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Lifelong learning competencies among chemical engineering students at Monash University Malaysia during the COVID-19 pandemic

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ABSTRACT

The importance of lifelong learning is an indisputable fact both for the development of a knowledge society and for personal development. It is essential and has been regarded as a learning outcome in engineering courses. The advent of the COVID-19 pandemic has resulted in a massive shift in the higher education landscape. The migration to online learning poses questions on whether students can cope with the sudden transition in learning from the perspective of lifelong learning skills. Hence, this study aimed to investigate the characteristics of lifelong learning competencies and factors affecting lifelong learning among chemical engineering students at Monash University Malaysia during the COVID-19 pandemic. A mixed-methods study (questionnaires and interviews) was conducted to address the research questions. Forty-two percent of the students completed the questionnaires voluntarily. Among these, six students were randomly selected for the interviews. The questionnaires of the lifelong learning scale and factor scale were adopted from the existing literature. Statistical analyses (ANOVA, t-test, and multiple linear regression) were used to analyse the differences based on gender and level of study and the correlation between the two scales. Thematic analysis was employed to analyse the interview scripts and support the quantitative analysis. The results showed that awareness, gender, and level of study do not affect lifelong learning competencies. Factors such as curiosity and openness to learning have affected the chemical engineering students’ lifelong learning competencies during the pandemic. Higher education should undertake to elicit curiosity and openness to learning among students to increase their propensity for lifelong learning.

1. Introduction

Lifelong learning is defined as intentional learning to enhance the quality of life. Learners are responsible for their learning (Dunlap and Grabinger, 2003). It originated from the term ‘l’education permanente’, coined by Faure (1972). The direct translation of this term is, ‘continuing to learn from cradle to grave’. The Faure Report describes lifelong education as ‘a master concept for educational policies in the years to come for both developed and developing countries’ (Friessen and Anderson, 2004). The UNESCO Institute for Lifelong Learning (UIL) (2020) embraces the notion of this attribute as a goal for education worldwide, with a focus on adult learning, continuing education, literacy, and non-formal basic education. It is a source for opening lifelong educational opportunities and the realisation of human potential, human rights, and democratic ideals. Competence-based education is an environment that allows learners to utilise knowledge from the transferred knowledge backed by reflective practice and go beyond it (Sloep et al., 2011). Competencies refer to domain-specific knowledge that is applicable in the present and future. What and how one learns should depend on the requirement of practice, not on sound principles. This type of learning is often known as learning to practice, situated learning, or tacit knowing (Le Deist and Winterton, 2005).

There are two types of competencies. First, Specific Competencies include the technical knowledge of a specific field such as Engineering, Medicine, etc. The second type of competency is Key Competencies. A key competency is a generic type of competency that is shared among all professionals. It includes the ability to communicate, teamwork skill, and even technology savvy. Technical knowledge is changing relentlessly. Therefore, there is a need to keep up with the changes. The Organisation for Economic Cooperation and Development (OECD), classify key competencies into three broad categories (Rychen and Salganik, 2003):

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1. Individual Competencies – to be able to manoeuvre with the environment (socio-cultural aspects such as the use of language and physical aspects such as information technology).
2. Relational Competencies – to be able to engage with others and interact in heterogeneous groups.
3. Autonomous Competencies – to responsibly manage one’s own life in the broader social context.

These are identified as critical competencies that are related to lifelong learning competencies. An individual needs to be capable of thinking and acting reflectively, which is vital to this framework. Reflective thinking and acting does not only apply to formulas or solving issues but also to facing changes, learning from failure, and thinking and acting accordingly (Rychen, 2003).

Continuing education, professional development, and lifelong learning all have the same meaning. These terms refer to an educational, development, and training cycle as the source of organisational success (Laal et al., 2014). Lifelong learning is the capability to be flexible to overcome an uncertain situation. Lifelong learning should include all formal, informal, and non-formal learning, regardless of whether it is intentional or unintentional (Candy et al., 1994).

Lifelong learning should encompass the following (Knapper and Cropley, 2000):

1. Last for an entire lifetime for every individual;
2. Lead to a structured acquisition, continuation, enhancement, or completion of knowledge, skills, and attitudes;
3. Foster its existence on people’s ability and motivation to learn;
4. Depend on all accessible educational influences on contribution including formal, non-formal, and informal.

It should be noted that learning is imperative in the education process, although it is not the same as education. It is also a danger to interpret lifelong learning as just a mastery of specific knowledge or skills. This hidden danger is further amplified by economic or technological forces, believing in the policies for lifelong learning and measurements, and the judgement of educational achievement as an easy way out for quantitative measurement (Kearns, 1999).

Career fields such as law, medicine, and engineering are complex domains, together with the advancing of technology and information; thus, it is innate for people to develop continuous learning. Both working and learning have become an inseparable activity (Dunlap and Grabinger, 2003). Engineering is a field that is indispensable in meeting the demands of people, economic development, and providing services to society at large. Engineering uses mathematical knowledge, natural science, fundamental knowledge of engineering, and modern technology and techniques, making it an application for solving problems (International Engineering Alliance (IEA), 2013). Continuous professional development is vital in the engineering context (Guest, 2006). It ensures continued professional development, skill upgrade due to the rapid technological development and socio-economic transformations (Volkova, 2019), maintaining highly comparative employability, and a respected occupation (De Castro et al., 2017). Thus, lifelong learning is inevitable for engineers as the field is complex and evolves with the rapid changes in technology. It is recommended that pursuing lifelong learning should start as early as one’s starts a career. It serves as a guide to achieving personal goals and career. The processes are as follows (Martínez-Mediano and Lord, 2012):

1. Gauging one’s knowledge, skills, and social network based on the requirement of the job.
2. Identifying one’s vital role as an engineer during the initial period of a professional career.
3. Developing a checklist of learning material/task relevant to one’s professional career with achievable time goals.
4. Monitoring the progress of one’s career development.
5. Staying updated and planning according to the key competencies of one’s professional career.

Engineers need to be able to think broadly and critically and to integrate methods regarding engineering. Apart from mastering the fundamental theory of engineering, engineers should be capable of adopting humanistic competencies. Employers also look for graduate engineers with excellent communication skills and mastery of soft skills (Basri, 2009). They need to be cooperative and collaborative in working on a project, which helps in professional development, improves the overall cohesion of the team, and contributes to solving problems, thus improving work quality (Martínez-Mediano and Lord, 2012).

Lifelong learning has been the centre of attention of governments, education providers, and administrators. Education accreditation bodies have included lifelong learning as part of the learning outcome. The European Higher Education Area (EHEA) emphasises that all graduates

![Fig. 1](image-url)  
**Fig. 1.** Details analysis on awareness of lifelong learning based on different gender.

| Gender | Total students | No. of respondents | Response rate (%) |
|--------|----------------|-------------------|------------------|
| Male   | 138            | 52                | 37.7             |
| Female | 121            | 57                | 47.1             |
| Level 2| 92             | 27                | 29.3             |
| Level 3| 95             | 32                | 33.6             |
| Level 4| 72             | 50                | 69.4             |

Table 1 Gender and level of study of the sample size.
must grow those learning skills that are essential for them to continue to undertake further studies with a high degree of autonomy (Martínez-Mediano and Lord, 2012). The Qualifications Framework in the EHEA emphasises that the aim is for graduates ‘to be able to identify their own training need in his/her study field and labour and professional’ (European Higher Education Area (EHEA), 2020). Besides, the Accreditation Board for Engineering and Technology (ABET) states that graduates should have a recognition of the need for, and the ability to engage in, lifelong learning (Accreditation Board for Engineering and Technology, Inc. (ABET), 2021). This statement also holds in one of the twelve graduate attribute profiles in the Washington Accord and Sydney Accord (International Engineering Alliance (IEA), 2013). Malaysia is also one of the countries that are intensely active in promoting lifelong learning. The Engineering Accreditation Council (EAC) in Malaysia adopts a set of graduate competency attributes that comply with the guidelines and policy of the Washington Accord. The EAC also emphasises the importance of lifelong learning for graduates (Engineering Accreditation Council (EAC), 2020). The Third Outline Perspective Plan of Malaysia stated that lifelong learning would become increasingly vital in the knowledge-based economy; where knowledge and skills need to stay updated and upgraded (Buntat et al., 2013).

The characteristics of lifelong learners have been extensively discussed in the literature and generally encapsulate two broad dimensions, namely (1) skills and abilities related to learning and (2) beliefs about learning and knowledge. Past research has mostly investigated ways in which the practice of life-long learning can be enhanced or practised more efficiently (Martínez-Mediano and Lord, 2012; Micieta et al., 2019) and focuses on the influential factors of student attributes on lifelong learning during normal learning (Castaneda & Cheng, 2019; Chen & Liu, 2019; Thongnak, 2021). Eschenbacher and Fleming (2020) present the challenges in lifelong learning and the relevance of transformative learning during the COVID-19 pandemic. Other studies mainly focus on the delivery of education, such as strategies to improve students’ learning experiences (Sutarto et al., 2020), supporting websites for teaching (Reimers et al., 2020), and virtual learning tools (Almarzooq et al., 2020).

Due to the COVID-19 pandemic, online teaching and learning has prompted technological developments in the education sector. Innovative practices and educational delivery to cope with the pandemic demands have increased. Mouzakis and Tuncay (2011) suggest that online learning has advantages over traditional classroom learning as it is learner-centred, can be conducted at any location, and is flexible. Nevertheless, some drawbacks of online learning have been reported, such as the creation of technophobia in learners, increased preparation time for learners, and lack of immediate feedback from learners. It is worth mentioning that online learning requires the ability of learners to access a relevant knowledge base to build on and to be motivated to learn through interaction, processing information, direct experience, and reflection (Collins, 2004).

Without a doubt, the willingness to learn and cope with the educational changes from face-to-face learning to online learning comes deep within an individual. Any efforts would be to no avail if the student does not choose to adopt these attributes. Openness to experience, change readiness, approaches to learning, self-efficacy, and beliefs have been found to significantly predict lifelong learning characteristics. Constructivism learning theory emphasises that learning is an activity that how individual learner perceive and their individual will, then further develop their own meaning of learning from the provided information (Bada and Olusegun, 2015). The principles of constructivism that are aligned to lifelong learning skills are increasingly influential in the online teaching and learning environment. Hence, the importance of lifelong learning should be further emphasised during the COVID-19 pandemic to overcome the challenges of online learning among students.

However, the authors have found no study related to the chemical engineering students’ lifelong learning competencies and factors affecting lifelong learning during the COVID-19 pandemic and online learning in the existing literature. Hence, this study aimed to examine chemical engineering students’ lifelong learning competencies and the crucial attributes that signify the tendency of lifelong learning during online learning due to the outbreak of COVID-19 pandemic. Apart from measuring the competencies of lifelong learning, underlying factors that influence lifelong learning characteristics among engineering students were also evaluated. The following research questions were considered:

1. What characteristics influence the competencies that chemical engineering students need for lifelong learning during online learning due to the COVID-19 pandemic?

Table 2

| Characteristics               | Survey statements | M   | SD  |
|-------------------------------|-------------------|-----|-----|
| Goal setting                  | A1. I prefer to have others plan my learning<sup>a</sup> | 2.88 | 1.08 |
|                               | A2. I seldom think about my own learning and how to improve it<sup>b</sup> | 2.68 | 1.23 |
|                               | A3. I feel I am a self-directed learner | 3.61 | 0.95 |
|                               | A4. I love learning for its own sake | 3.69 | 0.97 |
|                               | A5. When I learn something new, I try to focus on the details rather than on the "big picture" | 3.28 | 1.03 |
| Application of knowledge and skills | B1. I am able to impose meaning on what others see as disorder | 3.47 | 0.71 |
|                               | B2. I try to relate academic learning to practical issues | 3.89 | 0.87 |
|                               | B3. When I approach new material, I try to relate it to what I already know | 3.99 | 0.87 |
| Self-direction and evaluation | C1. I feel others are in a better position than I am to evaluate my success as a student<sup>a</sup> | 3.15 | 1.21 |
|                               | C2. It is my responsibility to make sense of what I learn at school | 4.11 | 0.79 |
| Locating information          | D1. I often find it difficult to locate information when I need it<sup>a</sup> | 2.82 | 1.06 |
| Adaptable learning strategies | E1. I prefer problems for which there is only one solution<sup>a</sup> | 2.78 | 1.17 |
|                               | E2. I can deal with the unexpected and solve problems as they arise | 3.40 | 0.78 |
|                               | E3. I feel comfortable under conditions of uncertainty<sup>a</sup> | 3.70 | 1.07 |

Notes: ‘M’ refers to the mean; ‘SD’ refers to standard deviation. <sup>a</sup> Represents statement with reverse coding.

<sup>b</sup> Indicates the statement is not rated.

<sup>c</sup> Represents the statement is reverse-coded.

<sup>d</sup> Indicates the statement is not rated.

<sup>e</sup> Represents the statement is reverse-coded.
2. What are the factors that influence lifelong characteristics among chemical engineering students during online learning due to the COVID-19 pandemic?

2. Methodology

2.1. Data collection and analysis

The emergency online learning method has been implemented in Malaysia’s higher learning institutions since the nationwide lockdown in March 2020. A cross-sectional study was completed in June 2020 immediately after three months of implementation of online learning. This study was conducted using a mixed-methods approach. The mixed-methods approach provides a distinct strength to widen the study to gain deeper insights (Creswell, 1999). The sample was drawn from chemical engineering students at Monash University Malaysia using stratified sampling. Different levels of study and the gender of chemical engineering students were considered in the sampling process, while race and ethnicity were not considered.

The survey sample consisted of 109 chemical engineering undergraduate students at Monash University Malaysia. An online Google form survey questionnaire was distributed to chemical engineering students in Level 2, Level 3, and Level 4 who were willing to participate voluntarily. Note that no students from Level 1 participated in this study because at Monash University Malaysia, the Level 1 engineering course is a general level where students do not specialise in any of the engineering branches. The characteristics of the students who participated are shown in Table 1. Gender and level of study were considered in the evaluation of the characteristics of lifelong learning to find out if there were any relationships.

The interview sample consisted of a random selection of six chemical engineering undergraduate students. Two students from Level 2, Level 3, and Level 4 each were randomly selected from the polls of students who had completed the Google form survey questionnaire. Random sampling method is adopted during the selection of students in the interview. The students were approached to get their agreement to take part in the interview voluntarily.

The purpose of the study was to identify which characteristics affect lifelong learning in chemical engineering students at Monash University Malaysia. The lifelong learning scale developed by Kirby et al. (2010) and Uzunboylu and Hürsen (2011) was used. In addition, the study also attempted to identify some of the underlying factors affecting the lifelong learning score using the ‘factors affecting lifelong learning scale’ developed by Poyraz and Bayrakci (2015) for online learning during the COVID-19 pandemic.

Fig. 2. Detailed analysis on characteristics of lifelong learning based on different gender.

Fig. 3. Detailed analysis on “Goal setting” characteristics of lifelong learning based on different levels of study of female and male students.
disagree and each item using a five-point Likert agreement scale (1 = strongly disagree and 5 = strongly agree). Thirty-four questions were distributed as follows:

1. The first question related to the awareness of lifelong learning in participants during online learning.

A quantitative study was conducted using a questionnaire covering the measurement of awareness, competencies, and factors affecting lifelong learning among chemical engineering students during online learning due to the COVID-19 pandemic. The questionnaire was developed on the Google Form platform. Participants were required to rate each item using a five-point Likert agreement scale (1 = strongly disagree and 5 = strongly agree). Thirty-four questions were distributed as follows:

1. The first question related to the awareness of lifelong learning in participants during online learning.

Table 3 Survey statements and descriptive statistics of factors influencing lifelong learning.

| Factors          | Survey statements                                                                 | M   | SD  |
|------------------|----------------------------------------------------------------------------------|-----|-----|
| Curiosity        | 1. I research what makes me curious                                             | 4.16| 0.85|
|                  | 2. I love learning especially when I want to learn                              | 4.31| 0.86|
|                  | 3. I am a curious person                                                         | 3.95| 0.86|
|                  | 4. I feel a necessity to learn about what makes me curious                        | 4.00| 0.84|
|                  | 5. I feel a need to question what makes me curious                                | 3.87| 0.97|
| Openness to learning | 6. I use different strategies while learning                                       | 3.53| 0.97|
|                  | 7. I change my strategy when I have difficulties                                  | 3.77| 0.94|
|                  | 8. I can find a way to learn regardless of the situation                          | 3.28| 1.07|
|                  | 9. I know how I can learn in the best way                                         | 3.52| 1.01|
| Access to information and information literacy | 10. I can find what I am looking for from different courses | 4.37| 0.65|
|                  | 11. I use different sources to reach information                                  | 4.34| 0.66|
|                  | 12. I can read graphics and schemes and comment on statistical data               | 3.81| 0.97|
|                  | 13. I can evaluate whether data are valid and reliable or not                     | 3.59| 0.80|
|                  | 14. I can use the data in different contexts and can show them with graphics or scheme | 3.70| 0.88|
| Engaging in self-direction and self-evaluation | 15. I don’t need help when I making a plan                                         | 3.03| 1.13|
|                  | 16. I am qualified enough to evaluate myself                                     | 3.06| 1.04|
|                  | 17. I have the ability to lead my own learning                                   | 3.72| 0.83|
|                  | 18. I am sufficient to direct myself                                             | 3.50| 0.88|
|                  | 19. I have skills to evaluate my own learning                                    | 3.36| 0.89|
|                  | 20. I have skills to arrange my own learning                                     | 3.73| 0.86|

Table 4 Gender differences in factors affecting lifelong learning scale.

| Factors                          | Gender   | M       | SD    | t     | df   | p    |
|----------------------------------|----------|---------|-------|-------|------|------|
| Curiosity                        | Male     | 20.67   | 3.59  | 1.12  | 107  | 0.266|
|                                  | Female   | 19.95   | 3.18  |       |      |      |
| Openness to learning             | Male     | 14.44   | 2.83  | 1.21  | 107  | 0.230|
|                                  | Female   | 13.79   | 2.81  |       |      |      |
| Access to information literacy    | Male     | 20.04   | 2.48  | 0.85  | 107  | 0.396|
|                                  | Female   | 19.58   | 3.08  |       |      |      |
| Engaging in self-direction and self-evaluation | Male     | 20.33   | 4.11  | -0.18 | 107  | 0.859|
|                                  | Female   | 20.47   | 4.44  |       |      |      |

Table 5 ANOVA results on different levels of study.

| Factors                  | Sum of Squares | df | M   | F   | p  |
|--------------------------|----------------|----|-----|-----|----|
| Curiosity                | Between Groups | 61.27| 2  | 30.63 | 2.76 | 0.068 |
|                          | Within Groups  | 1177.34| 106| 11.11 |     |      |
| Openness to learning     | Between Groups | 28.43| 2  | 14.21 | 1.80 | 0.170 |
|                          | Within Groups  | 835.46| 106| 7.88  |     |      |
| Access to information literacy | Between Groups | 29.63| 2  | 14.81 | 1.91 | 0.153 |
|                          | Within Groups  | 821.93| 106| 7.75  |     |      |
| Engaging in self-direction and self-evaluation | Between Groups | 36.18| 2  | 18.09 | 0.99 | 0.374 |
|                          | Within Groups  | 1930.06| 106| 18.21 |     |      |

Table 6 Multiple linear regression analysis to predict lifelong learning scores from multiple factors.

| Independent variables | Standardised coefficient | p   |
|-----------------------|--------------------------|-----|
| Curiosity             | 0.42                     | < 0.001|
| Openness to learning  | 0.21                     | 0.033|
| Access to information literacy | 0.14 | 0.118|
| Engage in self-direction and self-evaluation | 0.10 | 0.304|

Notes: $R^2 = 0.43$; Constant = 4.67.

2. The questionnaire was then followed by 14 questions extracted from the lifelong learning questionnaire developed by Kirby et al. (2010) and Uzunboylu and Hülsen (2011). The survey questions were based on the five characteristics of lifelong learning, namely:

i. goal setting.
ii. application of knowledge and skills.
iii. self-direction and self-evaluation.
iv. locating information.
v. adaptable learning strategies.

3. The remaining 20 questions were developed by Poyraz and Bayrakci (2015). They include the understanding of four factors that affect lifelong learning, namely ‘curiosity’, ‘openness to learning’, ‘access to information and information literacy’, and ‘engaging in self-direction and self-evaluation’ among students during online learning.

Next, the qualitative part of the study was carried out using a semi-structured interview via an online platform called Zoom Video (2020). Participants were asked about their understanding of lifelong learning from a set of questions. The entire session of each interview was recorded. The saturation of data based on respondents’ feedback was observed at the end of the interview, which validated the sufficiency of the number of respondents.

2.3. Methodology limitation/assumption

The data collection and analysis did not take into consideration the respondents’ pre-COVID-19 pandemic data. This study solely relied on lifelong learning competencies and characteristics affecting the students during the pandemic and online learning. A significance level of 0.05 threshold is used throughout all the statistical testing methods and analysis of the data. The qualitative analysis was done based on random
selection and on a voluntary basis, which may cause the results to be biased towards the hypothesis. The authors do not take into consideration of bias towards untruthful responses by the respondents as considering this was a voluntary survey.

2.4. Ethical consideration

Respondents were informed that participation was voluntary. Formal ethical approval was obtained from the Monash University Human Research Ethics Committee (MUHREC). All the respondents’ information was kept anonymous.

3. Results and discussion

The overall result of the awareness of the lifelong learning of the chemical engineering undergraduate students yielded a mean of 3.93, and the standard deviation was 0.91. This indicates a relatively high awareness among students regarding lifelong learning during online learning in this COVID-19 pandemic. Fig. 1 shows the distribution of the details analysis of students’ perception of their lifelong learning competencies during the online learning. When comparing female and male student awareness toward lifelong learning at different level of study, results indicate female have lacking of awareness of lifelong learning than male students through Level 2 and 3, but higher awareness than male students in Level 4. A two-tailed t-test between male and female students shows that males and females exhibit the same mean score for lifelong learning awareness (t = 0.42, df = 107, p = 0.67).

Further scrutiny was done using Spearman’s rho correlation to identify the correlation between awareness of lifelong learning and the lifelong learning score (Table 2). The survey questionnaire consisted of reverse coding. This was done to ensure the consistency of answers from respondents. Thus, the scores for the lifelong learning scales were added together to give a lifelong learning score for each participant. The lifelong learning scores were used throughout the analysis. There was a positive relationship between student’s awareness of lifelong learning and lifelong learning score, which was statistically significant (r = 0.25, p = 0.009). This suggests that awareness of lifelong learning is correlated with students’ lifelong learning scores. However, this r value shows a weak correlation (Akoglu, 2018). Students who showed high awareness of lifelong learning may not necessarily have the characteristics of a lifelong learner. This was observed during the interview when one of the Level 4 students responded, ‘Well lost, very lost; obviously, it is scary...’ when explaining the ability to handle a final-year research project during the online learning.

A descriptive statistic for the characteristics of lifelong learning was recorded in Table 2. The means of the first 14 questions ranged from 2.68 to 4.11 on a five-point Likert scale. The standard deviations ranged from 0.71 to 1.23. The internal consistency of the 14 questions, which was tested using Cronbach’s alpha, was 0.67. The survey questionnaire consisted of reverse coding. This was done to ensure the consistency of answers from respondents. Thus, the scores for the lifelong learning scales were added together to give a lifelong learning score for each participant. The lifelong learning scores were used throughout the analysis.

Fig. 2 shows the detailed analysis of how chemical engineering students perceive their lifelong learning characteristics. From the figure, it can observe that some similar trends of respondents from female and male students (agree and strongly agree) for questions A4, B1, B2, C1, D1 and E1. Both female and male students were confident and achieved high percentage of agreement of the characteristics of lifelong learning, i.e.: self-directed learner (A3, 65%), love learning (A4, 65%), able to relate academic learning to practical (B2, 72%), related to what been learnt (B3, 82%) and responsibility (C2, 82%). From the survey done, both female and male students were relatively lack in confidence to perceive their characteristic based on data collected from questions A5, C1 and E3, which obtained less than 30% of the agreement. Among all, the responses from the female and male students indicate an average of 15% of agreement that comfortable under condition of uncertainty (E3). This can be related to how they perceive themselves in adapting learning strategies especially online learning during the survey was conducted. The comfortable level of students to study online during the COVID-19 pandemic can be related to student readiness. Widodo et al. (2020) reported that student readiness in online learning depend on few aspects, such as: equipment capability, technology skills, motivation, and perceived usefulness on the benefits of online learning.

Fig. 3 shows the details analysis of the “goal setting” characteristics

Fig. 4. Coding tree for propensity towards lifelong learning.
Table 7
Some quotes obtained from the interview.

| Theme                                      | Sample of quotes                                                                 |
|--------------------------------------------|---------------------------------------------------------------------------------|
| Awareness of lifelong learning             | • Whatever knowledge I gained, I am able to picture how it can be used in the future, and how it will be used is not just in terms of career but also in terms of how to approach life. (Respondent 2)  |
| • It’s like you have to keep the motivation and passion to learn, not only on the academic side but also, like, along with your life. (Respondent 3) |
| • It’s something that I’ll learn for the rest of my life, that I’ll remember what I’ve learned. (Respondent 6) |
| Goal setting                               | Check                                                                                   |
| • I would first just read on it … read what the assignment is about before starting anything. (Respondent 4) |
| • I usually like to set, like, a milestone or a checkpoint in order to gauge my progress. (Respondent 2) |
| • In fact, I’ll basically … break it down into parts … if it’s a report, then that’s a section that you are supposed to do right. (Respondent 1) |
| • I get to assign, allocate all the tasks … means I have … I can arrange my progress according … to my … my schedule. (Respondent 3) |
| Time management                            | Plan                                                                                     |
| • I give myself a deadline. (Respondent 1) |
| • It’s like … how you convert energy that you would use quite often … cost evaluation. You will definitely use it … marketing evaluation. Those engineering parts you will use them in your daily life. (Respondent 6) |
| • I would still be able to extract that knowledge, and kind of apply it. (Respondent 1) |
| Application of knowledge and skills        | Online                                                               |
| • I’ll just google. (Respondent 3)         |
| • I would … databases like the web of science … library and such. (Respondent 6) |
| • I also try to talk to my friends, because sometimes someone else might understand it better than you. (Respondent 1) |
| • If I have someone else with me, maybe the person knows something that I don’t know, and we can exchange information. (Respondent 5) |
| Information literacy                       | Attitudes towards learning                                                            |
| • It does feel overwhelming at first, erm, because erm, we are because er … we do not know what’s in the end. (Respondent 2) |
| • Well lost, very lost; obviously, it is scary … but then, you will feel lost and scary at the same time. (Respondent 6) |
| Negative attitudes                         | Positive attitudes                                                                    |
| • Being calm about it … when you calm yourself … you can think better. (Respondent 1) |
| • For me, I think uncertainty is good, I like uncertainty. It makes my life more exciting. (Respondent 5) |
| Motivation                                 | Being self-motivated and then you target your work. I’m doing this because I’m interested because I want to know more … I think … you can sort of … understand and learn things better. (Respondent 1) |

Table 7 (continued)                                                                 |

| Theme                                      | Sample of quotes                                                                 |
|--------------------------------------------|---------------------------------------------------------------------------------|
| Awareness of lifelong learning             | • When it comes to learning something new … is to have interest or motivation in something new to learn to begin with. (Respondent 2)  |
| • I think it will be good to be constantly learning the new technology implemented so I can better improve my knowledge. (Respondent 5) |
| Openness to learning                       | • I do get easily intrigued … by … some new information, and I do take the time to side-track just a little to look into that … new information. (Respondent 2) |
| Curiosity                                  | • In order to keep up the trend, you have to keep learning, pushing yourself to learn more about the new technologies, invest some time and … also effort. (Respondent 3) |
| Self-direction and self-evaluation         | • … we must understand our flaws, what we are good at, and then, apply it to everyday life. (Respondent 4) |
| Adaptation towards learning                | • I think, for me, the most difficult part is adapting to it. (Respondent 5) |
| • I’ll just take a break from it … then, after the break, I’ll come back to it, with a fresh mind and fresh perspective, and sometimes it helps me to solve the problem. (Respondent 4) |
| • I’ll meet some obstacle … which makes me upset … we are still getting used to our comfort zone where we cannot have … basic knowledge about everything. (Respondent 3) |

of female and male students at different level of study, respectively. The percentage accounting of the total percentage of agree and strongly agree respond based on the Likert scale. It seems a similar trend of agreement from both female and male students at the different level of study perceived the “goal setting” understanding for A1, A2 and A5. The students in Level 2 usually new in the chemical engineering course, thus required guidance and more prescribed plan for their initial semester of study (A1). On the other hand, the results showed that Level 2 students learn to focus on ‘big pictures’ instead of details as compared to higher levels of study. This is due to the chemical engineering course covers the broad area of the general conceptual knowledge at the early study level while towards more specifics knowledge in the later year of study. Teaching-learning methods shall enable students to take full responsibility for their own learning and prepare them for lifelong learning ability (Engineering Accreditation Council (EAC), 2020).

An independent-samples t-test was conducted to understand whether there is a difference in lifelong learning based on gender (i.e.: dependent variable would be “lifelong learning score” and independent variable would be gender, which has two groups: male and female). The mean score for the male variable on the lifelong learning scores (M = 47.37, SD = 6.13) did not differ statistically significantly (t = 0.81, df = 107, p = 0.419), from that of the female variable (M = 46.42, SD = 6.03). This suggests that gender does not have a significant influence on lifelong learning.

One-way analysis of variance was performed on the level of study variable to determine how it was related to lifelong learning. The means of lifelong learning scores for Level 2, Level 3, and Level 4 were 47.93, 47.16, and 46.12, respectively. This suggests that no statistically significant difference exists between the level of study and lifelong learning (F = 0.82, p = 0.44, where F refers to F-ratio).

3.1. Factors affecting lifelong learning

The descriptive statistics for the 20 questions related to the factors influencing lifelong learning are shown in Table 3. The means of the items ranged from 3.03 to 4.38 on a five-point Likert scale. The standard deviations ranged from 0.65 to 1.13. The Cronbach’s alpha for each factor, ‘curiosity’, ‘openness to learning’, ‘access to information and information literacy’, ‘engaging in self-direction and self-evaluation’ was 0.83, 0.59, 0.75, and 0.85, respectively. The scores for factors
influencing lifelong learning were added together to produce a factor score for each factor. The factor scores were used throughout the analysis.

An independent-samples t-test was conducted to determine if the factors influencing lifelong learning were related to gender (Table 4). Our statistical analysis showed that gender does not contribute to any relationship with regard to all four lifelong learning factors, namely, curiosity, openness to learning, access to information and information literacy, and ‘engaging in self-direction and self-evaluation’. Since there was no statistically significant relationship in terms of both gender and level of study in the lifelong learning scores, the null hypothesis was accepted. This finding was aligned with study done by Kaplan (2017) that lifelong learning provides equal opportunities to individuals and removes restrictions such as learning, age, socio-economic status and educational level.

A one-way analysis of variance was performed to determine how the level of study was related to the factors (Table 5). There was no statistically significant difference between the level of study and curiosity (F = 2.76, p = 0.068). There was also no statistically significant difference between the level of study and openness to learning (F = 1.80, p = 0.170). Furthermore, no statistically significant difference was found between the level of study and access to information and information literacy (F = 1.91, p = 0.153). Lastly, no statistically significant difference was found between the level of study and engaging in self-direction and self-evaluation (F = 0.99, p = 0.374).

The above-stated results indicate that gender and level of study have no influence on either lifelong learning or the four factors. The scores for both gender and level of study were comparable. No gender differences on the lifelong learning scale concurred with the study done by Kirby et al. (2010) (undergraduate students from various background: art, nursing, education, business, information technology and science). Similar to the findings of this study, a study by Bayraklı and Dindar (2015) also found no significant gender-related differences in terms of the factors affecting lifelong learning (undergraduate students from Math-Science background). The group differences in the lifelong learning scores give an insight into the lifelong learning characteristics of chemical engineering undergraduate students. Nevertheless, it is noted that the results may not be comparable due to different mode of learning: face-to-face learning (results from Kirby et al. (2010) and Bayraklı and Dindar (2015)) and online learning (this study). It was found that the level of study had higher lifelong learning scores, presumably because the students were encountering problems during the study as more design and problem-solving projects (such as the design project and the capstone project) were being integrated into the undergraduate curriculum. This was meant to instill greater expertise in students regarding the information they believe is needed to solve problems (Burkholder et al., 2021). Another possible reason is the Dunning-Kruger effects, whereby this type of systematic miscalibration is found in a self-report measure such as the lifelong learning scale and the factors affecting lifelong learning scale that was provided (Pennycook et al., 2017). Furthermore, Perry Jr (1999) did an in-depth interview with university students, which showed that students view knowledge as either true or false at the beginning, and that it changes when students accumulate more knowledge and realise that the truth depends on the context. At the final stage, students are conscious of multiple perspectives, and sometimes require an input of their own opinion (Perry Jr, 1999). Level 4 students were more analytical and were aware of their strengths and weaknesses, probably because of their exposure to more qualitative problems, which is contrary to Level 2 students.

Based on the quantitative and qualitative respondents, students agreed more with the statement, ‘I love learning especially when I want to learn’, which implies curiosity, and the statement, ‘I change my strategy when I have difficulties’, which implies openness to learning. Participants who had higher curiosity and openness to learning had higher lifelong learning scores. This can also be seen in the interview, where the statement, ‘I do get easily intrigued… by… some new information, and I do take the time to side-track just a little to look into that… new information’ signifies curiosity. Openness towards learning can be seen in one’s participant’s statement, ‘I think it will be good to be constantly learning the new technology implemented so I can better improve my knowledge’, which shows the importance of being open to various learning settings (Table 6). Participants were open and curious towards learning, desired to understand concepts during learning, were capable of relating knowledge to life issues, and had a positive attitude towards learning. Based on previous studies, the assumption that had been made was that engagement in continuous learning activities can be displayed when learners have the characteristics of a lifelong learner (Livneh and Livneh, 1999). All these findings were significant, whereby more factors and characteristics can be incorporated into the lifelong learning scale for better measurement. Thus, understanding the factors that affect lifelong learning is important in creating an educational structure that cultivates lifelong learners during the COVID-19 pandemic. Multiple linear regression was calculated to predict lifelong learning scores based on factor scores. There were four-factor scores for each factor, the factor scores were ‘Curiosity’, ‘Openness to Learning’, ‘Access to information and information literacy’, ‘Engage in self-direction and self-evaluation’. Participants’ lifelong learning score increased by 0.42 for each score in curiosity, 0.21 for each score in openness to learning, 0.14 for each score in access to information and information literacy, and 0.10 for each score in engage in self-direction and self-evaluation. Both ‘Curiosity’ and ‘Openness to Learning’ are a statistically significant influence on lifelong learning scores (see Table 6) with p < .001 and p = 0.033, respectively.

3.2. Qualitative analysis from the interview

Six respondents were randomly selected from the 109 respondents who had completed the Google Form questionnaire. Interview transcripts were prepared. All themes were identified and related to a central theme of ‘Propensity towards lifelong learning’. A coding tree of the themes (see Fig. 4) was developed using thematic content analysis software, NVivo v.12. Although there was no direct reference towards the theme during the interviews, participants conveyed, discussed, and described techniques and feelings on how to approach online learning during the COVID-19 pandemic. Words such as ‘new’ and ‘motivated’ were used by participants to describe their learning experiences. Participants displayed characteristics that reflect propensity towards lifelong learning. Table 7 shows the quotes from the interview under each suggested theme.

The awareness can be seen in one of the responses in the interview, ‘It is something that I will learn for the rest of my life, that I will remember what I have learnt’. This awareness of the need for lifelong learning is prevailing in this globalised era. The awareness of the usefulness of lifelong learning for engineering professionals is essential and can be acquired via assignments in courses (Naimpally et al., 2012).

A characteristic that possibly affects lifelong learning in chemical undergraduate students is the ability to adapt to learning strategies. Students generally have the characteristics of goal setting, locating information, and applying their knowledge and skills. Goals setting can be seen in the interview responses, for example, ‘I usually like to set, like, a milestone or a checkpoint in order to gauge out my progress’, and ‘I get to assign, allocate all the tasks… means I have… I can arrange my progress according to my… my schedule’. The students were capable of locating the information form on online platforms such as Google, databases, and YouTube. Digital competencies are crucial in accessing relevant information. Digital competencies refer to the capability to capture, create, present, and store data using a computer (Uzunboylu and Tuncay, 2010). However, the participants tended to have a low adaptation to learning strategies. They expressed discomfort, being overwhelmed, and anxiety when uncertainty arises. One participant said, ‘I’ll meet some obstacle… which makes me upset… we are still getting used to our comfort
zone where we cannot have... basic knowledge about everything'.

There is no doubt that the students prefer practical and actual environments for the development of their skills. However, with the current COVID-19 pandemic, online teaching and learning activities should be flexible and should encourage lifelong learning among students.

Collaborative learning as an active method of teaching and learning should be considered to improve student’s lifelong learning as it promotes the development of communication skills, individual reasoning, and the ability to perform various social roles in collaborative activities (Sumtsova et al., 2018). Support programmes to assist students in transitioning from traditional face-to-face learning to online learning can be one of the ways to improve the awareness and competencies of life-long learning. This support programme can have diverse contents (e.g., town hall meeting, academic learning skills, advising and mentoring programmes, staff-students liaison committee meeting; and other general support services).

The chemical engineering students at Monash University Malaysia are also offered with an online learning mentoring programme (Monash University Malaysia, 2021) to enhance their online learning experience during this COVID-19 pandemic. This helps the students to enhance their ability to adapt to modern society, which correlates with their employability.

4. Conclusion

The purpose of the study was also to examine the characteristics of lifelong learning and factors influencing chemical engineering students at Monash University Malaysia when study online during the COVID-19 pandemic. It was found that gender and level of study have no significant effects on lifelong learning competencies among chemical engineering students. The authors conclude that the awareness of lifelong learning does not affect lifelong learning competencies, and lifelong learning competencies can be largely influenced by curiosity and openness to learning. Curiosity influences lifelong learning propensity two times more than openness to learning. Nonetheless, adaptation to learning strategies is currently lacking among chemical engineering undergraduate students at Monash University Malaysia. This could be mainly due to the sudden change from traditional face-to-face learning to online learning. Thus, nurturing key competencies should be a concern for higher education for the development of lifelong learning among students and online learning should be emphasised as it may become the new norm (Mellieon Jr and Robinson, 2020). Lifelong learning plays an important role in addressing the issue of learning activities that are undertaken by students throughout their life because lifelong learning enables students to improve their knowledge, skills, and competencies. Proper measurements and guidelines should be put in place to ensure that the lifelong learning skills of engineering students are explicitly measured. Future study can be carried by including post COVID-19 pandemic analysis study on how students lifelong learning competencies. Then, compare and contrast the results obtained to find the significant and correlation of both conditions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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