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Assessing Engineering Students Preparedness For Lifelong Learning And Self-Reflection Competency

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ASSESSING ENGINEERING STUDENTS' PREPAREDNESS FOR LIFELONG LEARNING AND SELF-REFLECTION COMPETENCY

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ABSTRACT
Lifelong learning is becoming increasingly important in the field of engineering. Higher education institutions (HEIs) are responsible for the transfer of field-specific knowledge, but also for preparing students for LLL. To do so, HEIs need a clear view of the extent to which engineering students are prepared for LLL. Research suggests two approaches in the assessment of LLL, namely (1) a holistic approach measuring general preparedness for LLL and (2) a specific approach measuring a subcompetency of LLL. The current study combines both approaches by using Kirby's lifelong learning scale (LLS) and Grant's Self-Reflection and Insight Scale (SRIS). Firstly, a correlation is found between the scales supporting the hypothesis that self-reflection is a subcompetency of LLL and the SRIS is useful for measuring preparedness for LLL. Secondly, the results indicate that early engineering students already have a relatively high level of self-reported LLL competencies, but with considerable room for growth resulting in a challenge for engineering education.

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1 INTRODUCTION

1.1 Lifelong learning in engineering (education)

As a rapidly evolving field, engineering requires constant adaptation and upskilling. With new technologies and developments emerging daily, knowledge that was once relevant can quickly become outdated (Chen, Lord, and McGaughey 2013; Van den Broeck et al. 2020). In addition to continuous developments in the field, the world is facing unprecedented global challenges such as climate change and social inequality, which requires engineers to master competencies beyond traditional engineering expertise (MacKenzie 2023; Dawe et al. 2022). Today, regularly updating one's competencies or lifelong learning (LLL) has become a requirement for engineers.

HEIs hold the responsibility of preparing students for their future career meaning that they also need to equip students with the necessary competencies for LLL (Yap and Tan 2022; Sankaran and Rath 2021; Van den Broeck et al. 2020). HEIs need to instil the importance of LLL in students and encourage them to take ownership of their learning process. By doing so, HEIs contribute to a workforce that is capable of meeting the challenges of an ever-changing professional environment.

1.2 Definition and measurement of lifelong learning

Defining LLL can be a complex task as seen in the many definitions in the literature. Fundamentally, LLL is the process of progressively acquiring, finetuning, and transferring of knowledge over long time spans while retaining previously learned experiences (Parisi et al. 2019). However, many authors go beyond this straightforward definition and accentuate the importance of the competencies that underpin LLL (Drewery et al. 2017) such as self-reflection, goal setting and self-monitoring. Self-reflection, for instance, is essential to set and reach learning goals and thus is necessary for lifelong learning (Love 2011; Mahajan et al. 2016). This way, LLL is defined using an underlying competency instead of a broad definition.

To prepare students for LLL, HEIs need a clear view on the extent to which engineering students are already equipped with the necessary competencies for LLL. Similar to the complexity of defining LLL, the measurement of LLL is equally challenging. Scientific literature has proposed a wide range of LLL questionnaires, such as the Evaluating Lifelong Learning Inventory (ELLI; Crick et al., 2010), the Jefferson Scale of Physician Lifelong Learning (JeffSPLL; Hojat et al., 2003) and the Lifelong learning scale (LLS; Kirby et al., 2010). These questionnaires result in a general indication of the preparedness for LLL, but start from a list of underlying competencies to create a comprehensive LLL measurement. The LLS (Kirby et al. 2010) for example, uses the characteristics defined by Knapper and Cropley (2000), namely goal setting, application of knowledge and skills, self-direction, and evaluation, locating information, and adaptable learning strategies to develop questionnaire items.

In a second approach, the extent to which students are prepared for LLL is measured using a questionnaire focusing on a subcompetency of LLL. Woezik et al. (2020) compared the effect of different didactic approaches on LLL preparedness using the Motivated Strategies for Learning Questionnaire (MSLQ). The authors argue that an increase in certain learning strategies from the MSLQ, like metacognitive self-regulation, indicate an increased preparedness for LLL.

Some research also compares a general LLL questionnaire with the measurement of an underlying LLL competency. In the context of engineering education, Chen et al. (2013) used the Autonomous Learner Scale to measure engineering students' study

habits in combination with the LLS by Kirby et al. (2010). In conclusion, a large body of research measures LLL using an independently developed questionnaire focused on the measurement of a competency underlying LLL.

1.3 The current study

In this study, the preparedness of engineering students for LLL is assessed using two measures. The first measure is the Lifelong Learning Scale (LLS; Kirby et al., 2010), which provides a general measurement of LLL preparedness. The second measure is the Self-Reflection and Insight Scale (SRIS; Grant et al., 2002), which assesses the underlying competency self-reflection. This study aims to inform HEIs and engineering educators and researchers by answering the question 'What is the state of engineering students' preparedness for LLL?'

2 METHODOLOGY

2.1 Sample and procedure

Both measurements were conducted in-class during a lecture break in the first weeks of the second semester using a link to an online questionnaire. Data was gathered from the first (N = 40; N♀ = 5) and second year (N = 40; N♀ = 4) students enrolled in the Engineering Technology programme. Participation was voluntary and free of compensation. Ethical permission was granted by the Social and Societal Ethics Committee or SMEC (G-2022-5292-R2(MAR)).

2.2 Questionnaire

The first part of the survey consists of the Dutch translation of the SRIS assessed with a five-point Likert scale (1 = Completely disagree, 2 = Somewhat disagree, 3 = Neither agree nor disagree, 4 = Somewhat agree, 5 = Completely agree). The SRIS consists of 20 items and two factors. The first factor 'Self-reflection' is defined by 12 items measuring the engagement in and need for self-reflection and the second factor 'Insight' is defined by 8 items.

The second part of the survey was composed of the 14 items of the LLS-questionnaire with a five point Likert scale, all loading on 1 factor. Kirby et al. (2010) constructed the survey starting from five LLL characteristics (Knapper and Cropley 2000), namely goal setting (5 items), application of knowledge and skills (3 items), self-direction and evaluation (2 items), locating information (1 item) and adaptable learning strategies (3 items).

2.3 Analysis

The questionnaires are first analysed separately and then combined. All calculations, tests and visualisations are executed in RStudio (R Core Team 2022).

In the individual analyses, the mean, standard deviation, minimum score, maximum score and IIC (inter-item correlation) are calculated for all individual factors. Scores on reversed items are reversed before calculations so all included statistics are scaled in the same direction. A high score indicates a better preparedness for LLL and vice versa. All variables for each of the questionnaires are included in Table 1 and 2.

Internal consistency is quantified by both the mean IIC and Cronbach alpha. The IIC is the mean correlation an item has with all other items in a scale. An acceptable mean IIC value is situated in the range of .20 to .40 (Piedmont 2014). A higher IIC indicates that an item is highly correlated with other items and has little added value. A lower IIC means that an item is unrelated to the other items. In the case of multiple lower IIC

values, these items probably measure a specific factor or construct. For the Cronbach alpha a value of .70 or more has been defined as an acceptable value (Yusoff, Arifin, and Hadie 2021) for questionnaire internal consistency.

The internal structure is assessed using confirmatory factor analysis on the two-factor structure of the SRIS and the one-factor structure of the LLS. Absolute fit is evaluated by the Root Mean Square Error of Approximation (RMSEA; <.08) and both the Tucker-Lewis Index (TLI; >.90) and Comparative Fit Index (CFI; >.90) are used to evaluate incremental fit (Yusoff, Arifin, and Hadie 2021). The two factors of the SRIS are also correlated with the level of significance set at .05.

Comparing both questionnaires is done using a correlational analysis with the level of significance set at .05. The SRIS factors and LLS factor are correlated and visualised using scatterplots.

3 RESULTS

3.1 Lifelong learning scale (LLS)

Descriptive statistics on item and questionnaire/factor level are included in Table 1. When inspecting the IICs in Table 1, it can be noted that the IIC values have a large range from -.20 to .33. The mean IIC ($\overline{IIC}$ = 0.14) is on the lower side according to the recommended range of .20 to .40. Subsequently, the standardized Cronbach alpha suggest a low but acceptable internal consistency (α = .70). Finally, to confirm the one-factor structure a confirmatory factor analysis was performed. Multiple goodness-of-fit indices indicate a reasonable fit (CFI = .80; TLI = .76; RMSEA = .07).

Table 1. Descriptive statistics of the LLS

	Mean	SD	Min	Max	IIC
LLS	3.44	0.43	2.57	4.57	
Goal setting	**3.41**	**0.55**	**2.20**	**4.8**	
I prefer to have others plan my learning (R)	3.40	1.10	1	5	-.01
I seldom think about my own learning and how to improve it (R)	3.51	1.00	2	5	-.18
I feel I am a self-directed learner	3.59	0.99	1	5	.22
I love learning for its own sake	3.24	1.08	1	5	.22
When I learn something new I try to focus on the details rather than on the 'big picture' (R)	3.30	3.30	1	5	-.12
Application of knowledge and skills	**3.77**	**0.63**	**2.33**	**5.00**	
I am able to impose meaning upon what others see as disorder	3.53	0.84	1	5	.26
I try to relate academic learning to practical issues	3.87	0.90	1	5	.33
When I approach new material, I try to relate it to what I already know	3.92	0.82	2	5	.31
Self-direction and evaluation	**3.42**	**0.68**	**1.5**	**5.00**	
I feel others are in a better position than I am to evaluate my success as a student (R)	3.39	1.10	1	5	-.20
It is my responsibility to make sense of what I learn at school	3.45	0.93	1	5	.31
Locating information	**3.12**	**0.88**	**1**	**5.00**	
I often find it difficult to locate information when I need it (R)	3.12	0.88	1	5	.18
Adaptable learning strategies	**3.27**	**0.69**	**1.33**	**5.00**	
I prefer problems for which there is only one solution (R)	3.26	1.09	1	5	.20
I can deal with the unexpected and solve problems as they arise	3.76	0.86	1	5	.28
I feel uncomfortable under conditions of uncertainty (R)	2.80	1.05	1	5	.06

3.2 Self-reflection and insight scale (SRIS)

Table 2 presents the descriptive statistics of the items and factors of the SRIS. The questionnaire shows a good internal consistency with a high Cronbach's alpha (α = .82) and a low mean ICC ($\overline{\text{IIC}}$ = .18). The IICs in Table 2 range from -.20 to .24 with mostly negative IICs for the Insight factor and positive IICs for the Self-reflection factor. This indicates the presence of two strongly distinct factors. The two-factor structure was largely confirmed with acceptable goodness-of-fit values (CFI = .80; TLI = .77; RMSEA = .10). As can be expected from the IIC pattern, the two factors are not correlated (r = .06, p = .62).

3.3 Relation between both measurements

The relation between the LLS and the SRIS is explored on factor level. The LLS factor correlates with both of the SRIS factors Self-reflection (r = .53, p < .001) and Insight (r = .34, p < .005). Figure 1 contains the scatterplots of both pairs of variables. The scatterplots includes one point for each individual at the x and y coordinates determined by the LLS mean score (x) and the Insight (left) or Self-reflection (right) mean score (y).

Table 2. Descriptive statistics of the SRIS

	Mean	SD	Min	Max	IIC
Self-reflection	**3.21**	**0.70**	**1.75**	**5**	
I frequently take time to reflect on my thoughts	2.92	1.18	1	5	0.18
I rarely spend time in self-reflection (R)	3.30	1.12	1	5	0.22
I often think about the way I feel about things	3.12	1.10	1	5	0.15
I don't often think about my thoughts (R)	3.57	1.16	1	5	0.24
I frequently examine my feelings	2.90	1.02	1	5	0.18
I don't really think about why I behave in the way that I do (R)	3.42	1.00	1	5	0.21
I have a definite need to understand the way my mind works	2.95	1.13	1	5	0.13
It is important to me to be able to understand how my thoughts arise	3.10	1.17	1	5	0.12
It is important to me to try to understand what my feelings mean	3.12	1.00	1	5	0.15
I am very interested in examining what I think about	3.12	1.10	1	5	0.16
I am not really interested in analysing my behaviour (R)	3.35	1.20	1	5	0.18
It is important for me to evaluate the things that I do	3.68	0.85	2	5	0.23
Insight	**3.49**	**0.62**	**1.88**	**5**	
Often I find it difficult to make sense of the way I feel about things (R)	2.34	0.95	1	5	-0.16
I am often confused about the way that I really feel about things (R)	3.48	1.00	1	5	-0.19
I'm often aware that I am having a feeling, but I often don't quite know what it is (R)	3.26	0.97	1	5	-0.14
My behaviour often puzzles me (R)	3.66	1.07	1	5	-0.20
Thinking about my thoughts makes me more confused (R)	3.27	1.13	1	5	-0.11
I usually have a very clear idea about why I have behaved in a certain way	3.62	0.90	1	5	-0.15
I usually know why I feel the way I do	3.47	1.07	1	5	-0.17
I am usually aware of my thoughts	3.75	0.78	2	5	0.08

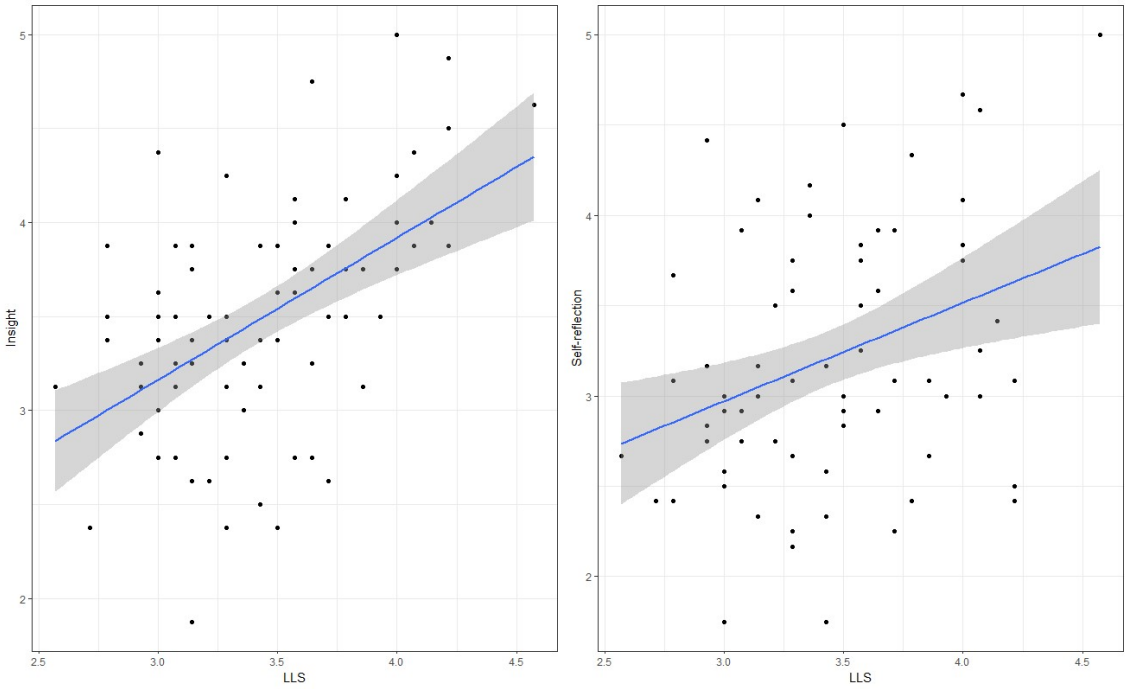

Figure 1: Scatterplot of LLS and SRIS subfactors

4 DISCUSSION

The current study assessed the preparedness of early engineering students for LLL using the LLS and the SRIS. The LLS is a comprehensive LLL questionnaire that takes a holistic approach on LLL, while the SRIS is a self-reflection questionnaire developed separately from the LLL research field. The latter was selected based on the hypothesis that self-reflection is a subcompetency of LLL since it is a central competency in achieving learning goals (Mahajan et al. 2016; Love 2011; Grant, Franklin, and Langford 2002). The measures were analysed independently and then combined.

4.1 Results of the LLS

Firstly, the analysis of the LLS data reveals that, on average, the engineering students rate themselves above the midpoint for each LLL characteristics included in the scale (M = 3.44). The mean overall LLS score is lower than in a study with engineering students from Malaysia (Yap & Tan, 2022; N = 109; M = 3.93; ΔM = 0.52). This difference in mean score could be caused by factors such as cultural setting, sample composition (especially gender balance), or the Covid-19 pandemic which was no longer a factor in the current study. However, more research is necessary to confirm this. In 2020, the LLS was also administered to students from the same programme at the same university (Van den Broeck et al.; N = 160) as the current study. In this study, a similar mean sum score was obtained (M = 3.37; ΔM = 0.04).

The highest mean score on a characteristic is on the 'Application of knowledge and skills' characteristic (M = 3.77). With items like 'I try to relate academic learning to practical issues', this is unsurprising considering the practical nature of the engineering technology programme. Additionally, for the item 'When I approach new material, I try to relate it to what I already know' not a single student indicated the lowest point of the scale, which is an encouraging result. The lowest mean score is for the 'Locating

information' characteristic (M = 3.12). However, it needs to be noted that this characteristic exists of only one item, namely 'I often find it difficult to locate information when I need it'. Overall, the results of the LLS show that the engineering students are located above the midpoint of the scale, but with significant room for growth.

The Cronbach alpha value of the LLS in the current study (α = 0.70) is considered low but acceptable, and is consistent with similar values reported in previous studies ranging from 0.52 to 0.73 (Kirby et al. 2010; Deveci 2022; Meerah et al. 2011; Yap and Tan 2022; Van den Broeck et al. 2020). Given the wide range of characteristics that the LLS attempts to capture, this level of internal consistency is expected.

4.2 Results of the SRIS

The analysis of the SRIS data shows that engineering students also estimate their Self-reflection (M = 3.21) and Insight (M = 3.49) competency to be above the midpoint of the scale. Previous research using the SRIS in the same programme as the current study (Tuyaerts et al. 2023) found similar results with a slightly higher mean for Self-reflection (divided into two subfactors) in the first bachelor ($M_{\text{Engagement in self-reflection}}$ = 3.32; $M_{\text{Need for self-reflection}}$ = 3.40) and second bachelor ($M_{\text{Engagement in self-reflection}}$ = 3.33; $M_{\text{Need for self-reflection}}$ = 3.33). For Insight, the mean was slightly lower in the first bachelor (M = 3.32) and second bachelor (M = 3.35) compared to the current study. Similarly to the LLS results, the SRIS results are positive but indicate room for growth.

Interestingly, a closer look at individual items reveals a response pattern. All items containing the words 'feel' or 'feelings' have mean response scores beneath the mean of the corresponding factor, for example 'I frequently examine my feelings' for the Self-reflection factor (M = 2.90; ∆M = 0.31) and 'Often I find it difficult to make sense of the way I feel about things' (M = 2.34; ∆M = 0.18). This is in contrast to items with behaviour or action as the focal point of reflection which are all higher than the mean score of the factor. Examples of this are 'It is important for me to evaluate the things that I do' (M = 3.68; ∆M = 0.47) and 'My behaviour often puzzles me' (reversed item; M = 3.66; ∆M = 0.17).

The absence of a correlation between the two factors self-reflection and insight (r = .06, p = .62) was also present in the original study by Grant et al. (2002; r = -0.03). In fact, this study even found a negative correlation (r = -.31, p < .001) when examining the congruent validity with a different sample. A large-scale data collection conducted by Silvia (2022) also found a weak correlation between the two factors (r = 0.07, p = 0.04) in line with the current study's findings. This indicates that the SRIS consists of two strongly distinct factors.

4.3 LLL and self-reflection

The LLS correlates with both the Self-reflection (r = .53; p < .001) and Insight factors of the SRIS (r = .34; p < .005). This is in line with the hypothesis that self-reflection is central to goal attainment (Grant, Franklin, and Langford 2002). In the context of LLL, self-reflection contributes to reflection on how one's progress towards a learning goal is going and how it can be improved. In this way, self-reflection is a necessary competency for LLL (Mahajan et al. 2016; Love 2011). The moderate to high correlation between the SRIS factors and the LLS further contribute to this hypothesis.

These results indicate that the SRIS could be used to provide insight into the preparedness for LLL. While a general LLL questionnaire may seem more useful at first glance due to its holistic and comprehensive approach, an opposing argument can also be made by looking at a different field of study. In personality research, it has

been established that broad personality factors are useful for predicting general outcomes, while underlying personality facets are better for predicting specific outcomes. For example, the Big Five personality trait conscientiousness is the strongest personality predictor of academic performance. However, underlying facets of conscientiousness, such as perfectionism are more useful for predicting specific academic outcomes like absenteeism and high honours attainment (Maccann, Lee, and Roberts 2009). Thus, by focusing on smaller personality facets a more fine-grained analysis of the role of personality in academic performance is achieved. Similarly, in the context of LLL, a questionnaire that focuses on a subcompetency of LLL, such as the SRIS, may have advantages by providing a more detailed analysis of LLL and by extension informing HEIs about the strengths and weaknesses of students.

Following this argument, there is a need for a framework that maps the different LLL competencies (and their associated questionnaires) and how they relate to each other, in order to make better predictions of LLL. Currently, the literature is flooded with newly developed LLL models, character lists, and questionnaires, but with little reference to each other. By constantly reinventing the wheel, little progress in our understanding of LLL is actually made.

5 SUMMARY AND ACKNOWLEDGMENTS

The measurement of LLL is a challenging task but is necessary to adequately prepare engineering students for their professional life. The current study attempts to tackle this task by combining a general LLL questionnaire with a questionnaire focusing on the LLL subcompetency self-reflection. The results indicate that (1) early engineering students have already a relatively high level of self-reported LLL competencies, but with room for growth and (2) that both scales correlate.

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