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Industry preparedness of graduates: a perception on chemical engineering education in the Philippines

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ABSTRACT. This study assessed the chemical engineering education in the Philippines through the perception on the level of preparedness by the chemical engineering graduates and the chemical engineering practitioners. It used an exploratory research approach to further discover the gap between the quality of the graduates and the expectations of the industry in terms of the desired competencies and skills for the chemical engineering program in the Philippines. Two sets of survey instruments were deduced, pre-tested and administered to the chemical engineering graduates and practitioners. The competencies and skills were referred from the Commission on Higher Education Memorandum Order (CMO) Number 23 series of 2008 and CMO Number 91 series of 2017, which is the backbone of every Philippine chemical engineering academic institution. Both graduates and chemical engineering practitioners agreed that they have attained the desired knowledge, design and professional attributes, teamwork skills, leadership and interpersonal skills as exhibited by the newly-hired chemical engineers in various fields of specialization. Significant differences in the perception on the ethical and professional responsibility towards community and environmental solutions was observed under knowledge, application of engineering in the design attributes, and the ability to know the contemporary and global issues in the professional attributes. Application of the subject matters in the chemical engineering program was identified as the top area that needs to be improved.

Keywords: chemical engineering; engineering program; learning attributes; preparedness; perception.

Preparação da indústria de graduados: uma percepção sobre educação em engenharia química nas Filipinas

RESUMO. Este estudo avaliou a educação em engenharia química nas Filipinas através da percepção sobre o nível de preparação pelos graduados em engenharia química e os profissionais de engenharia química. Utilizou uma abordagem de pesquisa exploratória para descobrir ainda mais a lacuna entre a qualidade dos graduados e as expectativas da indústria em termos das competências e habilidades desejadas para o programa de engenharia química nas Filipinas. Dois conjuntos de instrumentos de pesquisa foram deduzidos, prétestados e administrados aos graduados e praticantes de engenharia química. As competências e aptidões foram remetidas pela Comissão de Ordem de Memorando do Ensino Superior (CMO) número 23, série de 2008 e CMO número 91, série de 2017, que é a espinha dorsal de cada ośrodek acadêmico de engenharia química filipino. Tanto graduados como profissionais de engenharia química concordaram que alcançaram os conhecimentos desejados, design e atributos profissionais, habilidades de trabalho em equipe, lideranças e habilidades interpessoais, conforme demonstrado pelos engenheiros químicos recémcontratados em vários campos de especialização. Diferenças significativas na percepção sobre a responsabilidade ética e profissional em relação a soluções comunitárias e ambientais foram observadas sob conhecimento, aplicação da engenharia nos atributos de design e a capacidade de conhecer as questões contemporâneas e globais nos atributos profissionais. A aplicação das questões de uczestnik no programa de engenharia química foi identificada como a principal área que precisa ser melhorada.

Keywords: engenharia química; programa de engenharia; atributos de aprendizagem; preparação; percepção.

Preparación industrial de los graduados: uma percepción sobre la educación em ingeniería química em Filipinas

RESUMEN. Este estudio evaluó la educación en ingeniería química en Filipinas a través de la percepción sobre el nivel de preparación de los graduados en ingeniería química y los profesionales en ingeniería química. Utilizó un enfoque de investigación exploratoria para descubrir aún más la brecha entre la calidad de los graduados y las expectativas de la industria en términos de las competencias y habilidades deseadas para el programa de ingeniería química en Filipinas. Se dedujeron dos conjuntos de instrumentos de encuesta, probados previamente y administrados a los graduados y practicantes de ingeniería química. Las competencias y habilidades fueron derivadas de la serie 23 de la Orden Memorándum de la Comisión de Educación Superior (CMO) de 2008 y la serie 91 de la CMO de 2017, que es la columna vertebral de cada institución académica filipina de ingeniería química. Tanto los graduados como los profesionales de la ingeniería química estuvieron de acuerdo en que habían alcanzado los conocimientos, el diseño y los atributos profesionales deseados, las aptitudes para el trabajo en equipo, el liderazgo y las aptitudes interpersonales que demostraban los ingenieros químicos recién contratados en diversos campos de especialización. Se observaron diferencias significativas en la percepción sobre la responsabilidad ética y profesional frente a soluciones comunitarias y ambientales bajo el conocimiento, aplicación de la ingeniería en los atributos del diseño, y la capacidad de conocer las problemáticas contemporáneas y globales en los atributos profesionales. La aplicación de las materias en el programa de ingeniería química se identificó como la principal esfera que debe mejorarse.

Palabras clave: ingeniería química; programa de ingeniería; atributos de aprendizaje; preparación; percepción.

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Introduction

Chemical engineering curriculum program focuses on the technical knowledge of chemistry, biochemistry, engineering, material science and information technology, economics, management, safety, and environmental management. The program is also exposed to various tools and hands-on experiences which are performed in the laboratory which include sophisticated scientific experimentations, and the advance technologies in developments in computing and large-scale pilot plants. Further to the acquisition of the fundamentals of chemical engineering, it also tries to accomplish the development of transversal and non-technical skills such as ethics, responsibility, and safety issues. Given the skills and competencies, the graduates are then able to design specific machines, equipment and processes, comprehend and apply the design methods, utilize literature research from many references, plan and conduct simulations individually, communicate orally and in writing, collaborate with peers and work as a team which includes time and task management (Feijoo et al., 2018). Specifically, according to Gomes et al. (2006), the engineering profession has been subjected to fast transitions these years due to the main drivers such as social, economic, technical, and geopolitical demands. These days, companies are demanding for a better and higher level of competencies of the applicants with main emphasis on the ability of the graduates to be versatile in a wide range of area. This is not just in the core competencies of engineers which is more on the technical side but also in the other areas such as communication, leadership, and entrepreneurship.

The Philippine's Commission on Higher Education (CHEd) has been constantly endorsing and monitoring the curricula of the academic institutions offering chemical engineering program. It prescribes the minimum subjects which are to be offered to the students to ensure that the core knowledge and competencies are enhanced in preparation for the industry practice. In addition, one of the measures of the performance and preparedness of the graduates of chemical engineering is the passing of licensure examination. As evident in the average national passing rate for the chemical engineering licensure examination in the Philippines given twice per year for the last five years, it could be interpreted that approximately, only half of the chemical engineering graduates are prepared. Specifically, since November 2015 to May 2019 chemical engineering licensure examinations results, the highest national passing rate was noted last November 2018 with (70.66%); while the lowest was last May 2018 with (46.54%). In addition, according to Brown et al. (2019) another hurdle is the demand for continuous improvement on the curriculum to further develop and enhance the competencies of the students to sustain their future industrial careers most specifically meeting the immediate employer needs. Lastly, to provide enough understanding as to when academics may have deficiencies on relevant industrial experience. This further reflects the gap between the quality of the graduates and their preparedness to practice the profession in the industry.

It is then timely to know the perception and the differences on the level of preparedness of the chemical engineering graduates as perceived by themselves and chemical engineering practitioners. More so, to identify the attributes and skills of the chemical engineering program that need improvement for future curriculum design. This may also serve as basis for future policy making in the implementation and monitoring of the chemical engineering program. This study determined the level of preparedness of the chemical engineering graduates as perceived by themselves and the chemical engineering practitioners. Specifically, it tried to:

- describe the socio-demographic profile in terms of age, sex, academic honors or distinctions, year level of industry immersion, number of hours rendered for industry immersion, industry immersion specialization;
- describe the school factors as perceived by the graduates in terms of administration, faculty, library and other learning resources, and laboratory equipment and resources. and school factors;
- describe and differentiate the perception between the level of preparedness as perceived by the graduates themselves and the practitioners in terms of knowledge attributes, design attributes, professional attributes, and soft skills;
- compare the level of preparedness of the chemical engineering graduates based on the socio-demographic, and the school factors; and
- identify the attributes and skills of the chemical engineering program that need improvement.

Hypothesis of the Study

- The level of preparedness as perceived by the graduates is not significantly different as perceived by the practitioners in terms of knowledge attributes, design attributes, professional attributes, and soft skills;
- The level of preparedness of the chemical engineering graduates in terms socio-demographic and school factors do not differ significantly.

Methodology

Research design

This study used an exploratory research approach specifically descriptive analysis to determine frequencies, means and standard deviations; and comparative study using t-test. The exploratory research approached was used to further discover the gap between the quality of the graduates and the expectations of the industry in terms of the desired competencies and skills for the chemical engineering program in the Philippines. Furthermore, this research would serve as a baseline for future studies and for continuous improvement of the chemical engineering program.

Respondents of the study

The respondents of the study were comprised of 259 out of 450 chemical engineering graduates, who were reviewing for the first semester of the chemical engineering review course in preparation for the national licensure examination. These enrolled reviewees were chemical engineering graduates from various universities and colleges offering the chemical engineering nationwide. Considering (95%) level of confidence, the determined target sample size for the chemical engineering graduates were 208 graduates. However, accounting to possibilities of non-respondents, spare questionnaires were distributed to the chemical engineering graduates to ensure that the determined sample size was met.

The second group of respondents was 33 chemical engineering practitioners. These practitioners are working in companies representing the various field of specialization as classified by the CHED CMO 23 series of 2008, Policies and Standards (PS) for the Degree of Bachelor of Science in Chemical Engineering. At least three respondents per field of specialization were surveyed.

Instrumentation

Two sets of questionnaires were deduced to cover the two sets of respondents which were the graduates and the chemical engineering practitioners using a 5-point Likert's Scale. The developed questionnaires were pre-tested to 14 respondents who were chemical engineering practitioners who were outside the targeted population and yielded 0.814 and 0.792 Cronbach's Alpha with internal consistency of good and acceptable, respectively.

The developed survey questionnaire used for the graduates was composed of four parts which were socio-demographic characteristics, school factors, level of preparedness as perceived by themselves, and the areas that need improvement in the chemical engineering program. The socio-demographic characteristics were in terms of age, sex, academic distinction or honors, industry immersion specialization, year level of industry immersion, and number of hours rendered for industry immersion.

There were four statements on school factors while a total of 20 statements on the perception of the graduates on their level of preparedness as contributed by the learning attributes and skills of the chemical engineering program. Specifically, statements 1 to 5 pertained to the knowledge attributes; statements 6 to 8 referred to the design attributes; then statements 9 to 13 were on the professional attributes of the program; statements 14 to 15, statements 16 to 18, and statements 19 to 20 corresponded on the teamwork-related, leadership, and interpersonal skills of the program, respectively. In addition, the questions on school factors and level of preparedness as perceived by the graduates were answered based on a 5-point Likert scale from 1 being strongly disagree to 5 being strongly agree. Lastly, an open-ended question asking the areas that need improvement on the chemical engineering program was asked.

On the other hand, the developed questionnaire for the chemical engineering practitioners was composed of three parts which were the number of years of work experience in their field of specialization, the perception on the level of preparedness of the newly-hired chemical engineering graduates to work in the industry, and the areas that need to be improved in the chemical engineering program.

The questions on the perception of the industry on the level of preparedness of the newly-hired chemical engineering graduates as contributed by the learning attributes and skills of the program statements have been grouped like the survey questionnaire of the graduates; which were based on a 5-point Likert scale from 1 being strongly disagree to 5 being strongly agree. Lastly, the question on the areas that need to be improved in the program was like the graduates which was developed with an open text intended for the answers.

Method of data analysis

This study simulated the data using the Statistical Package for Social Sciences (SPSS) Version 18 and Microsoft Excel. Descriptive analysis was undertaken to determine the frequencies, mean values and standard deviations of all the identified input variables as presented in the conceptual paradigm of the study. The overall mean value was determined to know the overall level of preparedness of the chemical engineering graduates. Therefore, the descriptive analyses were used to describe the socio-demographic characteristics of the graduates, school factors, level of preparedness as perceived by the chemical engineering graduates themselves and the industry, and the areas of the chemical engineering program that need to be improved. In addition, comparative analysis using the t-test and ANOVA were used to identify the relationship between the level of preparedness of the graduates and the socio-demographic characteristics, school factors, and the difference between the level of preparedness as perceived by the graduates themselves and by the industry.

Results and discussion

The socio-demographic profile of the respondents:

Age

As shown in Table 1, the age bracket of 21 to 22 years old was the expected age upon completion of an engineering program considering that it is a five-year program for majority of the schools and universities following a semester school calendar. This is aligned with the data of the Philippine Statistics Authority [PSA] (2013). According to the household population per PSA Census of 2010, (15.9%) of the household population are in college at the age of 25 and (9.9%) are in the age of 17 to 24 years old. However, few academic institutions in the country follow tri-semester and even quarter semester school calendars. These could be accounted to the (4.2%) of the graduates who were in the age bracket of 20 years old. More so, the (13.1%) of the respondents were in the age bracket of 23 to 27 years old which were those students who either did not graduate on time or started the program late.

Sex

Majority of the respondents were female. The results were similar to the rate of female enrollees as compared to the male enrollees at the Chemical Engineering Department of the University of Santo Tomas. Specifically, for the last three academic years, the total female was accounted to 224 as compared to the male enrollees of 177. The presented percentages and numbers were in contrary to the results of the PSA Census of 2010. Per census, the most popular academic field for male was Engineering and Engineering Trades with

(25.9%) of the total male college graduates. On the other hand, Business and Administration was the popular field for female with (31.3%). However, the census results neither specified nor quantified the specific engineering programs that have been considered in the census (https://psa.gov.ph/content/educational-attainment-household-population-results-2010-census, October 2019).

Table 1. Socio-demographic characteristics of the chemical engineering graduates.

Parameters	Frequency	Percentage
Age	21 – 22 years old SD 0.924	
20 Years Old	11	4.2
21 Years Old	106	40.9
22 Years Old	104	40.2
23 Years Old	27	10.4
24 Years Old	4	1.5
25 Years Old	1	0.4
26 Years Old	1	0.4
27 Years Old	1	0.4
No Response	4	1.5
Sex		
Male	115	44.4
Female	144	55.6
Academic Honors or Distinctions		
With Academic Distinction	57	22.0
Without Academic Distinction	202	78.0
Year Level of Industry Immersion		
Second Year	3	1.2
Third Year	8	3.1
Fourth Year	163	62.9
Fifth Year	43	16.6
After Graduation	4	1.5
No Immersion	38	14.7
Number of Hours Rendered for Industry Immersion		
Less than 240 hours	46	17.8
More than or equal to 240 hours	173	66.8
No Response	40	15.4
Industry Immersion Specialization		
Food and Drug Manufacturing	82	31.4
Petrochemical Engineering	36	13.8
Paints and Coating Technology	19	7.3
Packaging Technologies	12	4.6
Energy Engineering	32	12.3
Semiconductor Technology	4	1.5
Environmental Management	57	21.8
Biotechnology	5	1.9
Entrepreneurship	3	1.1
Others	11	4.2

Academic honors or distinctions

Only (22%) of the graduates finished the chemical engineering program with academic distinctions. The qualifications for the academic distinctions may differ according to the different requirements, policies, and guidelines by the academic institutions.

Year of level of industry immersion

From the total graduate respondents, majority completed their respective industry immersions during their fourth year. The industry immersion was not mandatory in the CHEd Memorandum Order (CMO). The academic institutions were given the prerogative to incorporate the industry immersion in their respective curriculum.

It was noted from the results of this study that some respondents had multiple answers in the year level of industry immersion and in the industry immersion specialization. This was due to some of the institutions distribute the number of hours rendered for industry immersion per year level to touch-base various industries, as much as possible.

Number of hours rendered for industry immersion

As the industry immersion had not been required under the CMO 23 governing the respondents, there were no specific regulations on its implementation; hence, there was also no specific guideline as to the number of hours it needs to be taken and completed similar to the year level. Despite of this, majority still rendered their industry immersions in greater than or equal to 240 hours as referred to the declared total number of hours per new curriculum under CMO 91.

Industry immersion specialization

The top field of specialization for the graduate respondents was the Food and Drug Manufacturing. This is aligned with the article of Bellen (2017) on the Philippine chemical industry from which it was declared that the food manufacturing is still the largest manufacturing subsector in the Philippines as food, beverage and drug are the major commodities providing the basic needs of the society. With these premises, there are a lot of opportunities for the students to conduct their industry immersions (Bellen, 2017).

The school factors

The reliability of the school factors as perceived by the graduates are described in terms of administration, faculty, library and other learning resources, and laboratory equipment and resources. These school factors are mentioned and further structuralized in CMO 23 and CMO 91, respectively.

Table 2 shows that graduates agreed that the faculty members were competent and qualified to teach the subjects per the chemical engineering. This could be attributed to the governing standards in terms of the qualifications and competencies of the faculty members as prescribed and regulated by CHEd, Philippine Professional Regulation Commission (PRC), and the Republic Act (RA) 9297 also known as the Chemical Engineering Law.

Table 2. The school factors as perceived by the graduates.

	Item	M	SD	VD
1.	The administration in my academic institution provides academic governance and leadership to engineering programs by exerting efforts to achieve program educational objectives and program outcomes.	4.00	0.88	Agree
2.	The faculty members in my academic institution are competent and qualified to teach the subjects per the chemical engineering program set by CHEd and the Professional Regulations Commission.	4.08	0.86	Agree
3.	The library and other learning resources in my academic institution are enough to attain the learning outcomes of my program.	3.83	1.21	Agree
4.	The laboratory equipment and resources in my academic institution are enough for me to have hands-on experiences to attain the learning outcomes of my program.	4.06	0.66	Agree
	Pooled mean	3.99		Agree

Legend: 1.00 – 1.79 = Strongly Disagree; 3.40 – 4.19 = Agree; 1.80 – 2.59; = Disagree; 4.20 – 5.00 = Strongly Agree; 2.60 – 3.39 = neither Agree nor Disagree.

In the study of Lebcir, Wells and Bond (2008) on factors affecting the performance of the international students in universities in UK of project management, one of the categories considered affecting the performance of the students was the teaching style, language, communication, and assessment method of faculty members. However, in this study, the factors that led to the competencies and qualifications of the faculty members in teaching the professional chemical engineering courses were not quantified as it was not enumerated in the CMO references.

On the other hand, it was noted that the respondents agreed that the laboratory equipment and resources in their academic institutions were enough to have hands-on experiences to attain the learning outcomes of the program as shown in the mean value of 4.06. Laboratory works are essential to provide venue to demonstrate the application of the theories learned during classroom discussions to actual scenarios.

In the study of Ragusa and Ted Lee (2016) which focused on the chemical engineering researches focusing on the laboratory experiments concluded that having experiments helped the students better understand the theories and principles of the subject matter. This resulted to an increased learning and understanding of the students in the course content resulting in statistically significant increase of chemical engineering efficacy.

Consecutively, with the response under the school administration (average response = 4.00), it means that the graduates experienced the right administration as demonstrated by the right governance and leadership of the dean and the department or program chair.

The respondents also agreed that the library and other learning resources in their academic institution were enough to attain the learning outcomes of the chemical engineering program with mean perception of 3.00. The result for this school factor is already expected as nowadays, the references and other learning resources are available anytime and anywhere due to the existence of internet. With this technology, the students tend to browse the internet and search the needed information straight from their digital devices.

Level of preparedness as perceived by the chemical engineering graduates and chemical engineering practitioners

Table 3 shows the level preparedness of the graduates as perceived by themselves and by the practitioners. These results showed that the graduates perceived (x = 4.08) that the learning attributes and skills of the chemical engineering program helped them in preparation for their practice in the industry. Likewise, the perception of the industry (x = 3.92) was that the content of the chemical engineering program contributed to the preparation of the newly-hired chemical engineers as they experienced themselves in their respective field of specialization.

Table 3. Level of Preparedness as perceived by the chemical engineering graduates and by the chemical engineering practitioners in terms of the knowledge attributes of the chemical engineering program.

	Item	Chemical Engineering Graduates			Chemical Engineering Practitioners			Mean Difference	
		M	SD	VD	M	SD	VD	T-test	Sig.
A.	Knowledge Attributes	4.08	0.86	A	3.92	1.98	A		
1.	I can identify, formulate, and solve complex engineering problems by applying the principles of engineering, science and mathematics.	4.05	0.67	A	3.91	1.01	A	1.143	0.254
2.	I understand my professional and ethical responsibility.	4.35	0.80	SA	4.03	0.88	A	2.272*	0.024
3.	I can recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	4.23	0.77	SA	3.88	0.86	A	2.608*	0.010
4.	I know and understand the engineering and management principles as a member and leader in a team, manage projects and in multidisciplinary environments.	4.12	0.75	A	4.15	0.87	A	-0.222	0.824
5.	I am specialized in at least one field of chemical engineering practice, and the ability to apply such knowledge to provide solutions to actual problems.	3.65	1.06	A	3.61	1.30	A	0.271	0.786

Legend: 1.00 – 1.79 = Strongly Disagree (SD); 3.40 – 4.19 = Agree (A); 1.80 – 2.59 = Disagree (D); 4.20 – 5.00 = Strongly Agree (SA); 2.60 – 3.39 = Neither Agree nor Disagree (N). * = significant ($p < 0.05$).

Knowledge attributes

The noted highest mean response of the graduates on the knowledge attributes of the chemical engineering program was on statement 2 (mean = 4.35). The respondents strongly agreed that they understood the professional and the ethical responsibility of being a chemical engineer.

Therefore, the graduate respondents strongly agreed that they can recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts. On the other hand, the lowest mean response was noted on statement 5 which pertained on the specialization to at least one field. However, it was still within the agreed mean range; thus, the graduates still agreed that that they were specialized in at least one field of chemical engineering practice.

In summary, the graduates agreed that the program contributed to their level of preparedness to practice the profession in the industry in terms of the knowledge attributes with a polled mean answer of 4.08. This attribute pertained to the 'technical know-how' focused on the student's understanding and familiarity in various fields like mathematics, science, impact of engineering solutions, management principles and specialized knowledge. Specifically, the graduates were mostly prepared in demonstrating the professional and ethical responsibilities of a chemical engineer.

The results were driven by the current ideal behaviors and thinking of the graduates as they were still highly influenced by the different theories and principles learned from their respective academic institutions. In addition, one of the required subjects in the program is the Chemical Engineering Laws and Ethics, which details the roles and professional responsibilities as a chemical engineer. With these factors, the perception of the graduates in these statements were relatively higher than the other statements.

The same statements pertaining to the knowledge attributes of the chemical engineering program were asked to the chemical engineering practitioners. About (28%) of the respondents representing the industry has been practicing for more than 20 years in the industry. Majority of the practitioner respondents were mixed given the different distribution in terms of the number of years rendered in practicing the profession.

Considering the industry's perception on the contribution of the knowledge attributes of the chemical engineering program in the level of preparedness of the newly-hired chemical engineers, the highest mean noted was on statement 4 with mean response of 4.15. This implies that the practitioners in the industry agreed that the newly-hired graduates knew and understood the engineering and management principles as a member and leader of a team, manage projects and in multidisciplinary environments.

With the above industry perception, the practitioners perceived that the newly-hired chemical engineers were all knowing of the principles, theories, ethical and professional responsibilities, and engineering management. This could be attributed to the structure and composition of the chemical engineering program regarding the subjects that promotes the knowledge attributes such as the technical courses, basic engineering sciences and the allied courses with a total of 165 minimum credit units.

With a significant value of 0.024 and a positive mean difference of 0.325 for statements 2 and 3, it was noted that the graduates perceived that they can confidently understand their professional and ethical responsibility after taking the chemical engineering program. However, the practitioners perceived otherwise based on their experiences with the newly-hired chemical engineers.

The results on the gaps on the perception of the graduates and the practitioners pertaining to the knowledge attributes of the program were similar to the results of the studies of Symaco and Tee (2019) and Király and Géring (2019) which focused on technical skills and promotion of core activities such as research and learning, ethics, fairness and community development. From these researches, the proponents identified that one of the constraints in delivering the needs and expectations of the industry among the higher education institutions is to have a solid foundation of the program. In addition, in the study of Gomes et al. (2006) conducted in the School of Chemical and Biomolecular Engineering of the University of Sydney, the proponent identified that there should be a developmental roadmap included in the program to promote technical skills to meet the technical needs of the stakeholders in the industry.

Design attributes

In terms of the perception of the graduates on the contribution of the design attributes of the chemical engineering program on the level of preparedness, the mean response for the three questions resulted to 4.07. As this attribute centers on the on the student's design and analytical skills in creating experiments, systems, processes and solution in accordance with realistic constraints and standards; the graduates agreed accordingly that this attribute contributed generally in their level of preparedness. Similar response was noted from the part of the practitioners with a mean response of 3.91 corresponding to agreed verbal description, as presented in Table 4.

Table 4. Level of Preparedness as perceived by the chemical engineering graduates and by the chemical engineering practitioners in terms of the design attributes of the chemical engineering program.

Item		Chemical Engineering Graduates			Chemical Engineering Practitioners			Mean Difference	
		M	SD	VD	M	SD	VD	T-test	Sig.
B.	Design Attributes	4.07	0.87	A	3.91	1.98	A		
6.	I can develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions.	4.07	0.77	A	4.18	0.68	A	-0.900	0.369
7.	I can apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	3.94	0.78	A	3.33	1.55	N	2.191*	0.035
8.	I can identify, formulate, and solve engineering problems.	4.20	0.65	SA	4.21	0.70	SA	-0.133	0.895

Legend: 1.00 – 1.79 = Strongly Disagree (SD); 3.40 – 4.19= Agree (A); 1.80 – 2.59 = Disagree (D); 4.20 – 5.00 = Strongly Agree (SA); 2.60 – 3.39 = Neither Agree nor Disagree (N). * = significant ($p < 0.05$).

Statement 8 referred to the technical ability of the graduates to solve and formulate engineering problems which was the highest-ranking statement for both respondents as earlier discussed. This could be related to the number of units and subjects required by the program that hones student's capability of solving and formulating engineering problems. Specifically, a total of 142 minimum numbers of hours per week out of the 181 required total minimum numbers of hours per week was intended for the technical courses which include Mathematics, Natural/Physical Sciences, Basic Engineering Sciences, Allied Courses, and Professional Courses (Chemical Engineering). Approximately (78%) of the total time was intended on solving and formulating engineering solutions.

Despite the total number of hours rendered for the theories, principles and basics of the core of the chemical engineering program, the least ranking response for both respondents was focused on the application of these theories and principles in actual situation through the laboratory works. This was evident in the minimum number of hours per week on the laboratory works which was accounted to 63 hours excluding the number of hours for industry immersion. In addition, the minimum number of hours per week required for the laboratory works also included the computational laboratory which is being rendered to solve problem sets.

With a significant difference value of 0.035, it was identified that there was a significant gap on the response of the graduates and practitioners on statement 7. This significant gap on the design attribute is likewise identified by Király and Géring (2019) and Schweisfurth, Davies, Symaco and Valiente (2018). These researches pointed out that students were expected to have the capacity to provide solutions in general concepts and relationships, and to further comprehend, for instance the idea of public goods, outside single or group interests which are one of the expectations of the industry.

The proponents also identified the gap as one of the drivers towards evaluating the necessary amendments on the curriculum to promote its main thrust in sharing the society and environment. In addition, in the study of Samal and Bharati (2019) on the gaps in the engineering education in nanotechnology sector in India, it was identified that one of the weak points of the Indian engineering schools was the design competencies.

Professional attributes

Both group of respondents agreed that the chemical engineering program helped the graduates to focus on professionalism, ethics and communication skills that would meet the needs for engaging in life-long learning and for using advanced engineering tools. The top two ranking statements were the same for both the graduates and the practitioners which were statements 9 and 11 with mean responses of 4.23 and 4.22 from the graduates and 4.39 and 4.28 from the industry, respectively as shown in Table 5.

Table 5. Level of Preparedness as perceived by the chemical engineering graduates and by the chemical engineering practitioners in terms of the professional attributes of the chemical engineering program.

	Item	Chemical Engineering Graduates			Chemical Engineering Practitioners			Mean Difference	
		M	SD	VD	M	SD	VD	T-test	Sig.
C.	Professional Attributes	4.15	0.86	A	4.08	2.02	A		
9.	I can function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals and meet objectives.	4.23	0.95	SA	4.39	0.56	SA	-1.036	0.301
10.	I can communicate effectively with a range of audiences.	4.03	0.85	A	4.15	0.76	A	-0.743	0.458
11.	I can acquire and apply new knowledge as needed, using appropriate learning strategies.	4.22	0.63	SA	4.28	0.77	SA	-0.496	0.620
12.	I know and have concern for contemporary local and global issues.	4.19	0.98	A	3.73	0.84	A	2.515*	0.012
13.	I can use techniques, skills, and modern engineering tools necessary for engineering practice.	4.07	0.83	A	3.85	1.00	A	1.359	0.175

Legend: 1.00 – 1.79 = Strongly Disagree (SD); 3.40 – 4.19= Agree (A); 1.80 – 2.59 = Disagree (D); 4.20 – 5.00 = Strongly Agree (SA); 2.60 – 3.39 = Neither Agree nor Disagree (N). * = significant ($p < 0.05$).

The results could be attributed to the total minimum number of hours per week on the non-technical courses, accounted to 39 hours out of the total minimum number of hours of 181 hours. As an engineer, it is necessary to know and to be concerned on the arising issues and problem of the society that calls for the engineers to provide solutions. Through these subjects, the students were exposed to these fundamentals that can further inspire them through practicing their profession. Moreover, other schools, colleges and universities still add or include other subjects that can be under the professional attributes such as elective courses which are focused on the latest trends.

The lowest scoring statement for the professional attributes as perceived by the graduates was statement 10 (mean = 4.03). Although with the lowest response, the graduates still agreed that they can communicate effectively with a range of audiences. This could be attributed to the low confidence and self-esteem of the graduates as the program did not provide much weight on oral communication which was intended only for one subject with 3 credit units. In addition, it could also be attributed to poor socialization due to the influence of technology such as social media.

On the other hand, the lowest scoring statement for the industry was on statement 12 (mean = 3.73). Therefore, the practitioners still agreed that the newly-hired chemical engineers know and have concern for contemporary local and global issues. This could be further attributed to the limited exposure or experiences in the actual issues on real scenarios of the graduates which was similar to the results of the lowest scoring statement on knowledge and design which were on specialization and actual applications of the theories and principles of the program.

With a significant value of 0.012 and a positive mean difference of 0.452; it was then identified that there was a significant difference between the perception of the graduates on their ability to know and have concern for contemporary local and global issues as compared to the perception of the practitioners which were similar to the studies of Byrne’s (2006), Glassey, Novakovic and Parr (2013) and Bussemaker, Trokanas, and Cecelja (2017) which focused on the importance of the chemical engineering education to help the graduates to be effective engineers with the right professional skills needed by the professional institutions, government offices and other employees globally. These studies focused on the importance of the chemical engineering education to help the graduates to be effective engineers with the right professional skills needed by the professional institutions, government offices and other employees globally. More so, it was identified in the study of Yong and Ashman (2019) that the Australian employers were dissatisfied in the communication skills on the chemical engineering curriculum of The University of Adelaide. However, there was no significant difference identified regarding the level of preparedness to communicate effectively in this study.

Soft skills (Teamwork-related skills, leadership skills, and interpersonal skills)

Three soft skills as contributed by the chemical engineering program were likewise considered in knowing the level of preparedness of the graduates as perceived by themselves and by the industry which were teamwork skills, leadership, and interpersonal skills. The mean answer of the graduates under the teamwork-related skill was 4.04 with 3.83 mean answer from the industry, as shown in Table 6.

Table 6. Level of Preparedness as perceived by the chemical engineering graduates and by the chemical engineering practitioners in terms of the soft skill attributes of the chemical engineering program.

	Item	Chemical Engineering Graduates			Chemical Engineering Practitioners			Mean Difference	
		M	SD	VD	M	SD	VD	T-test	Sig.
D.	Teamwork Skills	4.04	0.87	A	3.83	1.96	A		
14.	I can recognize the difference between groups and teams and understand when will each is more appropriate.	4.05	1.01	A	3.94	1.09	A	0.570	0.559
15.	I can understand and manage and mediate conflicts in a team.	4.02	0.83	A	3.73	0.80	A	1.923	0.056
E.	Leadership Skills	3.95	0.88	A	3.63	1.90	A		
16.	I can obtain organizational outcomes through effective goal setting, delegation, problem solving and decision making.	4.14	0.70	A	3.88	0.89	A	1.946	0.053
17.	I can develop strategic plans with relevant people to achieve goals.	4.12	0.71	A	3.91	0.84	A	1.599	0.111
18.	I can recruit, hire and train people to represent the company.	3.58	1.12	A	3.09	1.53	N	1.886	0.067
F.	Interpersonal Skills	4.13	0.89	A	4.09	2.02	A		
19.	I can demonstrate respect for others' viewpoints and can exhibit calm behaviors in situation of conflicts.	4.19	0.94	A	4.27	0.52	SA	-0.480	0.631
20.	I can give critical feedback effectively; conversely receive and reflect on critical feedback from others.	4.07	0.83	A	3.91	0.88	A	1.049	0.295

Legend: 1.00 – 1.79 = Strongly Disagree (SD); 3.40 – 4.19= Agree (A); 1.80 – 2.59 = Disagree (D); 4.20 – 5.00 = Strongly Agree (SA); 2.60 – 3.39 = Neither Agree nor Disagree (N). * = significant ($p < 0.05$).

On the other hand, the mean response of the graduates and the industry on the leadership skills were 3.95 and 3.63; thus, the graduates and the industry perceived that the chemical engineering program developed their leadership skills which they can use when they start building their careers in their chosen industries. Lastly, the average response of the graduates and the practitioners on the interpersonal skills were noted to be 4.13 and 4.09, respectively. Therefore, both group of respondents perceived that the graduates were prepared in demonstrating the interpersonal skills after completing the chemical engineering program. The highest mean response of the graduates was similar to the practitioners with mean values of 4.19 and 3.27, respectively pertaining to statement 19 under the interpersonal skills. The graduates and the practitioners agreed that that they can demonstrate respect for others' viewpoints and can exhibit calm behaviors in situation of conflicts. Conversely, the graduates agreed that they can recruit, hire, and train people to represent the company; while the practitioners neither agreed nor disagreed in the statement. Basically, it is understandable that newly-hired chemical engineers are not yet qualified to recruit, hire, and train people. This trait and responsibility though are given to the first-line to top-line managers which is part of the legitimate and expert power of a manager.

These soft skills were asked in this study as these skills were not specifically addressed or linked in the learning attributes. Communication skills; however, were specifically identified and established under the professional attributes. Although these skills were not specifically listed or enumerated in one of the learning attributes, these were still associated, demonstrated, and exercised in the laboratory works and other activities as executed in the delivery of the subjects. Depending on the academic institution and teaching methods, various learning activities as part of the requirements can be given to the students such as group works and group activities. These kinds of arrangement and activities are prominent in subjects like Equipment Design, Plant Design, and Research/Thesis in the chemical engineering program. Specifically, students are grouped and requested to work as a team and to come-up with one desired output as a group. With the students working in groups and as a team, it further enhances and develops the teamwork skills, leadership as someone needs to lead the group, group management and interpersonal relations with other groupmates. These could then be attributed to the earlier results on the highest mean response both for the graduates and practitioners.

Teamwork, leadership, and interpersonal skills were considered as the soft skills that need to be developed and enhanced in implementing the chemical engineering and the engineering program holistically. These skills were identified specifically in the studies of Byrne (2006) and Yong and Ashman (2019). The proponents identified that the graduates nowadays are constrained not just with the technical skills but also with the wide range of soft skills such as teamwork, leadership skills, and knowledge or expertise in management, humanities, and even in law. Conversely, given the results of this research on the chemical engineering program as rendered in the Philippines, there were no significant gaps identified. The perceptions of the graduates were aligned with the practitioners on the level of preparedness on teamwork, leadership and interpersonal skills.

Level of preparedness of the chemical engineering graduates based on socio-demographic and school factors

Socio-demographic profile

The socio-demographic characteristic results of the graduates were then compared with the level of preparedness. The t-test was simulated for the sex, academic distinction, number of hours rendered for immersion; while, the Analysis of Variance (ANOVA) was used for the age and the year level the industry immersion was taken. The results are shown in Table 7.

Table 7. Difference of the means on the level of preparedness of the chemical engineering graduates as perceived by themselves in terms of the socio-demographic characteristics.

Parameters	T-test				
	t	df	Sig.	MD	SED
Sex	0.157	217.367	0.875	0.010	0.062
Academic Distinction	0.173	91.654	0.863	0.124	0.071
Number of Hours Rendered for Industry Immersion	1.805	74.225	0.075	0.134	0.074
	ANOVA				
	SS	df	MS	F	Sig.
Age					
Between Groups	2.352	7	0.336	1.458	0.183
Within Groups	56.930	247	0.230		
Total	59.282	254			
Year Level of Industry Immersion					
Between Groups	3.983	5	0.797	3.609**	0.004
Within Groups	55.846	253	0.221		
Total	59.830	258			
Industry Immersion Specialization					
Between Groups	4.857	10	0.486	2.183*	0.019
Within Groups	54.957	247	0.222		
Total	59.814	257			

Legend: ** = highly significant ($p < 0.01$); * = significant ($p < 0.05$).

There were no significant differences noted from the results of the t-test in terms of sex, academic distinction and the number of hours rendered for the industry immersion with significant values of 0.876, 0.863, and 0.075, respectively at (95%) level of confidence. On the other hand, considering the results from the ANOVA simulation of the age, the year level the industry immersion was taken, and the industry immersion specialization; only the year level of the industry immersion and the industry immersion specialization was observed to be highly correlated and correlated with the level of preparedness of the graduates with significant value of 0.004 and 0.19, respectively.

Specifically, the graduates who took the industry immersion on their third-year and the fourth-year levels were perceived to be highly prepared. In addition, those graduates who had industry immersion in the Food and Drug Manufacturing, Petrochemical and Paint industries were prepared as compared to those who did not take industry immersion.

It is then expected that the third year and the fourth-year levels resulted to a highly significant value. Considering the year level, the chemical engineering students on their third-year and fourth-year have already been exposed to the major subjects particularly on the chemical engineering core subjects which can be applied and of relevance to the industry immersion. From the results of the socio-demographic characteristics of the graduates, the result was aligned having fourth-year as the top-ranking year level that the industry immersion was completed by (62.9%) of the respondents.

Furthermore, the results on the comparison of the level of preparedness of graduates based on the socio-demographic characteristics were similar to the results of the study of Rizvi, Rienties, and Khoja (2019). The research focused on the role of the demographics influencing the performance of the students in terms of region, index of multiple deprivation band, education, age, gender, and disability. The proponents of the study identified that the strong predictors to the performance of the students were the region, neighborhood poverty level and prior education. The age and sex were not identified as factors in influencing the performance of the students. These results were likewise similar to the study of Oyeyipo, Odeyinka, Owolabi, Afolabi, and Ojelabi (2018) that focused on the age differences between the engineering students' performances. On the other hand, Sathapornvajana and Watanapa (2012) considered gender as well in the study on student's intention in choosing their educational program. There were also no conclusive results that the age and sex were factors influencing the performances of the students.

School factors

The level of the preparedness of the graduates as perceived by them was compared with the perception on the school factors in terms of school administration, faculty members, library and other learning resources, and laboratory equipment and other resources.

It was then observed that the level of preparedness as perceived by the graduates themselves was correlated with laboratory equipment and other resources, school administration, and the faculty members. Specifically, the correlation between the level of preparedness of the graduates with the availability of the laboratory equipment and resources as well as the academic governance and leadership as executed by the school administration are significant at (99%) level of significance with Pearson correlation values of 0.224 and 0.177, respectively. On the other hand, the correlation between the level of the preparedness of the graduates with the competencies and qualification of the faculty members was significant at (95%) level of confidence with a Pearson correlation value of 0.137. Lastly, there was no significant correlation between the level of preparedness of the graduates with the availability of the library and other learning resources.

In summary, the results on the correlation between the school factors and the level of preparedness of the graduates were similar to the studies of Lebcir et al. (2008) and Ragusa and Ted Lee (2016). As earlier presented in the earlier discussions, both studies focused on the faculty members' method of teaching and style as one of the drivers in the level of preparedness of the students and the availability of the laboratory equipment specifically for the chemical engineering students as discussed in the two researches.

Attributes and skill areas of the chemical engineering program that need improvement

Both the graduates and the practitioners were asked of the areas that need to be improved on the chemical engineering program as shown in Table 8.

The top-ranking category with (21.08%) of the total valid responses of the graduates was on application of the chemical engineering principles, knowledge, and theories to actual scenarios. Specifically, the respondents raised that there should be more application of the theories and principles such as experimentations. Consecutively, majority of the graduates agreed that the program that they took was enough to give them the fundamental knowledge and the technical know-how; however, it was not focused on the applications of the theories. Furthermore, to focus on the advanced software applications which are widely used by the industry and to have more applications to local settings and problem solving focusing on innovation and real-life problems and develop more of effective experimentation works.

Table 8. Attributes and Skill Areas of the Chemical Engineering Program that Need Improvement.

Area/Category	Chemical Engineering Graduates Frequency	(%)	Chemical Engineering Practitioners Frequency	(%)
Chemical Engineering Applications	35	21.08	16	59.26
Industry Immersion	24	14.46	2	7.41
Facilities and Equipment	24	14.46	-	-
Experimentation Design, Tools and Laboratory	18	10.84	-	-
Curriculum	14	8.43	-	-
Faculty Members	13	7.83	-	-
School Administration	7	3.61	-	-
Field of Specialization	6	3.01	2	7.41
Health, Safety, Environment and Ethics	5	4.22	-	-
Others	20	12.05	7	25.93

The other two categories with the second highest ranking at (14.46%) was in the aspect of the industry immersion or the on-the-job training program and in facilities and equipment considered as a school factor. It was noted from the responses that majority suggested to have a longer number of hours in the industry immersion and to further provide more fields of specialization from which the students can conduct their immersions.

In addition to the industry immersion, another second ranking category was on improved facilities and equipment which is one of the school factors considered in this study. Most of the respondents answered that the facilities and equipment specifically with the laboratories need to be improved to have more effective hands-on learning experience. This was tantamount to the first rank leading towards applications and experimentations.

It is also noteworthy that (12.05%) of the graduates indicated miscellaneous areas or points. Some of these cited topics were on the uplifting of the reputation or image of the chemical engineering in the industry, revisiting the current Chemical Engineering law and other laws that governs the practice of the profession, requiring continuing professional development and many more.

On the other hand, the results for the areas that need improvement as commented by the practitioners were observed to be similar with the graduates. The top-ranking category for the industry was also on the application of the subject matters with (59.25%) respondents. Specifically, the industry pointed out that there should have more application with the common software that are being used in the industry such as on design applications, process control, and automation. The second top-ranking area for the industry was with the miscellaneous comments with (25.95%) of the total comments. Most of these were on having electives focused on management systems, financial management, active and social learning instead of passive learning and many more.

The third top-ranking area for the practitioners that needs to be improved was on the exposure to industry which is tantamount to industry immersion. This was likewise similar to the second top-ranking area for the graduates, with (7.41%) from the total respondents. The industry specifically suggested that there should be more exposure time for the students in the industry to be acquainted with the new technologies such as renewable energy, utilization of the new machineries and the like. This can also further develop the soft skills of the students such as communication skills, technical presentation skills and interpersonal skills.

Final considerations

The significant gaps identified on the knowledge attributes of the chemical engineering program were related towards ethical and professional responsibilities of a chemical engineer with self-discernment on the impact of providing solutions to the community and environment. In terms of the design attributes of the chemical engineering program, there was a significant difference between the perception of the graduates and the practitioners regarding the application of engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. In addition, it was then identified that there was a significant difference between the perception of the graduates on their ability to know and have concern for contemporary local and global issues as compared to the perception of the practitioners. On the other hand, there were no significant difference noted between the perception of the graduates and the industry in terms of the teamwork-related, leadership, and interpersonal skills.

There were significant differences between the level of preparedness of the graduates with the year level the industry immersion was rendered and the industry immersion specialization. On the other hand, there were no significant differences observed on the level of preparedness of the graduates in terms of age, sex, academic honors or distinctions, and the number of hours rendered for industry immersion. In addition, the availability of the laboratory equipment and resources, strong governance and leadership of the administration, and the competencies and qualifications of the faculty members were found to be correlated with the level of preparedness as perceived by the graduates themselves. Conversely, the availability of the library had no significant relationship with the overall preparedness of the graduates.

The area that needs to be improved were the same for both the graduates and the practitioners which is more on the application of the subject matters such as the common software that are being used in the industry, design applications, process control, and automation.

It is then recommended that there should be improvement and more enforcement on some areas of the knowledge, design and professional attributes of the chemical engineering program to mitigate the significant gaps between the perception of the graduates and in the industry. Specifically, to focus more on the understanding of the professional and ethical responsibility after taking the chemical engineering program; application of the engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors; and knowing the contemporary local and global issues.

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