# Promoting Reflections in Chemical Engineering Education

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***Abstract*—Reflective thinking or reflection is important for the 21st century graduate attributes as reflective thinking will facilitate the students' development on critical thinking, problem solving and life-long learning skills. It is therefore important to include this reflection practices to students in the early stage of their study. However, the reflection is not traditionally integrated in teaching and learning courses in Higher Education (HE) even though the course learning outcomes are markedly adopted in all courses since 2010. In this work, reflection activities were promoted in the 2nd year course i.e. material and energy balance in School of Chemical Engineering, Suranaree University of Technology (SUT). The aim of this study is to stimulate students' reflection skill on their learning. Students are voluntary to participate in reflections. Short reflective writing was provided to students along the process of learning. One assignment, one review test, one quiz, one midterm exam and course learning outcomes (CLOs) and Learning Styles (LS) assessment were intentional selected and used as experiences for students to reflect on their knowledge or subject-content and skills according to CLOS and LS. Students reflected mainly on their competent on specific subject-content and skills required in CLOs. It is found that students have moderately ability to deeply think and analyze on the reflective writing related to subject-content and skills. Future direction aiming to develop students' reflection are discussed.**

***Index Terms*—chemical engineering Education, reflection, reflective thinking, critical thinking**

## I. Introduction

Reflection is a key element in learning and is the process that turns information and knowledge to wisdom [1]. It is a human way of making meaning in life [2]. Reflection turns experience into learning and make the better future. Developing students' capacity for reflective thinking is part of developing their capacity both in critical thinking, problem-solving and lifelong learning skills. In addition, working and living in accelerated increase in technological, economic and social changes become more difficult than before. Higher Education Institution (HEI) is therefore responsible to prepare students for work and life.

Currently the reflective learning or thinking is significantly incorporated in an undergraduate curriculum in higher education [3]-[5]. There is a consortium of promoting reflection in engineering education in the USA, which is a portal for educators to share their experiences and practices on integrating reflection in education. It is also believed that the reflective thinking would finally become a critical thinking and enhance life-long learning skill [5]. It is therefore necessary to include reflections in teaching and learning process.

In this work, the reflection activity is integrated in teaching and learning material and energy balance course for the sophomore students at the Chemical Engineering (ChE) School, Engineering Institute, Suranaree University of Technology (SUT), Thailand.

## II. Background of SUT

SUT was established in 1990 as the first public autonomous university, exterior the civil service system, under the supervision of the Royal Thai Government. SUT promotes administrative proficiency and efficiency in its operations; a scholarly community consisting of the learned and the learners, as well as all kinds of knowledge in Arts, Sciences and Technology, beneficial to both individuals and society. SUT determinedly pledges to maintain excellence in all of its commitments; to advance the quality of life; to seek applications in the collection and creation of knowledge, moral ethos and wisdom, for the eternal growth of human kind. By high autonomy, flexibility, and efficiency principles, SUT maintains centralized services and coordinated missions administrative paradigm. Most operations decided at the university level while minimizing operation from external bodies. These result in the organization and workflow development that most suits university affairs, and accordingly the most optimal resources utilization. [6]

Admission of the undergraduate students has been done by quota system, without any written tests. Student selection criteria has been considered from their academic background from high schools. With this scheme, 80

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percent of prospective students are given an opportunity to choose their field of study prior to enrollment. They consist of the following quota categories: school quota, provincial quota, quota for students with special talents in science and technology, quota for students under The Promotion of Academic Olympiad and Development of Science Education Foundation (POSN), sports quota, music and performing arts quota and merit quota for students recognized for their virtues.

The trimester system divides each academic year into 3 teaching terms, each of which consists of 13 weeks. This allows students to efficiently spend their time on their studies and enables cooperative education to be integrated. Hence, students can work at firms, factories or companies full time with no interruption and thus gain more hands-on experience.

## III. Background of SUT Chemical Engineering School

School of Chemical Engineering at Suranaree University of technology (SUT ChE) recruited undergraduate students' first batch in 1993. According to the trimester system, students spend 12 terms to finish their studies. The first year subjects are the same for all schools in Engineering Institute. The school entry selection has been done via 2 ways. In the first way, approximately 20 – 50% of students can make their decision to enroll in ChE at their first year of entry. The rest of first year students would choose the school after finish their first year of study. However, because of the limited seats available in each school, the selection process after the first year of their study has been conducted by using the students' grade point average or GPAX; the student whose GPAX is the highest is the first student to choose the school and able to choose any schools he/she would like to. This causes the problem for some students who do not get the school they desires. In order to ease the problem, the Institute of Engineering allows students to transfer the school before their third year of study.

Teaching material and energy balances has faced vital problems in enhancing students' ability due to quality of quality, learning styles and skills of new generation students. SUT ChE have tried many tasks or ways to enhance students' ability such as special extra class teaching and tutorial, group-based learning, active learnings, and etc [6]. This is the first time that SUT ChE decided to promote reflective thinking to students.

## IV. Integrating Reflection in Engineering Education

Helping students to reflect can support the learning process in many ways. It is suggested that learning happens with reflection and educators can "provide structured opportunities and time to ensure that continual reflection takes place." [5] Moreover Ambrose (cited from [5]) has noted that "Educators are responsible to assist students in learning not only the material or content, but also teaching them how to learn on their own as lifelong learners."

Reflection was built on 4 theories i.e.

(1) The experience has the potential to lead to learning by Dewy (1933) or experiential learning [5].

(2) The Experiential Learning Model (ELM) by Kolb (1984) which emphasizes on the 4 cycles elements of learning from experience i.e. observation and reflection of experience, formation of concepts or new idea from reflection and finally testing the new concept or idea [5].

(3) Reflection as a key to professional activities such as reflective practices, reflection on action and reflection in action by Schon (1987). Reflection in action is a key practice to handle the complex problems of professional practice. [5]

(4) Critical reflection as a process of questioning assumptions by Mezirow (1998) [2].

The concept of reflection can be picturized as shown in Fig. 1.

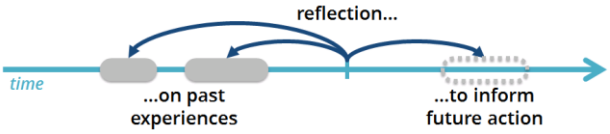


Figure 1. The reflection: the intentional bridging the past to the future [7]

Reflection can be provided to students by intentional selection of activities that may be focus on disciplinary knowledge, identity development and planning for students' future development [5]. For years, reflection has been integrating a lot in Medicine and Nursing Educations [8] but not much has been done in Engineering Education. In Thailand, the word "reflection" has mostly been used in some 2-3 days academic activities or workshops. It is also recommended for the cooperative and work-integrated education (CWIE) to set reflection activity for students after their placements. However, there is limited report, research or findings of the useful of reflections in CWIE [9]. It is also argued that if the reflection is good for students, why don't we incorporate it in undergraduate curricula?

The objective of this work is to integrate the reflection in teaching the second course of Principles of Chemical Engineering. The main idea is to set up the reflection activity for students to reflect on their competency on subject-content and subject-skill from assigned assignment, tests and exams. The data collected from student's reflection is interpreted and analyzed. Findings from this work should be considered as a tool to enhance students reflective thinking and for a lecturer to develop active teaching and learning in the class.

## V. Procedure

### A. The Reflection Process

The reflection process adopted from Gibbs Reflective Cycles as shown in Fig. 2, has been used to promote the reflection thinking to students in the class of Principles of Chemical Engineering II. The Gibbs Reflective Cycle starts clockwise at Description, Feelings, Evaluation, Analysis, Conclusion and ends at Action plan, to finally return to Description again.

One assignment, one review test, one quiz, one midterm exam and CLOs) and LS assessment were intentional selected and used as experiences for students to reflect on their knowledge or subject-content and skills according to CLOS of Principles of Chemical Engineering II. Students engaged in reflection activities was on a voluntary basis. However, the importance of reflection was explained and the lecture encourage students to engage in reflection activity.

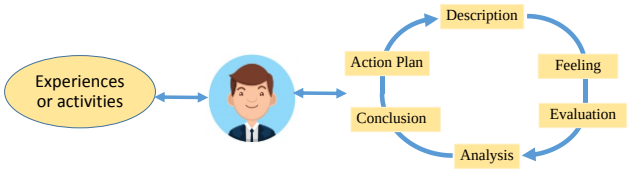


Figure 2. The reflection process adopted from Gibbs reflective cycles [10].

Each step is explained below:

*Step 1: Description*

Students think deeply back at their experiences. The questions provided to them are about the subject-content and skills needed in that activities. They would describe the subject-content and skills that relate to their competent, or detail of it without drawing any conclusion on it.

*Step 2: Feeling*

Students are asked how they feel about their experiences. The intention on this process is to create students' awareness of their levels of knowledge and skills.

*Step 3: Evaluation*

Students are asked to evaluate whether their experiences were perfect or need improvement and what are the correct concepts or idea of the experience. They could also take educators' comments into account and think about those comments.

*Step 4: Analysis*

Students are asked to analyze what they have learned from their experiences. This stage would be better to run parallel with step 3.

*Step 5: Conclusion*

Students are asked to think back at their experiences and ask themselves "what makes it better or what should they do if these experiences happen again in the future?" If they have imperfect outcomes, they have to find the right subject-content and plan to fix problems or mistakes.

Step *6: Action plan*

Students are asked to plan for better future outcomes. They have to get back to the subject-content and skills they have to improve. It is recommended that educators should ask students to keep these promises and follow up their improvements.

If we train students to practice this again and again. The reflective thinking will be simultaneously prompt within their thinking. It will finally make them to do things or work better and better and enhances their critical, problem-solving and lifelong learning skills.

### *B. Course Selection*

This work selected the "Principles of Chemical Engineering II" of trimester 2/2017 (March 25 – July 5, 2018) with 3 credits, which mainly focuses on the multiphase system, condensable and non-condensable system, and energy balances. 30 students enrolled in this course after they passed the prerequisite course "Principles of Chemical Engineering I". However, most of students took the prerequisite course twice to pass it. Students' grade point average (GPAX), out of 4.00, is shown in Table I.

TABLE I. STUDENT GRADE POINT AVERAGE (GPAX)

| GPAX | No. of Students |
|---|---|
| 1.75 – 2.00 | 5 |
| 2.01 – 2.50 | 11 |
| 2.51 – 3.00 | 12 |
| 3.01 – 3.50 | 2 |
| 3.51 – 4.00 | - |

The course learning outcomes were discussed on the first day of the class or class orientation. Course assessments are both formative and summative as shown in Table II.

TABLE II. PRINCIPLES OF CHEMICAL ENGINEERING II COURSE ASSESSMENT

| Assessment | Weight (%) |
|---|---|
| Short quizes 10 papers | 25 |
| Assignments and class participation | 10 |
| Midterm exam | 25 |
| Final exam | 40 |

### *C. The Activities Used for Students Reflective Thinking Practices*

Only some activities were intentional selected for the reflection process. Detail of assignments, quizzes or exams are shown in Table III.

The review test on material balance was provided to students to test their academic levels at the first week of the class. After grading the papers with marks and comments, the papers were returned to them and let them consider and write down their problems in subject-content, skills and how they present their solutions. Were their answers were organized in sequences and correct?

TABLE III. DETAILS OF ACTIVITIES FOR REFLECTIVE THINKING PRACTICES

| Activities (topic) | Details of activities |
|---|---|
| Review Test | *Objective*: to evaluate students' knowledge and skills of solving material balance reactive process.<br>*Skills*: apply knowledge from their 1st course Principles of Chemical Engineering I, analytical, problem solving, numerical and presentation skills. |

| | |
|---|---|
| Assignment | *Objective*: to evaluate students' knowledge of condensable and non-condensable system<br>Skills: apply knowledge, analytical, problem solving, numerical and presentation skills. |
| Quiz | *Objective*: to evaluate students' knowledge of PT diagram and phase description<br>*Skills*: apply knowledge from their 1st year, problem solving, and analytical skill |
| Midterm Exam | *Objective*: to evaluate students' knowledge of ideal gas, condensable and non-condensable system, multiphase system, material balances involving multiphase system, and humidity chart<br>*Skills*: apply knowledge, analytical, problem solving, numerical and presentation skills. |
| Assessment or reflections on CLOs and LS | *Objective*: to evaluate students' CLOs and LS<br>*Method*: students evaluate themselves on CLOs and LS. |

One selected quiz, a PT diagram and phase description, was tested as a pre-test. Students should know about this topic before from their 1st year of study. Students would evaluate themselves why they do not have good marks on this test. What are their problems and how they improve themselves?

Assignment on condensable and non-condensable system was provided to them after lecture and examples. This topic was found to be very difficult to understand for students for years. After received their works back with comments from the lecturer, student were asked with the following questions: list all things to be improved from those commented and suggested by the lecturer, discovered themselves and list more subject-content and skills that they should improve, and write methods or ways they would do to improve themselves.

The midterm exam was provided to students in the 7th week. There were 6 questions in the midterm exam. The reflection question in this time are mainly concerned about students' knowledge on subject-content. After received the paper test back, students were required to answer these following questions: what are their mistakes or problems in subject-content in each questions.

The final reflection on course learning outcomes was done in the last week of the class. 19 CLOs and LS rubrics questions were provided to students to evaluate themselves using google form. There are 4 levels in each CLO and LS, i.e. no standard or failing (N), sub-standard with fair level (F), standard or good (G) and super-standard or excellent (E). Students' reflection results on their CLOs and LS will be compared with their grading in this course by a lecturer but it will not be discussed here as the assessment process is not finished yet.

## VI. Findings

### A. Reflection on a Review Test

The first experience was a review test which evaluated students' previous knowledge on material balance course from *Principles of Chemical Engineering I*. The material balance with reactive processes problem was assigned for students to work on it. Subject-content are limiting reactant, complete reaction, % conversion, degree of freedom (DOF) analysis and solving material balances. Skills required in these problems are reading, analytical thinking, systematic thinking, and numerical skills. After grading, the papers were returned to students. Students were asked to list all comments and suggestions from lecturer, and to evaluate their ability levels in 1 – 5 scales. Level 1 means poor or need improvement while Level 5 mean excellent or above standard. In addition, students were required to present their mistakes in subject-content and express the right answer or solution. Moreover, they were asked to inform what they would do to improve themselves. Reflections from 19 students are shown in Table IV.

TABLE IV. Listing of Subject-Content Problems on A Review Test

| No. of Problems | No. of Students | Problems Found |
|---|---|---|
| 0 | 2 | Blank |
| 1 | 6 | *Specific problems*: significant figures, units, incomplete flowchart writing, DOF analysis<br>*Too broaden problems*: material balance |
| 2 | 4 | *Specific problems*: units, incomplete flowchart writing, DOF analysis<br>*Too broaden problems*: material balance<br>*Misplaced problems*: reading |
| 3 | 4 | *Specific problems*: incomplete flowchart writing, DOF analysis, , Ideal gas Equation of State, mole and concentration, complete reaction and conversion<br>*Too broaden problems*: material balance<br>*Misplaced problems*: reading, writing, numerical analysis |
| 4 | 3 | *Specific problems*: incomplete flowchart writing, DOF analysis, numerical analysis, Ideal gas Equation of State, mole and concentration, complete reaction and conversion<br>*Too broaden problems*: material balance<br>*Misplaced problems*: numerical analysis |

Details of problems and right answers from students' view can be used to identify that they really know their problems and their knowledge in material balances or not. Students leveled their knowledge with 3 or fair while in lecturer's opinion they need improvement or went back to review again on material balances and practice more. Students who wrote very broaden problems showed that they did not understand material balances. From their writing statements showed that most students do not have reflective thinking skill. In addition, this data would help lecturer to prepare their teaching and provide suggestion or tutorial class for students before forward to the next topics.

Moreover, information on students' skill on reading, analytical thinking, systematic think and numerical

analysis can be useful to both lecturer and students in teaching and learning development.

### B. A Reflection on Assignment

Selected assignment, Problem 5.40, from Elementary Principles of Chemical Process, 3rd edition, was used as experience for students to reflect on their ability both in subject-content and skills. The question is about partial pressure and total pressure, equilibrium vapor pressure or saturation pressure, condensable and non-condensable species, and ideal gas equation of state. The same pattern of questions in the first reflection was used again. Results from 21 students are shown in Table V.

TABLE V. LISTING OF SUBJECT-CONTENT PROBLEMS OF A REFLECTION ON ASSIGNMENT

| No. of Problems | No. of Students | Problems Found |
|---|---|---|
| 0 | 1 | Blank |
| 1 | 5 | *Specific problems*: significant figures, units, incomplete flowchart writing<br>*Too broaden problems*: material balance |
| 2 | 4 | *Specific problems*: basis selection, units, incomplete flowchart writing, duty of unit operation<br>*Too broaden problems*: material balance |
| 3 | 4 | *Specific problems*: incomplete flowchart writing, duty of unit operation, Ideal gas Equation of State, mole and concentration, complete reaction and conversion<br>*Too broaden problems*: material balance<br>*Misplaced problems*: English reading, academic writing |
| 4 | 7 | *Specific problems*: incomplete flowchart writing, duty of unit operation, Ideal gas Equation of State, mole and concentration, complete reaction and conversion<br>*Too broaden problems*: material balance<br>*Misplaced problems*: English reading, academic writing |

It is found that students can write more details on their mistakes or problems in subject-content, which are more specific than the first reflection. However, they still evaluate themselves with Level 3 or fair even though they found problems in that issues. In addition, they still presented their subject-content problems misplaced. This means that they need to be more careful in readings and fill in in the right place. The quality of being prudent is also important in chemical engineering profession.

### C. A Reflection on a Quiz

Using a short quiz on a PT diagram of water as an experience for students' third reflection. This quiz was test on student knowledge on water PT diagram. Students should know about phase equilibrium, phase description on the diagram and can read corresponding temperature and pressure related to phase descriptions. The phase diagram is not a knowledge for students. They learned this subject-content in their first year or even in their high schools. This quiz not only tested their knowledge but also their recollection from previous study. Nevertheless, in the pre-test the average mark was 2.9 out of 15, which was very low. The highest mark was 8, and lowest mark was 0. This mean that students forgot what they learned in the past and they really did not know about the subject-content. Interesting question is student experience the same problem as in the review test.

Students were asked to do reflection by answering questions as follow: 'did they suspect it would be a short quiz on the PT diagram?', 'did they learn and know about PT diagram before, evaluate themselves from their marks?', 'what are their problems in this issue?' and 'how to know the PT diagram better?'. The questions brought to students through the google form. Only 12 students responded in this reflection. Three students said that they did not know that there would be a quiz that day. Only one student mentioned that he never ever learned about the PT diagram before. All of them said that they were still confused about equilibrium, the PT diagram, and phase description and they would try to read, review and study more on this issue.

### D. A Reflection on the Mid-term Exam

A mid-term exam was used as an experience for the fourth reflection. There were 6 questions in 2-hour examination. The subject-content and skills of the exam are shown in Table VI. After grading, the papers were returned to students and let them reflect on their abilities on subject-content and skills. In a reflection form, students were told in short about the subject-content and skills needed to solve the problems. 24 students responded through the google form.

TABLE VI. MIDTERM EXAMINATION: SUBJECT-CONTENT AND SKILL ASSESSMENT

| Question # | Subject-content and Skills Test | Marks |
|---|---|---|
| 1 | Content: saturation temperature and pressure, phase description<br>Assessment: understanding | 5 |
| 2 | Content: phase description, steam table<br>Assessment: understanding and know how to read/use steam table (only saturated liquid and saturated vapor) | 14 |
| 3 | Content: phase description, steam table<br>Assessment: understanding and know how to read/use steam table (all phase descriptions) | 10 |
| 4 | Content: T-v diagram of water, phase description<br>Assessment: understanding and know how to specify and draw the phase descriptions of water from Problem # 3 on the T-v diagram | 15 |

| | | |
|---|---|---|
| 5 | Content: material balance of combustion reaction, determination of dew point of product gases<br>Assessment: solving material balances, know how to find dew point, apply knowledge, analytical and numerical skills | 25 |
| 6 | Content: material balance on adiabatic air humidification, Psychrometric chart<br>Assessment: understanding solving material balances on humidification, know how to read/use Psychrometric chart, apply knowledge, analytical and numerical skills | 20 |
| | Total | 89 |

*On Question # 1*, students were asked to write a short descriptive answer for saturation temperature and pressure and know the phase descriptions of water in this equilibrium state. However, they could not write the right words for saturation temperature and pressure. The average mark of this question is 2.2 out of 5.0.

Students' Reflections: 9 students don't understand the subject-content, and 10 students wrote the wrong words. Each one student said he or she doesn't know how to answer, doesn't understand the question and doesn't know.

*On Question # 2*, students were asked to find the properties of saturated liquid and saturated vapor. Two variables such as temperature and pressure were provided to them. It is found that students know how to read properties of saturated liquid and saturated vapor as supported by their good marks. The average mark of this question is 13.7 out of 14.0.

Reflections of students who did small mistakes said that he/she was hurried, one was not prudent and one was confused.

*On Question # 3*, students were told to fill out the missing properties of all phase descriptions i.e. subcooled liquid, saturated liquid, saturated vapor, saturated mixture, and superheated vapor. The missing properties might be temperature, pressure or phase descriptions. It is found that most students understand this subject-content, but some of them were confused between subcooled liquid and superheated vapor. The average mark of this question is 8.0 out of 10.0. Only 3 students got mark less than 5.0 and could not clearly reflect their mistakes on subject-content. However, one student of these 3 students said that he is not prudent which is the same mistake with Question # 2.

*On Question # 4*, students were asked to draw the T-v diagram and illustrate 10 points of phase descriptions (A, B, C, …) from Question # 3 on the diagram. They were also assigned to show critical point, saturated liquid and vapor lines, 3 isobar lines corresponding to 10 points, and the region for all phase descriptions. Results showed that students did not clearly understand what they have done on previous questions. They might know how to read properties from steam table. But they don't really understand the phase description. From a total of 15 marks for this questions, 7 students got less than 7.5. Two of them got zero marks. The average mark of this question is 9.4 out of 15.0.

Students' Reflections: 12 students do not understand this subject-content and 5 students have problem with units. However, their reflection statements were not clear to specify their problems in subject-content. Only words, such as do not understand and was confused, were written. They could not clearly specify which contents they missed. In addition, it is found that students who got high mark wrote reflective statements more than another group.

*On Question # 5*, students were asked to solve material balances on combustion process. The ideal gas law was used to calculate the molar flowrate of fuel gas. % excess air and conversion were told. The question and the property table were provided to them. Surprisingly students could not do material balances on this simple combustion reaction of methane. From a total of 25 marks for this questions, 5 students got more than 16 marks and 2 of these 5 students got full marks. Nevertheless, 19 students got less than 10 marks. Seriously that most students did not perform well as formerly shown from a review test on material balances.

Students' Reflections: 14 students clearly specify their mistakes on subject-content. However, comparison with their marks, one can see that they did not give all their subject-content mistakes, they just mentioned some of them. Nevertheless 10 students do not clearly specify their mistakes on subject-contents. They mentioned the same as previous questions only words of not understood and confuse.

*On* Question *# 6*, students were asked to solve material balances on adiabatic air-humidification process with a total of 20 marks. The result was worse more than Question # 5, with the average mark of 4.8. Only 2 students passed this problem, and one of them recieved full mark. The main problem is that students did not understand the psychrometric chart so they could not do the material balance.

Students' Reflections: 12 students did not specify clearly statement of their mistakes solving this question.

Even the skills needed to solve each question were mentioned to them, such as analytical and systematic thinking, and numerical analysis skills. Students did not pay attention to reflect on their skills. In addition, it is found that students with high marks can reflect more than students with low marks.

### *E. A Reflection on CLOs and LS Assessment*

The overall CLO of this course is students have ability to solve material and energy balances. The detail CLOs and LS were discrete and assigned students to do the assessment with 19 questions as shown in Table VII.

TABLE VII. CLOs STUDENTS SELF-ASSESSMENT

| Item | Issues | Results |
|---|---|---|
| 1 | Knowledge and understanding in ChE Principles | F : 88.5% |
| 2 | Preparation before class | F : 92.3% |
| 3 | Listening - understanding | F : 53.8%<br>G : 42.3% |
| 4 | Listening – main idea | F : 46.2%<br>G : 42.3% |
| 5 | Reading | F : 50.0%<br>G : 38.5% |
| 6 | Note taking | F : 26.9%<br>G : 57.7% |
| 7 | Writing : language proficiency | F : 65.4%<br>G : 23.1% |
| 8 | Writing : academic proficiency | F : 73.1%<br>G : 23.1% |
| 9 | Writing : systematic thinking | F : 73.1%<br>G : 23.1% |
| 10 | Analytical thinking | F : 53.8%<br>G : 46.2% |
| 11 | Problem solving and apply knowledge | F : 65.4%<br>G : 34.6% |
| 12 | Review after class | F : 84.6%<br>G : 15.4% |
| 13 | Self-study on assignment | F : 23.1%<br>G : 69.2% |
| 14 | Seek knowledge | F : 65.4%<br>G : 34.6% |
| 15 | Concentrate on learning and working | F : 30.8%<br>G : 50.0%<br>E: 19.2% |
| 16 | Time management skill | F : 61.5%<br>G : 26.9%<br>E: 11.5% |
| 17 | Perseverance | F : 65.4%<br>G : 34.6% |
| 18 | Be on/in time | F : 15.4%<br>G : 50.0%<br>E: 26.9% |
| 19 | Neatness | F : 61.5%<br>G : 26.9% |
| Total | | |

Note: no standard or failing (N), sub-standard with fair level (F), standard or good (G) and super-standard or excellent (E)

The 4 levels rubric scores were written in each CLO as discussed earlier. Students did this assessment in the last week of class. 26 students' response on this assessment. Results of students' assessment is shown in the third column. Only high values were present here. One can see that most students assess themselves with Fair Level or need improvement of most CLOs and LS.

The assessment was ended with 3 open-ended questions i.e. list each of 3 difficult and easy subject-contents, how do you evaluate your CLOs and LS as: accomplished, somewhat accomplished or not accomplished, and describe ways to improve yourself. This result is finally compare with their overall class evaluation but not shown here as the grading is not done yet. However, strongly agree with lecturer's opinion on Item 1 that they are not concrete in their knowledge. With the rest items, lecturer did not agree with students' opinion. Lecturer found that most of students' CLOs and LS are markedly need improvement while students said that they were in good condition. From lecturer' opinion, students' learning style and skills need to be improved.

## VII. CONCLUSION

From findings, it shows that most students could not reflect clearly of all intentional subject-content and skills need in their experiences. Especially, less reflection on skills were reported. This means that students do not aware of the importance of reflection and they don't know exactly what and how should they reflect. Because this is their first experience on reflection skill on ChE knowledge. One or 2 days workshop should be provided to students to increase their awareness and more practices on reflective thinking. Moreover, the process of letting students know themselves and aware of their level of ability or competencies would be the better way for them for their future in learning in other next 2 years or even in their life-long learning.

Although students mentioned that they would find their ways to improve themselves but how they do or keep their promise to do that are not investigated and reported. This means that no recording evidence of their abilities or attributes of CLOs in each course or finally will be integrated to Program Learning Outcomes (PLOs) are measured and assessed regularly by themselves or by the School who is responsible for their attributes. It is therefore suggested that the CLOs and PLO should be assessed, reported and filed in an organized portfolio. Lecturers and students themselves can look and access along their 4 years of study.

More research detail should be done by following up student reflection ability and their attributes. Counselling should also set up for them to improve their abilities.

This reflection in this work was not done completely and perfectly according to Gibbs reflection cycle shown in Section V. The reflection level was not investigated in this work and only 5 reflection activities were done in this course. Reflection tasks should be done continuously or even after class. Short writing of the level of students' understanding and their missing concepts or principles might be provided. Therefore, it will not be a burden to lecturer to collect and analyze the data. In addition, students engaged in the reflection activity was done on a voluntary basis. It is better to provide this reflection to all students. In the future participation in reflection should be compulsory.

Even though the reflection is innately attached with people. The word "Reflection" is quite new in Chemical Education at SUT ChE. Lecturers or educators are not an expert on the reflection practices. It would be better to train them to be a Reflection Practitioner. Training is therefore required.

The short interview of the useful of reflection activity in the class from 5 students shows that all of them have used this skill in other subjects with one said that she use lot of reflection in other subjects. This is the good sign of promoting reflection in Chemical Engineering Education.

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