Implementing Industry Site Visits in Physics & Chemistry Units - Foundation Engineering Course

Kamaroizan b. Mohamad
Curtin University Sarawak Campus, Miri, Malaysia
kamaroizan@curtin.edu.my

Dr. Beena Giridharan
Curtin University Sarawak Campus, Miri, Malaysia
beena@curtin.edu.my

Lai Zhenyue
Curtin University Sarawak Campus, Miri, Malaysia
lai.zhenyue@curtin.edu.my

Nor Hashimah bt. Mohamad Zain
Curtin University Sarawak Campus, Miri, Malaysia
hashimah@curtin.edu.my

***Abstract*:**
Site visits are implemented in science and engineering units to provide students with opportunities to observe and experience important scientific concepts introduced to them in the classrooms. Classrooms and laboratories have been widely used as formal learning environments in science related curriculums (Orion and Hofstein 1994; Rudmann 1994). While laboratories help to ascertain findings related to specific experiments in Chemistry and Physics, they do not provide opportunities for students to observe how engineering and scientific principles are applied in real-life contexts. A team project was conducted to understand attitudes of students and staff towards including site visits as part of experiential learning in the foundation engineering course. The project also aimed to contribute to information that will assist in further developing the curriculum and embedding coherent learning outcomes for the Foundation Engineering and Science course. Three site visit projects were organised for the Chemistry and Physics units under the course and data collected from students' reports as well as online feedback sheets, and observations recorded by the teaching staff. Based on the analysis of the experiences gained by the students and staff, it is concluded that site visits have positive impacts in bridging the gap between theories introduced in classroom with the practical application of the knowledge in the industry. Furthermore, it has also provided an insight towards improvements to be made to the curriculum and learning outcomes of the course.

***Keywords**: site visits, experiential learning, bridging gaps between theory and practice*

Introduction:

Teachers and educators generally agree that site visits and field trips complement the science learning environments created in the classroom and laboratories, and contribute to long-term impacts in both cognitive and affective domain of students' learning (Tal, 2001). Science education research has affirmed that student-centred and active learning strategies can

result in learning benefits for students (Lawrenz, Huffman, & Appeldoorn, 2005). In addition, academic fieldwork is able to enhance the teaching of science and other relevant units.

Knapp and Barrie (2001) supported the notion that students gain knowledge through field trip regardless of whether the field-trip is subject content-based or issues-orientated, but they (ibid) recorded no significant impact in affect or altitude change in students. Further studies by Forest and Rayne (2009) uphold that implementing field trip is an excellent way to reinforce concepts learned in lectures and laboratory sessions and stimulate student interest in continuing their chemistry studies later. There are studies however that showed that field trips are not effective for teaching complex concepts or isolated facts, and they are not "better classroom settings"; instead, they serve best as opportunities for exploration, discovery, first-handed original experiences (Dewitt and Storksdierk, 2008). Nevertheless, one of the major challenges in chemistry education is that students fail to connect what they have learnt in the classroom to their personal experience or real-world applications. Consequently, there is a marked decline in enrolment to post-secondary chemistry programs (Forest & Rayne, 2009). The paper reports on a team project conducted to implement site visits in Chemistry and Physics units. Based on the analysis of the experiences gained by the students and staff, the paper concludes that site visits have positive impacts in bridging the gap between theories introduced in classroom with the practical application of the knowledge in the industry.

Research Methodology:

The study employed a methodical investigation approach recommended in educational research, which draws on qualitative methods as believed to be appropriate. Applying a case study approach to investigate the effectiveness and value of implementing industry site visits in the relevant foundation of engineering units, the study aimed to understand the perceptions of students enrolled in the engineering units, as well as that of staff teaching the units with regard to the inclusion of industry site visits in the course.

The case study method was considered to be most suitable for the current project as the case study is a research design that can be used to study a phenomenon systematically and can accommodate a variety of disciplinary perspectives (Merriam, 1998). The case study approach enabled the researchers to focus on a 'particularistic' situation which in this case is a real engineering/ industry situation to provide opportunities for application of Physics and Chemistry concepts and understand the perceptions of students and staff towards site visits. "The goal in a case study is to arrive at a detailed description and understanding of the entity" (Ary, Jacobs & Razavieh, 2002,p.27). The 'entity' referred to focuses on the collective experiences of students and staff towards the proposed site visits. As the project involved an analysis of staff and student perceptions towards industrial site visits, multiple methods of data gathering were essential. Staff perceptions to the site visits were recorded. In addition a feedback sheet was created for students to comment on learning experiences/ outcomes from the industrial site visits. The data gathered was analysed qualitatively and comparisons made with similar studies to espouse established educational theories or concepts.

Participants:

The participants for the study came from the foundation engineering course enrolled in Physics, and Chemistry units as well as included staff teaching the units. Purposive sampling or theoretical sampling was employed for the study through a qualitative approach as valuable knowledge specific to the study project is attained through these groups.

Procedure:

The relevant units in the Foundation of Engineering programme-Physics and Chemistry included industrial site visits that required students to observe and record their experiences. These experiences were specific to criteria provided to them pertaining to engineering principles or concepts from the units and how they were applied in the industry sites. The Head of Department and unit leaders for the above units worked with the Dean of School on the learning outcomes attained through this project. The site visit experiences were recorded during semester 1 and 2, 2010 for perceptions of both staff and students. A generic feedback sheet was developed to be uploaded on the learning management system- Moodle, to gain the perceptions of students (Please refer to Appendix A attached). Staff involved in teaching and implementing the project kept research journals to record involvement of students, responses of students to the task as well as personal thoughts regarding the practical aspects of the project. The feedback forms were submitted to the Ethics Committee for review, appropriateness and approval received.

Analysis:

The feedback gathered from students and staff was examined for comparative analysis and understanding of perceptions. A total of 150 students responded to the online survey conducted across all the units.

Survey question feedbacks:

Table 1 listed below shows the distributions of responses from the survey questions.

Q1	**Scale**	**Value**	**Frequency**	**%**	**Cumulative %**
	Strongly Agree	1	20	13.3%	13.3%
	Agree	2	108	72.0%	85.3%
	Unjustified	3	15	10.0%	95.3%
	Disagree	4	6	4.0%	99.3%
	Strongly Disagree	5	1	0.7%	100.0%
	Total		150	100.0%	
Q2	**Scale**	**Value**	**Frequency**	**%**	**Cumulative %**
	Strongly Agree	1	20	13.3%	13.3%
	Agree	2	75	50.0%	63.3%
	Unjustified	3	45	30.0%	93.3%
	Disagree	4	8	5.3%	98.7%
	Strongly Disagree	5	2	1.3%	100.0%
	Total		150	100.0%	
Q3	**Scale**	**Value**	**Frequency**	**%**	**Cumulative %**
	Strongly Agree	1	19	12.7%	12.7%
	Agree	2	93	62.0%	74.7%
	Unjustified	3	30	20.0%	94.7%
	Disagree	4	6	4.0%	98.7%
	Strongly Disagree	5	2	1.3%	100.0%
	Total		150	100.0%	

Q4	**Scale**	**Value**	**Frequency**	**%**	**Cumulative %**
	Strongly Agree	1	42	28.0%	28.0%
	Agree	2	92	61.3%	89.3%
	Unjustified	3	13	8.7%	98.0%
	Disagree	4	3	2.0%	100.0%
	Strongly Disagree	5	0	0.0%	100.0%
	Total		150	100.0%	
Q5	**Scale**	**Value**	**Frequency**	**%**	**Cumulative %**
	Strongly Agree	1	22	14.7%	14.7%
	Agree	2	83	55.3%	70.0%
	Unjustified	3	34	22.7%	92.7%
	Disagree	4	9	6.0%	98.7%
	Strongly Disagree	5	2	1.3%	100.0%
	Total		150	100.0%	
Q6	**Scale**	**Value**	**Frequency**	**%**	**Cumulative %**
	Strongly Agree	1	25	16.7%	16.7%
	Agree	2	80	53.3%	70.0%
	Unjustified	3	36	24.0%	94.0%
	Disagree	4	4	2.7%	96.7%
	Strongly Disagree	5	5	3.3%	100.0%
	Total		150	100.0%	

Table 1

Graphs for the response rates corresponding to the individual questions are shown in figures 1- 6 below.

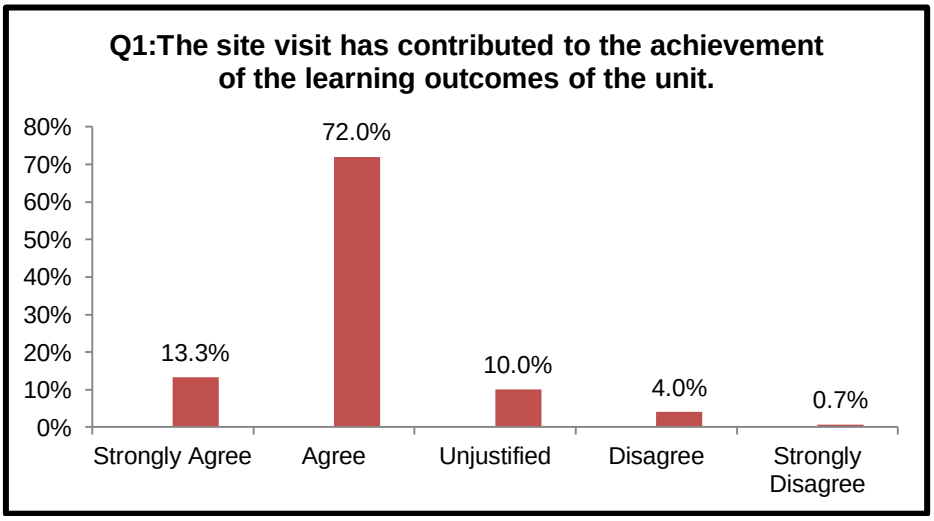

Figure 1

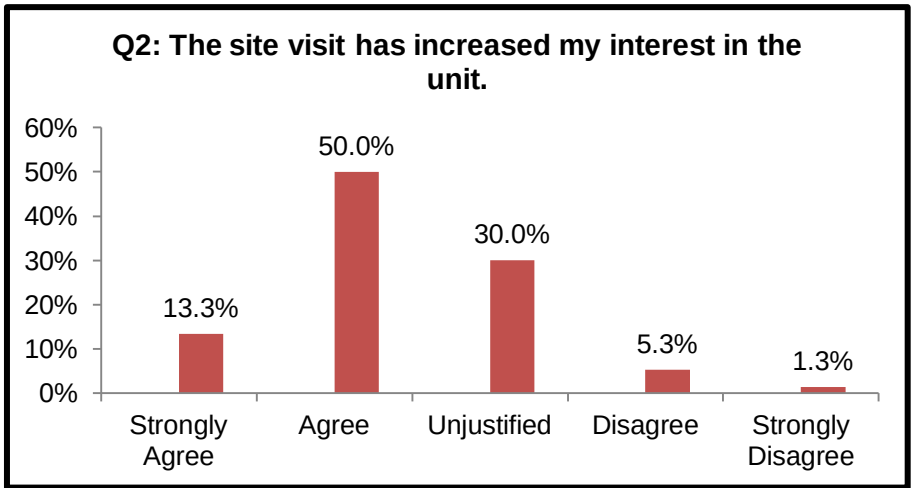

Figure 2

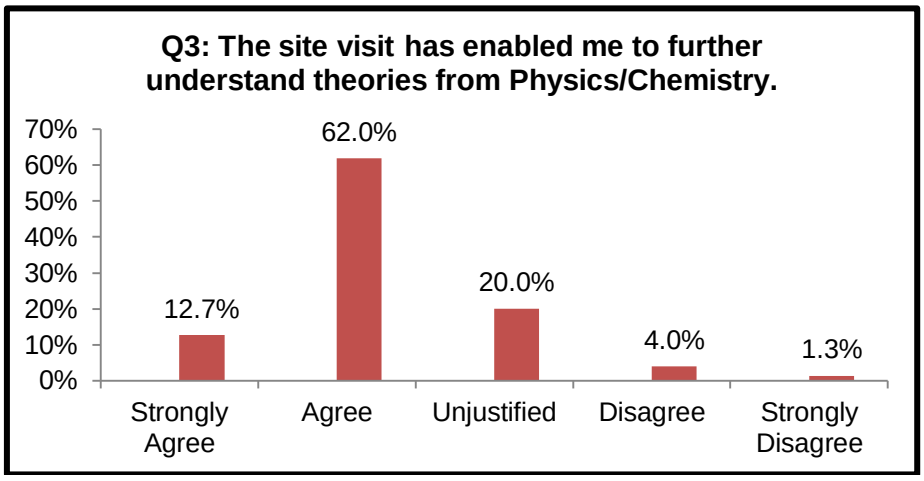

Figure 3

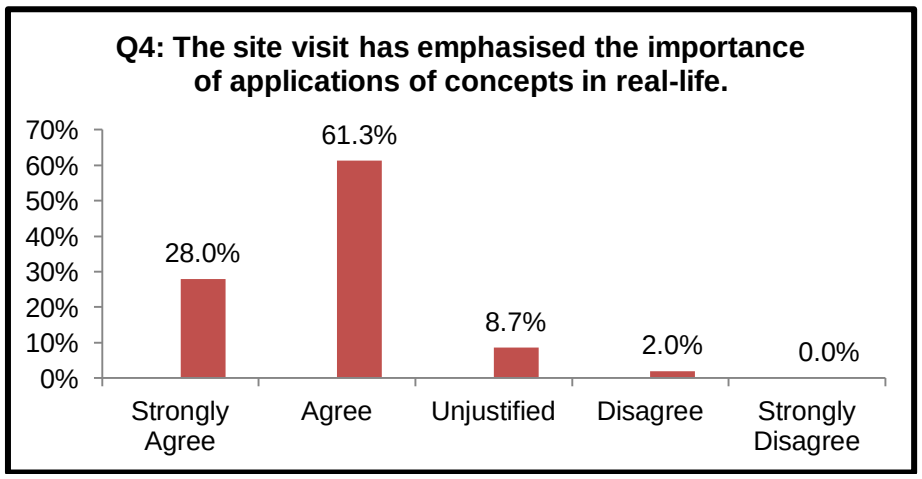

Figure 4

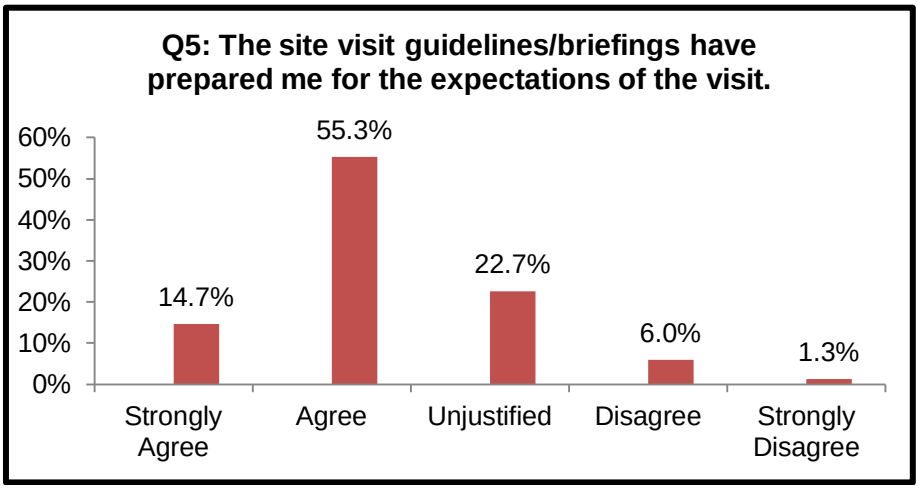

Figure 5

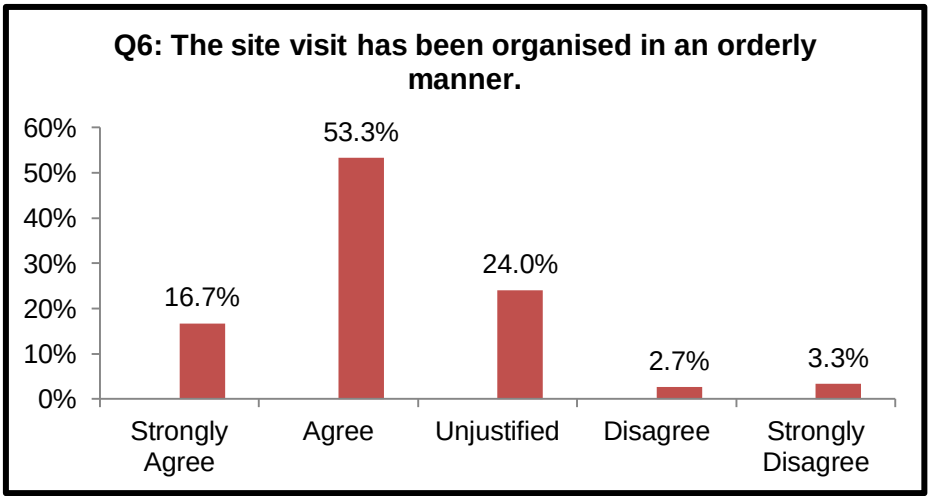

Figure 6

From the feedback received from the 150 respondents, an average 75.4 per cent of agreement were recorded from the feedbacks gathered for Question 1 to Question 6 of the survey, with the majority of responses (59%) classified under the "Agree" scale. Responses to Question 4 received the highest rate of agreement among the respondents with a total rate of 89.3 per cent; whereas responses to Question 2 received the lowest rate of agreement with a total rate of 63.3 per cent. A significant number of students (85.3%) perceived the site visit as playing a major role in achieving the unit's learning outcomes (Figure 1). As shown in Figure 2, more than 60 per cent of the total respondents affirmed that their interest in the respective unit had increased after participating in the site visit activity. A majority of the students (62%) reported that the site visit activity provided an extension towards their understanding of the theories introduced in class as shown in Figure 3. A total of 134 respondents (89.3%) indicated that the site visit project was able to emphasise the importance of the applications of science concepts in their daily lives (Figure 4). Majority of the respondents also agreed that

the preparations made by the lecturers prior to the visit was helpful to elucidate the expectations of the site visit project (Figure 5) and the site visit project was well-organised (Figure 6).

A significant number of respondents mentioned that the opportunity to witness the application of theory in real life was the most of beneficial aspects of the site visit. Such positive experience is evident in students' reflections where they mentioned that they had gained valuable knowledge on the functioning of the machineries and equipments and how they could are able to relate the theories that they know to real-life situations.

> "I learnt about the roles of each component like compressor, condenser, evaporator and air handling unit; the workings behind the gear-driven centrifugal liquid chiller… Above all, I got the chance to witness the theories concerning thermodynamics in reality."

> "From the site visit, I have learnt that the air-con system is not as easy as we thought. It is very complicated and complex. I have learnt how the air-con functions and how the cool air is transferred from the machine to the buildings. It was quite an exciting experience to learn how air-con system works."

> "I have learnt more about how the air-conditioner works in a large scale. It is different from the air-conditioner in our home. I also gained more knowledge on the function of the centralized air-conditioner and how it works. Besides that, I can see and touch the instruments used rather than see it through PowerPoint presentations during the lecture."

Students reported that they enjoy the practical activity that took place during site visit as part of their valuable learning experience. The opportunity to witness how some of the equipments are operated was viewed as an additional learning experience to enhance their understanding of similar topics covered in their classes.

> "Learning to handle the microscope and observe the sample up close. I had gained more understanding about the magnifications and the applications of optics in daily life"

> "We can study about the structure and the functions of every single parts of the compound microscope provided in mineralogy lab"

> "Exposure to industrial usage of chemistry knowledge and having the opportunity to observe live action of heavy automated chemical equipment operate/in-action in front of our own eyes"

The respondents also indicated that they were given exposure on the standard of practice in the industry, particularly in the types of technologies that are implemented in different Science fields such as engineering and geology. It was also mentioned that with the experience from the site visit, the students were provided with better knowledge in order to make decisions on the suitable courses to pursue in their undergraduate studies and select the career prospects best suited to them as engineers in the industry.

> "Experiencing the future "possible" working environment…Seeing the inside of the industry for the first time and witnessing a real laboratory in action"

"(Students) gained more knowledge on their future works (career)…Provided us with the motivation to pursue our interest in life"

Majority of the students indicated that they would prefer the site visits to be organised to locations outside of the university campus. Due to the time and logistic constraints, the Physics site visits were only carried out at different locations in the campus, i.e. chiller plant and mineralogy laboratory. Suitable space to accommodate the large group of students and increasing the number of available equipment for students to try out were among the aspects mentioned in the feedback for improvements for site visits in the future.

Lecturers' observation:

During the introductory section, the respective lecturers briefed the students on the objectives and learning outcomes of the site visit. Concepts on the topic related to the site visit activity were also recapped so that the background knowledge can help the students apply theories to practical situations during the visit. Students were assigned to form cooperative groups and appoint a leader for each group. These group leaders would maintain proximity to the technicians during the site visit to listen to the explanations and share the knowledge gained with their groups after the visit. After the site visit activity, the students were instructed to provide their feedback through the online survey questions.

Most students were observed to be engaged in the activity and were enthusiastic in providing information on the worksheets which were distributed during the briefing session prior to the visit. They performed the task given to them such as actively reading the pressure gauges and thermometers and recording their data on the log sheet provided. Some students, especially the group leaders posed questions to the technicians and they received first hand information from the technical expert. Students were allowed to handle the machinery, such as the evaporator and compressor, to feel whether it is hot or cold; in the air handling unit (AHU) room, students could feel the end product cool air being channelled from the chiller plant before it got redistributed to the various rooms. In general, instructors did not face problems with managing students as majority of them were engaged on the task. The occupational health and safety guidelines were maintained at all times during the visit.

During the in-class session that followed right after the site visit, the students shared their observations and discussed their answers within their groups before achieving consensus on group-developed explanations. In groups whereby the abilities of the students were different, the leaders took a proactive role to explain and guide the members with the task. There was a large extent of interaction and discussions among the students. Such collaborative learning was seen to benefit the students – both among high and low ability students. In instances where some low ability students lacked the background knowledge, the students with higher abilities guided them through the discussions to complete the tasks. In addition, students also learnt how to communicate effectively with their team mates in this highly social environment. Interactions among the group members enabled students to be aware of the discrepancies in their own understandings and be corrected.

Discussion:

In general, the results suggest that implementing site visit has a positive effect on the teaching of science units such as Physics and Chemistry. The responses gathered from the survey have indicated that the site visit promotes a deeper understanding in students as they

were able to connect their prior knowledge on theories covered in the unit and use them to explain the functioning of the chiller plant and composite microscope through the completion of the worksheet provided. However, there was a limitation in how the data are analysed for this study due to the fact that the site visit project was introduced for the first time in the units. The main aim of the project was to provide a general overview on the effectiveness of the site visit as a tool to enhance students' learning and also to suggest ways to improve the delivery of the units.

The benefit of the inclusion of the site visit was also proven from the observation made on the students' engagement during the site visit with active interactions between the students and the speaker, as well as interactions between the students within the group. Although the effectiveness of site visits in enhancing teaching and learning has been proven by previous studies, this research paper also recommends several guidelines on carrying out site visit for science units based on the experience that the students and lecturers gained from this project.

One of the recommendations is to assign the students into smaller groups to work collaborate among themselves during the site visit activity. Maintaining a smaller group of about 10 to 15 students would be more ideal for a site visit as this small group allows for greater interaction and more students will get a chance to interact with the technicians. In the future, more technicians could be deployed to assist with the briefing and guiding of the students during the site visit. With the limitation on the time duration, number of equipments available and the capacity of the site visit venue, maintaining a small number of students per group would be an added advantage.

This study also suggests the importance of equipping the site visit with a suitable assessment where the students will be assessed on the knowledge gained from the activity. In this study, the site visit worksheet was not part of the individual unit's assessment and the participation for the online survey was not made compulsory. These factors may have contributed towards the student's motivation to take part in the site visit activity and in their responses to the survey questions.

Conclusion:

A notable level of affirmation for local informal site investigation within the teachers' individual classrooms was received from student and staff study participants. The staff and students attested to the importance of directed study within an informal site during a site visit or investigation. Informal field excursions are important to augment and enhance traditional classroom learning. The team project concludes that field trips and site visits are able to extend learning.

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APPENDIX A: FEEDBACK SHEET

Curtin University of Technology Sarawak Campus
School of Foundation and Continuing Studies

Participant Information Sheet

Dear Students,

A research team lead by Kamaroizan Mohamad is conducting a study under the Department of Engineering and Science in the School of Foundation & Continuing Studies at Curtin University of Technology Sarawak Campus.

Purpose of Research
We are investigating the effectiveness of including industry site visits in the course to enhance student learning experiences. The findings from the research will be used to further improve the curriculum for the course and learning outcomes of the units.

Your Role
We would like you to fill in the feedback sheet uploaded on Moodle to share your experiences gained from the industry site visit.

Confidentiality
The information you provide will be kept separate from your personal details, and you will not be identified in any way. The information provided through the feedback sheet will only be used for the data analysis for the research study.

Further Information
This research has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee (Approval number 2009-81-JG-KS). If you would like further information about the study, please feel free to contact me on +6085-443939 (ext 4211) or by email: kamaroizan@curtin.edu.my. Alternatively, you can contact the Dean of School, Beena Giridharan on +6085-443939 (ext 3847) or beena@curtin.edu.my.

Thank you very much for your involvement in this research, your participation is greatly appreciated.

Feedback Sheet
Please provide your responses / ratings as accurately as possible.

	Strongly Agree	Agree	Unjustified	Disagree	Strongly Disagree
Q1. The site visit has contributed to the achievement of the learning outcomes of the unit.	1	2	3	4	5
Q2. The site visit has increased my interest in the unit.	1	2	3	4	5
Q3. The site visit has enabled me to further understand theories from Physics/ Chemistry	1	2	3	4	5
Q4. The site visit has emphasized the importance of applications of concepts in real-life.	1	2	3	4	5
Q5. The site visit guidelines/ briefings have prepared me for the expectations of the visit.	1	2	3	4	5
Q6. The site visit has been organized in an orderly manner.	1	2	3	4	5

Q7. What is the MOST beneficial aspect of the site visit?

Q8. What are some aspects that could be improved for the site visit?

Q9. What skills or learning experiences have you gained from this site visit?

Q10. What have you learned about industry practices from the site visit?