinking	6. How is the chemical knowledge used in the creation of today's technology affecting humans and society?		Mr. Ken: The use of many chemicals can cause greenhouse effects and global warming.	Mr. Shawn: Chemicals used in agricultural spraying directly affect humans from exposure by inhalation and remain in the body and the environment may cause toxic substances such as the production of electricity from nuclear plants. For example, the tsunami in Japan resulted in a nuclear explosion and released toxins to spread to and contaminate fruits, vegetables, water, and animals, so when we consume these fruits, vegetables or animals, they would have some effects on the body. Technology that facilitates and makes our life is easy and some things can cause negative side effects such as factories
	Application of reasoning	8. How is the production of chemicals essential to human life?		Mr. John:It accelerates the growth of the plants to produce fully.	Mr. Banjop: Very important because man's life is often associated with chemicals. Whether it is gasoline, the use of medicines; it requires a process involving chemical compositions.

Aware-ness	Awareness of moral in the aspects of responsibility	11. How should human beings contribute to prevent damage as a result of activities related to chemistry?		Mr.Charlie: Provide a better understanding of how to use it carefully not to have effects on the environment	Mr. Daeng: By providing knowledge of the chemical activity and its effects; studying and applying knowledge in the right way. Not using chemicals in farming and burning toxic waste; no construction of nuclear power plants; reduce energy consumption of petroleum; reduce the greenhouse effect, etc.
	Attitude towards chemistry	13. Is learning chemistry important to the student learning, and how?		Mr. Banjob: To obtain knowledge and understanding more for learning.	Mr. Daeng: It is very important to determine the effects and the chemical values, relationships related to other subjects together. Chemistry as scientific knowledge is required for all engineering branches: for planning to solve problems or seeking answers systematically, the methodological procedure is as follows: Observation, data collection and data analysis. The way of seeking knowledge can be applied to other subjects. Thus allowing students to plan a systematic way to understand the chemical processes in order to find out additional knowledge that is important because it enables us to know how substance occurs and can be performed manually.

the research findings of Mozeika and Bilbokaite (2010). They investigated the level of knowledge of 15–16 year-old Latvian and Lithuanian students as one of the scientific literacy aspects in chemistry and found that the level of students' knowledge was comparatively low on an average scale, with 52 percent correct answers. The study also found that encouraging students to contribute to learning was associated significantly with the students' positive attitudes toward chemistry. The current study's result of a low level of chemical literacy was also consistent with the results of a study on chemical literacy by Witte and Beers (2003). They surveyed the chemical literacy of students aged about 17 years in the Netherlands studying chemistry and found that the ability of students to answer questions correctly was relatively low (less than 50%). In addition, this result was consistent with the research findings of Shwartz, Ben-Zvi, and Hofstein (2006) and Celik (2014). Shwartz et al. (2006) who investigated the attainment of chemical literacy among 10^{th}–12th grade chemistry students in Israel. The conceptual chemical literacy was assessed by the ability of students to determine the correctness of chemical explanations of daily phenomena and found that the score ranged between 21 percent and 55 percent, indicating that the majority of students did not attain conceptual chemical literacy. The ability to explain chemistry in daily life was somewhat less accurately complete which was not sufficient for success in further learning chemistry. Celik (2014) used some parts of tests developed by Shwartz et al. (2006) to measure the chemical literacy of first-year students in the Department of Secondary Science and Mathematics Education in Turkey and found that the students' level of holistic chemical literacy was somewhat low as well.

Therefore, the current investigation's results on the chemical literacy levels of first year undergraduate students in Faculties of Engineering in Northeast Thailand have showed that there is a need to develop teaching and learning activities to promote and enhance the development of chemical literacy for engineering students. The management of teaching and learning activities of basic chemistry in higher education should provide an opportunity for students to gain experiences that can be applied in making decisions and solving the problems that arise from the effects of daily chemical activity in the field of chemical engineering for the better.

Conclusion and Recommendation

The results of the investigation into the chemical literacy levels of first year undergraduate engineering students have highlighted the fact that chemical literacy among basic chemistry students remains low. The low level of chemical literacy is not sufficient for these people to put their knowledge of chemicals to good use in their career workplace. The findings reflect that there is a need to develop a way of managing learning activities concerning basic chemistry, especially for engineering students. In addition, they must be provided with the knowledge of chemistry in everyday life as normal people, and then in the future, they will have a much better chance to use chemicals at higher and more effective levels than they otherwise would.

Conflict of interest

None.

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