2023-10-10

Engineering Science Students’ Self-Regulation: A Baseline

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Recommended Citation

TUYAERTS, Shan; DE LAET, Tinne; VAN DEN BROECK, Lynn; and LANGIE, Greet, "Engineering Science Students’ Self-Regulation: A Baseline" (2023). *Research Papers*. 121.
https://arrow.tudublin.ie/sefi2023_respap/121

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ENGINEERING SCIENCE STUDENTS' SELF-REGULATION: A BASELINE

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Conference Key Areas: *Engineering Skills and Competences, Lifelong Learning for a More Sustainable World*

Keywords: *Engineering Education, Lifelong Learning, Self-Regulation, Higher Education*

ABSTRACT

Today's society is characterized by swift technological advancements. Engineers cannot solely rely on what they learned at university, as new technologies pop up quickly. They need to participate in lifelong learning (LLL) in order to keep up with the state-of-the-art. Self-regulation is a core competency for lifelong learning that can be used as a proxy for it in an educational context. This study aims to establish a baseline for engineering students' self-regulation. Their levels are measured by the Self-Reflection and Insight Scale (SRIS), consisting of three subscales: need for self-reflection, engagement in self-reflection, and insight. 1128 students enrolled at KU Leuven's Faculty of Engineering Science (response rate = 36.6%) completed the SRIS. Mean scores are compared across study phases by use of Kruskal-Wallis and post-hoc Wilcoxon tests. Effect sizes are interpreted using Cohen's d. Students' engagement in reflection does not differ significantly across cohorts, but some significant differences are found in terms of need for reflection, insight, and self-regulation as a whole. The engineers' results are compared to other SRIS measurements reported on in the literature. Our study shows

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differing scores between males and females, which contrasts other studies' findings. Over the next three years, the SRIS will be administered to the same cohorts to determine whether a natural growth exists. These results will be supplemented with qualitative methods to gauge the effectiveness of future interventions.

1 INTRODUCTION

Engineers learn to work with contemporary technologies as part of their studies. As technological advancements succeed one another at a very rapid rate in today's society, it is important that engineers continue to keep track of new findings in their field and participate in lifelong learning [1]. Lifelong learning competencies, which prepare students for successful learning after higher education, are thus of great importance. Higher education institutions can have a big impact on their development in future engineers.

Developing lifelong learning competencies in engineering students is not straightforward though, as there is no consensus yet as to what exactly the umbrella competency of lifelong learning entails [2, 3]. Earlier research finds several competencies to be essential for lifelong learning, including metacognition and self-regulation [4]. Self-regulation has even been established as a core competency that can be used as a proxy for lifelong learning in the context of education [5], an approach also taken in this research.

In this paper, a first measurement of Flemish Engineering Science students' self-regulation levels is presented. We refer to the results as a baseline for students' self-regulation, as a proxy for lifelong learning. This baseline is a first essential step in our longitudinal research on the natural growth of self-regulation in engineering students, and by extension their lifelong learning competencies. Additionally, this baseline will also aid in evaluating the effectiveness of our future interventions on self-regulation. Belgium's higher education system offers several types of engineering programs. The most common ones are Engineering Science, Engineering Technology and Bioscience Engineering. Our overarching longitudinal research is concerned with all three of them. While this paper presents results related to Engineering Science students, a similar baseline for Engineering Technology students by the authors is currently in proceedings [6].

This paper addresses the following research questions:

- RQ1: What are Flemish Engineering Science students' baseline self-regulation levels?
- RQ2: To what extent do these levels differ across different study phases?
- RQ3: To what extent do these levels differ between male and female students?

Section 2 outlines this research's methodology, including the context in which the survey was administered, an overview of which students were given the opportunity to participate, and a note on how data was collected, processed and analyzed. The results, presented in Section 3 in tabular and graphical form, are further discussed in Section 4, where the findings are compared with those presented in the literature. To conclude, Section 5 provides a brief summary of the obtained results.

2 METHODOLOGY

2.1 Context and Participants

Flemish Engineering Science students' higher education starts with a three-year bachelor program, after which students follow a two-year master program. In this paper, students' progress in these programs is referred to as their study phase: either they are currently enrolled as a bachelor student (BA1, BA2 or BA3), or they are in one of their master years (MA).

2.2 Survey and Collected Data

Grant et al. define self-reflection as "(...) the inspection and evaluation of one's thoughts, feelings and behavior" and insight as "(...) the clarity of understanding of one's thoughts, feelings and behavior" [7]. They developed the Self-Reflection and Insight Scale (SRIS) and argue that it can be used to measure self-regulation. The SRIS is a 20-item scale that consists of three subscales: need for self-reflection (n = 6, e.g. *"I am very interested in examining what I think about"*), engagement in self-reflection (n = 6, e.g. *"I frequently examine my feelings"*), and insight (n = 8, e.g. *"My behavior often puzzles me"*). Participants are asked to rate the 20 items on a 1-5 Likert scale: a score of 1 corresponding to 'Strongly disagree', and a score of 5 denoting 'Strongly agree'. Statements can be positively or negatively phrased. Roberts and Stark confirmed that the three subscales behave as factors [8]. A Dutch translation of this survey, validated by Van den Broeck and Langie, was offered to bachelor students of the three phases and to second-year master students enrolled at KU Leuven's Faculty of Engineering Science. The survey was not offered to first-year master students because this group is less suitable for comparison with students of one-year master programs. The survey was presented as part of an on-campus lecture and students who were not present could access it through a link on the online learning platform used by KU Leuven. Participation was voluntary. To supplement the students' SRIS results with their current study program, phase, and sex (as listed on their ID), their university ID and e-mail addresses were also collected to allow for matching with university background data. This study is approved by the Social and Societal Ethics Committee (SMEC) (G-2022-5676).

2.3 Data Processing and Analysis

1128 responses were collected, corresponding to a response rate of 36.6%. Only fully completed entries were withheld (n = 1045), resulting in a response rate of 33.9%.

Negative statement scores were inverted and a score for each factor was calculated by taking the average score over all items loaded on that factor. An average over all statements was calculated to represent an overall self-regulation score.

Data was analyzed using nonparametric Kruskal-Wallis tests, followed by post-hoc paired Wilcoxon tests if the Kruskal-Wallis proved to be significant. Cohen's d was calculated to gauge the effect size of the identified significant differences. Scale reliability was measured using Cronbach's alpha and considered to be good ($\alpha = .80$).

3 RESULTS

3.1 RQ1: What are Flemish Engineering Science students' baseline self-regulation levels?

Table 1 presents the descriptive statistics for Engineering Science students' overall SRIS scores (self-regulation), and the scores on the three subscales (Engagement in Self-Reflection, Need for Self-Reflection, and Insight). The scores are reported separately per study phase.

3.2 RQ2: To what extent do these levels differ across different study phases?

Figure 1 visualizes the results reported in Table 1. Engineering Science's self-regulation as a whole does not differ across groups, nor does students' engagement in reflection.

First-year students report a higher need for self-reflection than second-years ($d = 0.36$, $p < .000$) and third-years do ($d = 0.39$, $p < .000$). Third-year students rate themselves slightly higher on insight than second-year students do ($d = 0.23$, $p = .009$).

Table 1: Engineering Science students' overall self-regulation levels, and levels of engagement in self-reflection (Engagement in SR), need for self-reflection (Need for SR), and insight on a 1-5 scale per study phase.

Study Phase	**Self-Regulation**		**Engagement in SR**		**Need for SR**		**Insight**		
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*n*
1st (Bachelor)	3.50	0.42	3.50	0.69	3.65	0.65	3.38	0.56	231
2nd (Bachelor)	3.42	0.47	3.37	0.72	3.39	0.75	3.47	0.64	496
3rd (Bachelor)	3.35	0.52	3.39	0.77	3.34	0.90	3.33	0.66	256
Master	3.38	0.49	3.37	0.73	3.46	0.83	3.34	0.66	62
All	3.42	0.47	3.40	0.73	3.44	0.78	3.41	0.63	1045

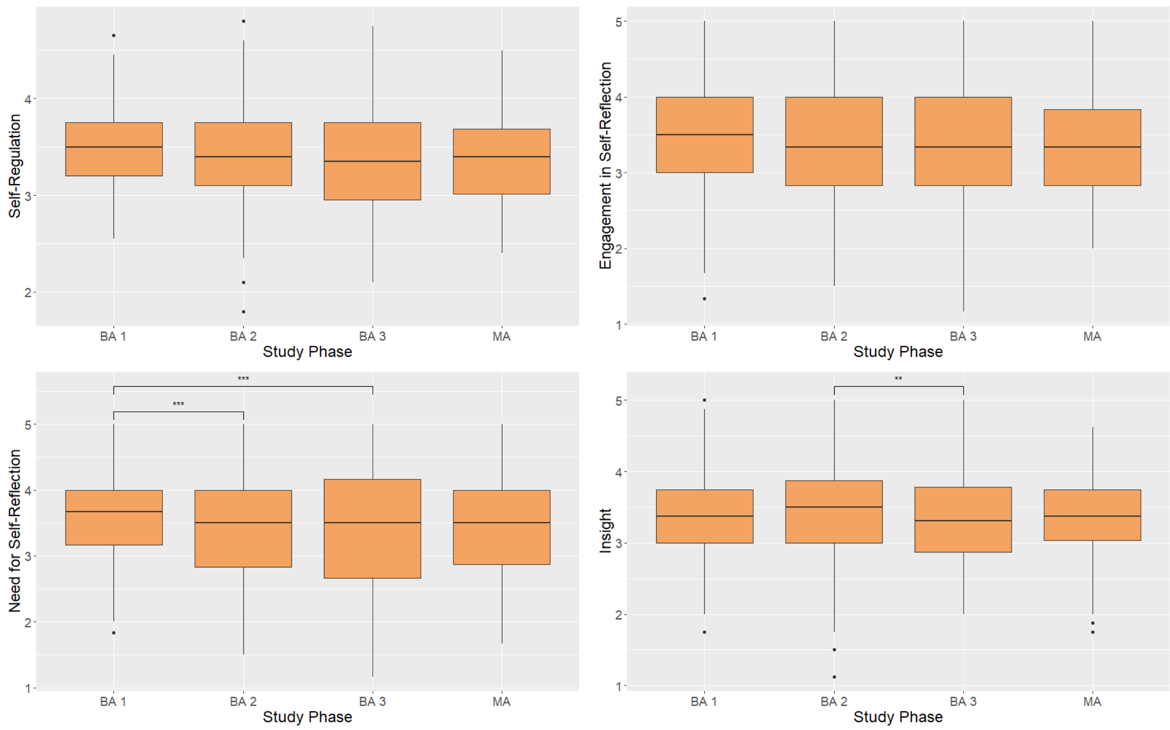

Figure 1: Distribution of scores per study phase. Left to right, top to bottom: Self-Regulation, Engagement in Self-Reflection, Need for Self-Reflection, Insight.

3.3 RQ3: To what extent do these levels differ between male and female students?

Table 2 provides a summary of SRIS scores grouped by sex. Figure 2 offers a visualization of these results.

Students' self-regulation as a whole does not differ significantly between males and females for any study phase. Males report less engagement in self-reflection than females in their first ($d = 0.42$, $p = .017$) and third years ($d = 0.33$, $p = .017$). Similarly, first-year ($d = 0.42$, $p = .017$) and third-year males ($d = 0.36$, $p = .011$) also rate their need for self-reflection lower than their female peers. When it comes to insight, however, males report higher levels than females in all study phases ($d_{BA1} = 0.51$, $p_{BA1} = .006$; $d_{BA2} = 0.32$, $p_{BA2} = .018$; $d_{BA3} = 0.33$, $p_{BA3} = .028$; $d_{MA} = 0.72$, $p_{MA} = .036$).

Table 2: Male and female engineering students' average self-regulation levels, along with their scores on the three subscales: Engagement in Self-Reflection (Engagement in SR), Need for Self-Reflection (Need for SR), and Insight.

Study Phase	**Self-Regulation**		**Engagement in SR**		**Need for SR**		**Insight**		
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*n*
Males									
1st (Bachelor)	3.49	0.41	3.45	0.68	3.60	0.64	3.43	0.55	191
2nd (Bachelor)	3.41	0.47	3.36	0.71	3.37	0.76	3.49	0.64	446
3rd (Bachelor)	3.33	0.51	3.32	0.74	3.27	0.91	3.38	0.67	194
Master	3.38	0.48	3.30	0.74	3.36	0.89	3.46	0.58	46
All	3.41	0.47	3.37	0.71	3.40	0.79	3.45	0.63	877
Females									
1st (Bachelor)	3.54	0.48	3.73	0.70	3.87	0.67	3.15	0.58	40
2nd (Bachelor)	3.44	0.49	3.53	0.77	3.59	0.64	3.29	0.55	50
3rd (Bachelor)	3.41	0.56	3.60	0.84	3.56	0.85	3.16	0.58	62
Master	3.39	0.53	3.56	0.71	3.74	0.57	3.00	0.79	16
All	3.45	0.52	3.60	0.77	3.66	0.73	3.18	0.60	168

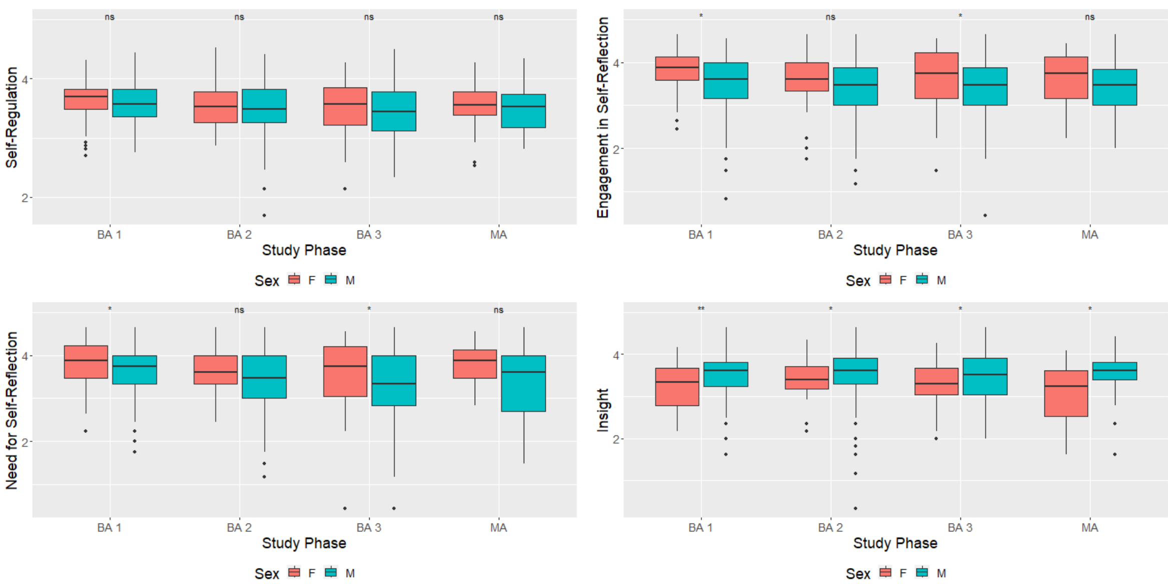

Figure 2: Distribution of scores per study phase and sex. Left to right, top to bottom: Self-Regulation, Engagement in Self-Reflection, Need for Self-Reflection, Insight.

4 DISCUSSION

To allow for a meaningful comparison and interpretation of the obtained results, it is necessary to know how students at other universities and from other disciplines rate themselves on the SRIS. To this end, a literature search was conducted to look for studies that administered the SRIS to university-level students of different countries and disciplines. Table 3 summarizes these results as reported on in the literature. If the SRIS was administered using a different Likert scale or factor calculation (e.g. taking the sum instead of averaging), the reported descriptive statistics were recalculated to make them comparable to KU Leuven's results. Grant et al. originally intended for the survey to load on three factors, but could only confirm two [7]: self-reflection and insight. Hence, they only reported a score for a combination of engagement in and need for self-reflection, instead of separate values. Some authors follow their example. These are marked with an asterisk in Table 3, in which we duplicated their self-reflection result for both engagement in and need for reflection. Roberts and Stark, on the other hand, verified that the three-factor structure is valid for medicine students, which is the approach taken by this study. Some authors report scores for more than one group. For example, Grant et al. present separate scores for people who keep a diary and those who do not. If an aggregate of all groups is available, this score is included as such in Table 3, otherwise the pooled mean and standard deviation are calculated by the authors. Mosalanejad et al. present SRIS measurements taken before and after an intervention. As there is no intervention in our study, their pre-test measurements are more appropriate for comparison and have hence been included in Table 3. Results from a previous study by the authors, measuring the self-regulation levels of students of a different Flemish engineering program called Engineering Technology, have also been included [6].

Table 3: Engineering Science students' average SRIS scores, repeated from Table 1, compared to those found in the literature. Studies that only report a score for self-reflection as a whole are marked with an asterisk (*).

Study	**Domain**	**Country**	**Engagement**		**Need**		**Insight**	
			M	*SD*	*M*	*SD*	*M*	*SD*
KU Leuven	Engineering	Belgium	3.40	0.73	3.44	0.78	3.41	0.63
KU Leuven [6]	Engineering	Belgium	3.33	0.72	3.41	0.72	3.35	0.63
Grant [7] *	Psychology	Australia	3.40	0.41	3.40	0.41	2.77	0.41
Nakajima [11]	Psychology	Japan	3.32	1.01	3.28	1.07	2.90	1.05
Roberts [8]	Medicine	UK	3.90	0.65	3.75	0.67	3.64	0.62
Naeimi [12]	Medicine	Iran	3.88	0.80	3.96	0.81	3.62	0.94
Carr [13]	Medicine	Australia	2.81	0.36	3.54	0.63	2.41	0.37
Paloniemi [14]	Medicine	Finland	3.27	0.75	3.75	0.72	3.01	0.50
Mosalanejad [10]	Medicine	Iran	2.96	0.45	2.77	0.43	2.55	0.33
Bulmer [15] *	Healthcare	USA, Canada	3.86	0.72	3.86	0.72	3.64	0.70
Aşkun [16]	Mixed	Turkey	3.26	1.23	3.50	1.18	3.10	1.17
Harrington [17] *	Mixed	USA	3.38	0.76	3.38	0.76	3.66	0.70

Engineering Science students and Engineering Technology students report similar levels on all subscales [6]. Even though the differences on the engagement and insight subscales are significant, their effects are very small ($d_{ENG} = 0.10$, $p_{ENG} = .026$; $d_{INS} = 0.09$, $p_{INS} = .018$). In the rest of the discussion, Engineering Science students are simply referred to as engineering students and only their results, as reported in Section 3, are used for comparison.

Along the spectrum of scores found in the literature, our engineering students appear to score rather average on all three subscales. When it comes to engagement in self-reflection, the medicine and health care students of Roberts and Stark, Naeimi et al. and Bulmer et al. rate themselves at least 13.5% higher than our engineers. That is not to say that medicine students engage more in self-reflection than engineering students do, as the lowest scores also concern medicine students. Grant et al., Harrington and Loffredo and Nakajima et al. report (engagement in) self-reflection scores very similar to our engineering students, their samples being taken from either a mixed pool or psychology students. Our engineering students appear to rate their need for self-reflection somewhere in the middle as well. There is no clear pattern as to which disciplines or countries experience more or less of a need than others. In future studies, a combination of quantitative SRIS ratings with qualitative insights may help interpret these divergent results. With a mean score of 3.44, our engineering students have reported a level similar to that of Aşkun and Cetin's, Harrington and Loffredo's, Carr and Johnson's and

Grant et al.'s students. The insight levels reported by the our engineering students appear to be relatively high. Roberts and Stark, Bulmer et al., Harrington and Loffredo, and Naeimi et al. all report higher mean insight scores ranging from 6.2% to 7.3% higher than our engineers' average. Așkun and Cetin's Turkish students report the highest insight ratings among the other studies, leaving a 9.1% gap between them and our engineering students.

We found that male engineering students report lower levels of engagement in and need for self-reflection, and higher levels of insight than females do. These findings are in contrast with some results of other studies, such as those by Chang et al. [18], Carr and Johnson, Paloniemi et al. and Grant et al.. Roberts and Stark also observe that males report higher levels of insight, but find no differences when it comes to the other factors. Așkun and Cetin claim the opposite: in their study, males score higher on the combined self-reflection subscale, but there is no significant difference when it comes to insight. Our male and female students do not exhibit significant differences when it comes to their total SRIS score, but this total score is the result of differently distributed subscale scores. As presented in Section 3, females report lower levels of insight than males do. First-year and third-year females report a higher need for, and more engagement in, self-reflection than their male peers do. Evidently, these differing scores on the subscales even out when summed up to the total SRIS score. It is unclear whether the total SRIS score can be validly compared across these cohorts, as it is not indicative of the same subscale levels. Consequently, we advise that researchers always look at the distribution of the subscale scores and not only look at the total SRIS result. Alternatively, triangulation by supplementing with qualitative measurements may also help interpret results.

The differences between engineers in different stages of the study program are in contrast with studies by Bulmer et al. and Roberts and Stark, who report no significant differences between such groups. Carr and Johnson report an increase in need for self-reflection, as well as a decrease in engagement in self-reflection, towards the end of the program. These findings also contrast with the results presented in this paper, as engineering students report a lower need for self-reflection towards the end of the program and their engagement in self-reflection does not differ significantly. Our engineering students also exhibit a small apparent increase in insight, whereas the medicine students of Carr and Johnson's study do not.

Self-report instruments such as the SRIS have their limitations [19] and it is unclear to what extent the obtained results are influenced by this. The complexity of the self-regulation construct further aggravates this problem, as what is measured by the survey may also partially be attributable to other, unknown factors. To help clarify these and future results, follow-up research utilizing qualitative methods will be conducted to help discover an explanation for the observed effects.

5 SUMMARY AND ACKNOWLEDGMENTS

This paper presents a baseline for Flemish engineering students' self-regulation levels. These students report scores that are neither particularly high nor low when compared to other SRIS measurements presented in the literature. Some differences between male and female engineers can be observed in terms of self-reflection, and males report higher levels of insight than female engineers do.

This research is funded by KU Leuven internal funds. It is part of the C2 project ZKE2362 - C24M/22/029. Future work building on these results will include qualitative measurements to aid interpretation of the findings, subsequent SRIS administrations at regular intervals to determine whether a natural growth occurs, and the development of interventions on self-regulation.

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