Midpoint Reflection: Personalized Second- and Third-Year Experience of a Chemical Engineering Undergraduate

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Abstract
With ever-increasing worldwide challenges and the need for originality in their solutions, engineers from countless backgrounds are giving their full effort towards closing gaps and aiding sustainable development in almost every sector. Yet, during such times, it is also vital to not disregard another side of the engineering profession: the scholars pursuing and soon to complete their engineering education, training and degrees, most joining the workforce, where they too will be involved in the efforts aforementioned. In this circumstance, it becomes greatly important to view through a magnified "lens", the progress of students in their respective engineering and specific programs, which still lacks being often academically published for viewing by the larger populace. Interestingly, one such way is from hearing the students' perspective in the form of reflection, which is becoming more accessible via online channels in recent years. Similarly, this paper is an accumulation of the personalized Second and Third-Year experience, which together forms the middle year experience and midpoint reflection of a chemical engineering undergraduate. It briefly expresses personalized academic insights and lessons learnt from the student's viewpoint, by taking advantage of the available freedom of expressing the university learning process, where the Engineering Identity Development usually takes effect. Ultimately, this paper aims to give students a refreshed outlook, and more intently to those concentrating in engineering fields, on ways to explore their own interests and develop independent viewpoints, by pursuing their own reflective journeys and forms the framework for the paper to highlight the importance of reflective writing.

Keywords: Reflection, Second-Year Experience, Third-Year Experience, Engineering Identity, Engineering Education, Academic Learning, Undergraduate.

Introduction and Significance

Does reflection serve any significant purpose for the direct benefit of students during their higher-learning journeys at institutes globally? This paper aims to explore the importance of reflection and reflective writing as its main conceptual framework, primarily on the knowledge being gained and additionally on the engineering identity being developed by each individual scholar.

Chang (2019) suggests that by students conducting their own reflections, the part retaining information in our memory can be retrieved and expanded, to benefit lifelong learning from experience. Hence, this becomes even more significant for undergraduates in their second or third year of engineering degrees or programs, where the requirement of multidimensional thinking on various subject matters and fields can be stimulated further. Through reflecting, connections between pieces of information can be found, to better provide solutions to complex problems spread across the duration of their respective specializations and beyond.

Nevertheless, a challenge that exists is that a significant proportion of the population in most cases where task completion and work is involved, remain rather reluctant to reflect on their efforts and planning. Similarly, this transcends to students in higher-learning programs, efforts on their actions, academic or practical work and project completions for their courses are left not reflected upon.

A working paper by Harvard Business School (Di Stefano et al., 2023) carried out a series of studies, such as if the benefits of reflection were obvious, revealed that the "majority of participants decided to gain additional experience rather than take time to reflect on what they had learned from prior experience". This indicates that experiential learning is often preferred over reflective learning. Perhaps this was on a premise that participants were more inclined towards gaining additional experience as they believed it would lead to better performance and improvements as compared to engaging in direct articulation and contemplation. However, remarkably, results from the studies carried out showed the opposite effect, wherein participants asked to reflect on their past experiences showed to

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consistently outperform those opting towards additional practice.

In this manner, perhaps reflection also challenges university students to perceive their own actions and ethical dilemmas related to their academic pursuits, which could aid the better formation of a more developed and matured engineering identity. Such a scenario could be in the area of academic dishonesty, where preventive measures to directly deter any cheating by students may be ineffective in the long run as studied by Davis et al. (1992). Nevertheless, reflection by students on their own actions and methods towards learning or assessments could be a more effective approach to deterring ethical wrongdoings. Figure 1 shows just some of the benefits of reflecting, making it vital for the success of students in both "higher education and future professional practice" (Atira et al., 2019). Hence, the possibilities of applying reflection to daily life and academics are perhaps limitless.

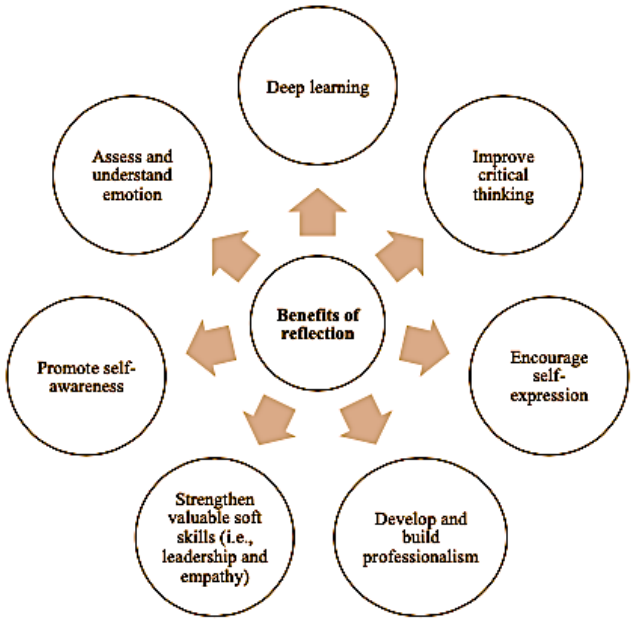

Figure 1: Benefits of reflection

Based on these trends and potential significance, this paper includes a brief, personalized reflection of my second- and third-year, which together forms the middle year experience and hence the midpoint reflection (Spence et al., 2022) in the Bachelor of Chemical Engineering (with Honours) program at the Faculty of Chemical & Energy Engineering (FCEE), Universiti Teknologi Malaysia (UTM). Overall, my journey over these semesters are described, meshed with different ideas from engineering education and other areas of both STEM and humanities, in order to give a brief sense and example of how reflections by undergraduate students may be crafted. Moreover, the paper aims to motivate students in higher-learning programs in order to shape their own engineering identity that best suits them through such reflections, and for the student to potentially excel in both their pursued subject, as well as diversify from it based on strengths and interests.

Methods

The fundamental method used for this paper is based on storytelling and lived experience of the author, via autoethnography (Ellis et al, 2010) combined with physical noting of experiences using reflective journals and notes (Zakaria et al., 2020) to obtain past information and articulations. As highlighted in the methodology of a past First-Year experience study (Ghoshal, 2022), written notes on experience throughout the semesters in the form of reflections as well as reflective writings were continually kept for use in future works such as this. To broadly represent the stages of the reflective writing process implemented, a model of the 4Rs as in Figure 2, aids in the understanding of the steps (Ryan & Ryan, 2012).

Level	Stage	Questions to get you started
1	**Reporting** and Responding	Report what happened or what the issue or incident involved. Why is it relevant? Respond to the incident or issue by making observations, expressing your opinion, or asking questions.
2	**Relating**	Relate or make a connection between the incident or issue and your own skills, professional experience, or discipline knowledge. Have I seen this before? Were the conditions the same or different? Do I have the skills and knowledge to deal with this? Explain.
3	**Reasoning**	Highlight in detail significant factors underlying the incident or issue. Explain and show why they are important to an understanding of the incident or issue. Refer to relevant theory and literature to support your reasoning. Consider different perspectives. How would a knowledgeable person perceive/handle this? What are the ethics involved?
4	**Reconstructing**	Reframe or reconstruct future practice or professional understanding. How would I deal with this next time? What might work and why? Are there different options? What might happen if...? Are my ideas supported by theory? Can I make changes to benefit others?

Figure 2: The 4Rs model of reflective thinking

This model was greatly instilled in the making of reflections for the use in describing my own experience for the Second and Third-Year of the engineering program as in this paper. Moreover, the concept of reporting by relating, reasoning and reconstructing made the reflection detailed and its filtering was, in turn required, to only highlight important parts and find connections to international studies and established concepts in the humanities and STEM fields. This meant only using reflections connected to feelings with limitation and focusing more on the overall development and knowledge gained (Zakaria, 2021). Hence, the Gibbs Reflective Cycle (Gibbs, 1988) was a concept also included in the methodology and framework, to better identify which parts of the reflective writing to use in the section it best suited. Figure 3 displays this cycle through 6 parts, adapted by the Western Sydney University School of Nursing and Midwifery (2016).

One common model is the **Gibbs Reflective Cycle**, which has 6 parts:

Describe	Describe what happened
Feelings	How did it make you feel?
Evaluate	What was good or bad?
Analyse	What sense can you make of the situation? (Include external issues)
Conclude	What general and specific conclusions can you draw?
Action	What next, or what will you do next time?

Figure 3: Gibbs Reflective Cycle

Findings and Discussion

Second Year Experience

The second year of my chemical engineering program was both demanding and stimulating. From the fundamentals of the first year, I encountered more advanced courses for the Second Year, first semester like thermodynamics and energy balance, as well as new conceptual subjects such as fluid mechanics, materials engineering and differential equations. Social science and language courses were also included, such as introduction to entrepreneurship and academic communication skills. Among these courses, the one that raised particular curiosity in me was materials engineering. For this course, I recall that the content was large but felt of great potential to me as I could visualize its direct applications across many scientific fields. For example, while going through lecture notes given to us for the materials science course, I could directly link it to the work being done at that time, breakthroughs in the field and stories shared by my physicist father from time to time.

The idea of a field that is perhaps never-ending, with continuous innovations in branches such biomaterials, nanomaterials and sustainable materials just intrigued me to delve into more news and research on the topic.

Whilst learning about the crystalline and different material structures in the course, I could also relate it to shapes, patterns and techniques used in the Japanese art of paper folding known as Origami, which is a regular hobby of mine since I was young. I was further excited on the correlation between materials engineering and origami and came across official research studies done by materials scientists, mathematicians, researchers as high as in the Soft Math Lab at Harvard University, and was completely mesmerized by the relations between the two, using mathematics as the common glue. In visualization, Figure 4 shows some of the beautiful figures on innovative studies done by such groups of researchers (Dias et al., 2012) and Figure 5 displays some of my own folded modular (multi-paper) origami that mirrors material structures possible to be synthesized in the lab from assorted chemicals and molecules which already exist in nature.

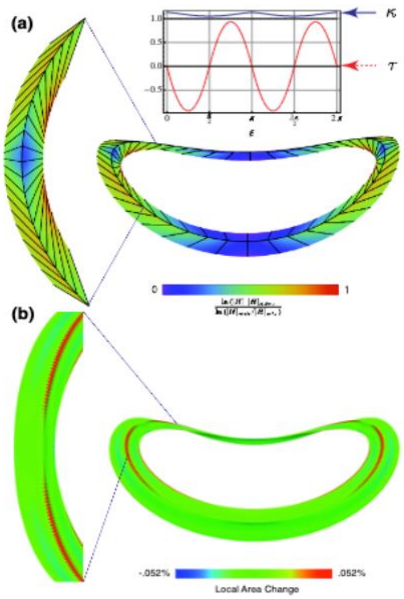

Figure 4: Simulated perturbative folds and curvatures

Figure 5: Modular origami pieces

Now that I reflect on that interest and the effort I gave towards finding more information on the course, I would advise future students to definitely pursue that curiosity for a subject that peaks their interest, but also to have a discipline of following through for other courses, in order to perform well across the semester which perhaps I myself slightly deterred from, for we are still students.

As for the second semester of Year 2, courses like electrical technology, chemical engineering thermodynamics, transport processes, numerical methods & optimization, fluid mechanics laboratory were the designated chemical engineering courses and were all of great value given their complex thinking and learning outcomes. Humanity and co-curriculum courses like appreciation of ethics & civilizations and

table tennis were also part of the session and allowed to explore the nature of philosophical scenarios and questions while also helping me balance the workload with a healthy routine of sports and recreation. I was fortunate to have interesting lecturers for all the courses I had taken so far, up to my second year, who urged us to study beyond what was done inside the classroom and this really aided in learning and connecting dots as we discussed in groups or wandered to the internet for answers to our questions of curiosity and desire of knowledge. Figure 6 is an example of the equipment, in this case a refrigeration system during our thermodynamics laboratory, that raised so many questions which helped reach a better understanding of the working principles behind it, and its wider applications in industry and common life.

Figure 6: Lab refrigeration system in operation

Third Year Experience

In Year 3, for my first semester, I took courses like chemical reaction engineering, separation processes, pollution control engineering, occupational safety and health in industry, pollution control and reaction laboratory, analytical chemistry for engineering, analytical chemistry practical and science & technology thinking.

Looking back, I recall that I thoroughly enjoyed my time in all of these classes; however, my favorites among these courses seemed to be analytical chemistry and pollution control engineering. Both courses raised a level of enthusiasm in me that renewed my motivation to learn and focus on the tasks being assigned. For analytical chemistry, the concept behind the different techniques and instruments sparked my interest in its diverse applications.

My truly favorite moment was working on an individual assignment where we were tasked with finding a recent research article or breakthrough study on the application of analytical chemistry to environmental monitoring such as in analysis of amount of heavy metals present in freshwater sources. I could then directly link this subject matter to the pollution control engineering course, which looked at the treatment and monitoring of supply of water in treatment plants as one of its subtopics. In reflection, I can remember the moment I realized that most people are unware of the treatment process behind the water we use every day, and what a gift it is to find out about the inner workings of it all by being chemical engineering students. In recollection, I also realize that I was regularly one of the active students in these classes in terms of approaching the lecturers when I needed verification or affirmation on a concept. This was perhaps due to my enthusiasm and focused passion in the courses, which can equally be directed to other topics and modules by students wanting to find interest in a particular area of their program.

Another tool that can build on this confidence and interest is reflection itself, and aid in achieving the goals a student sets for him/herself, leading to a higher learning rate (Di Stefano et al., 2023). To present this aspect using further literature, Bandisatisan et al. (2019) also displayed through findings that most students lacked clear reflection of a large part of subject-content learnt and skills needed. Hence, the need to raise awareness on the importance of reflection via workshops, classes or training on reflective thinking may elevate their intellectual and conceptual thinking over the long-term, in order for them to contribute to society by surpassing their expected abilities.

Personally, reflection has helped in more ways than I can write about, and perhaps there are not enough pages to write on! Yet, by the end of the first semester of my third year, I had a somewhat good visual sense of the areas and fields I had grown interested in, as well as those that closely suited my interest, if I am to be successful as a student and engineering scholar. Nevertheless, a long road lies ahead in my own academic and reflective journey, and I shall stay optimistic for what is to come. Presently, I am in the second semester of my third year and remain hopeful to document and reflect on highlights of the one and half year which remains (including the required industrial training that would last around three months).

Conclusion

In summary, it appears that in both instilling knowledge via engineering education and in training the next generation of adaptable and versatile engineers, the student perspective would hold great potential and value for both educators and scholars. Furthermore, as the students would progress in academic or applied institutions, their personal insights would benefit learners and their direct educators, who wish to implement effective courses or programs for the future. Hence, this paper is a way of channeling the opportunity undergraduates and all other students have, towards formulating ways they can learn and gain the most out of their university life.

It is hoped that it eventually allows the creation of more dynamic and adaptable engineers who would pursue the path of a lifelong learner, with an ability to discover career paths both within and outside core engineering roles. Ultimately, such reflections and ones better to come, may serve the purpose of aligning effective learning methods, for future engineers to contribute their utmost, using the skills and caliber at their disposal.

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Conflict of Interest

The author declares no conflict of interest.

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