ENGINEERING STUDENTS' SELF-REGULATION COMPETENCIES – THE RELATIONSHIP BETWEEN PERCEPTIONS AND SUMMATIVE SCORES

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ABSTRACT

There is no doubt about the importance of lifelong learning (LLL) and the responsibility that Higher Education Institutions (HEIs) hold to guide and support students in the development of LLL competencies so that each graduate is prepared for a life full of learning. With self-regulation considered as a core and malleable competency for LLL, HEIs can develop interventions to support the development of students' self-regulation competencies. It is, however, of great importance to determine the effectiveness of these interventions. Therefore this study, focusing on first and second-year engineering students, aims to gain insight in the use of and relation between two methods for measuring self-regulation competencies: a validated self-reported questionnaire on self-regulation competencies and summative scores on students' self-reflection report. Students' mean scores on the questionnaire were compared across the different summative scores (A/B/C score Critical and A/B/C score Concrete) and across the year of study programme (first year and second year) by use of ANOVA and t-tests. Few significant differences are found, but two general trends are interesting to examine further: (1) Students with the highest summative scores do not report the highest self-regulation competencies, and (2) Second-year students have overall a higher self-reported level of self-regulation competencies in comparison with first-year students and a higher percentage of second-year students obtain the highest summative score on their self-reflection. In the next steps of this research, interventions focusing on self-regulation will be developed and implemented in the curriculum. When determining the effectiveness of these interventions both measurement methods will be used. However, statistical methods will be explored to control for the Dunning-Kruger effect, seen in the self-reported questionnaires and students' possible natural growth in self-regulation competencies will be taken into account as well.

KEYWORDS

Self-regulation, lifelong learning competencies, assessment, self-reported perceptions, Standard: 11

INTRODUCTION

Lifelong learning is an explicit part of the outcomes in the European Higher Education Area (EHEA) where all university graduates must “have the learning skills to allow them to continue to study in a manner that may be largely self-directed or autonomous” (European Qualifications Framework 2005). It is therefore the responsibility of higher education to deliver graduates who are ready for lifelong learning (LLL). The latter is also confirmed by Martinez-Mediano & Lord, (2012, pg. 130): “Universities play a critical role in promoting lifelong learning through research on the topic, training of teachers to believe in the importance of lifelong learning and serving as role models and providing learning experiences which encourage students to continue learning throughout their lives.”

LLL is, however, a container concept and there is no agreement yet about what lifelong learning entails precisely (Cruz et al., 2020; Qanbari Qalehsari et al., 2017). Fortunately, there is no doubt about the importance of LLL and the responsibility that Higher Education Institutions (HEIs) hold to guide and support students in the development of LLL competencies so that each graduate is prepared for a life full of learning. In their systematic review about competency methods in engineering education, Cruz et al. (2020) list the most frequently used criteria for lifelong learning competencies in engineering: self-reflection (17 studies), locating and scrutinizing information (16 studies), willingness, motivation, and curiosity to learn (11 studies), creating a learning plan (10 studies), and self-monitoring (6 studies).

Combining three of the competencies, mentioned above as creating a learning plan, self-monitoring, and self-reflection, results in the concept self-regulation. The most cited self-regulation model, according to the comparative review of Panadero (2017), is the model of Zimmerman (2000). Zimmerman (2000) distinguishes three action phases: (1) forethought, (2) performance/volitional control, and finally (3) self-reflection. Self-regulation is considered as a core competency for LLL (Clark, 2012; Naeimi et al., 2019; Schober et al., 2007) and in their study, Lord et al. (2012) even suggest that in an education context self-regulation is a proxy for LLL.

In a scoping review focusing on what HEIs can do to support students’ in the development of LLL competencies, Van den Broeck et al. (2022) conclude that almost all interventions focus on a student-centred approach. This student-centred approach is implemented via a specific teaching method, or via the focus on self-regulation and reflection, or via the use of peer and self-assessments. This is not unusual, since being prepared for lifelong learning is indeed a personal matter which starts from the individual. These results also show that self-regulation is not only a core LLL competency, but also a malleable one. Consequently, HEIs can develop interventions to support the development of students’ self-regulation competencies. It is, however, of paramount importance to determine if these interventions are effective and thus to gain insight in how students’ self-regulation competencies can be measured.

Validated self-assessment instruments are often used to evaluate effectiveness (Khamis et al., 2020; Torres et al., 2017). Although these instruments are widely used, it is important to take into account a possible difference between a self-assessment and an external assessment (Bradley et al., 2022). This is known as the Dunning-Kruger Effect, in which low performers overestimate their competencies and high performers underestimate their competencies (Dunning, 2011).

The current study aims to determine if there is a difference between engineering students’ perceived self-regulation competencies and the summative scores on their self-reflection reports. In addition, this study will analyse if there are differences between first-year and second-year engineering students. The research questions are the following:

> **RQ1.** To which extent is a relationship present between students' summative scores on self-reflection reports and their self-reported self-regulation competencies?
>
> **RQ2**. Are there differences between first-year and second-year students' self-regulation competencies, both students' summative scores on self-reflection reports and students' self-reported competencies?

METHOD

Context and participants

The present study includes first and second year engineering students from the Faculty of Engineering Technology, KU Leuven (Belgium). The Faculty of Engineering Technology implemented a complete curriculum reform, with a first cohort starting in the academic year 2020-2021. One of the focal points of this new curriculum is the increased importance of professional competencies (Langie et al., 2022). Throughout the Bachelor's programme, students follow lectures about professional competencies. Moreover, these professional competencies such as communication, leadership, project management, team dynamics, etc., are not only 'taught' in the lectures, but also 'trained' and 'evaluated' during the regular courses such as laboratories and projects. With competency development being a continuous process, where knowledge, attitudes, and skills become more and more intertwined (OECD, 2018), it is important to provide students with handholds to keep track of their progress. At one of the campuses of the Faculty of Engineering Technology it was therefore decided to implement an e-portfolio, with different self-reflection assignments, for students.

Data collection

Summative scores on self-reflection reports

The problem-based learning courses in which the data were collected spanned the full second semester (12 weeks) of the academic year 2021-2022. Apart from technical reporting, students had to contribute to peer feedback, focusing on professional competencies (e.g. communication and teamwork), and had to write self-reflection reports. The first-year students had to write three self-reflection reports, evenly spread across the semester. The second year students had to write one self-reflection report in the middle of the semester. Students received an A/B/C score on how critical and concrete they were in their self-reflection reports. For the first-year students, a weighted score for the three self-reflection reports was calculated. Students who did not submit their self-reflection reports received an NA, resulting in a score of zero on that part of the course.

Self-reported self-regulation competencies

During one of the professional competencies lectures, students were asked to fill out a survey. Students' perceptions about self-regulation competencies were measured via the Self-Reflection and Insight Scale (SRIS). This survey of (Grant et al., 2002) measures: (1) Self-reflection, which combines the two scales engagement in reflection (6 items) and need for reflection (6 items), and (2) Insight (8 items). Students answered each item on a five point Likert scale (1= Totally disagree, 5= Totally agree).

Analysis

Students' mean scores of the overall SRIS and of the three subscales were compared across the different summative scores (A/B/C score Critical and A/B/C score Concrete) and across the year of study programme (first year and second year) by use of ANOVA and t-tests. Assumptions were checked via Shapiro-Wilk tests (for normality) and Levene's tests (for equality of variances). To gauge the effect sizes, Cohen's d was calculated. A chi-square test of independence was performed to examine the relation between year of study programme and the summative scores on self-reflection reports.

RESULTS

Of the 72 first-year engineering students, a total of 49 completed the SRIS (response rate = 68%). Of these 49 students, four students did not submit their self-reflection reports, resulting in a total of 45 complete datapoints (response rate = 63%). Of the 55 second-year engineering students, a total of 39 completed the SRIS (71%). Four students did not submit their self-reflection reports, resulting in a total of 35 complete datapoints (response rate = 64%).

Table 1. First-year engineering students' self-regulation competencies

First-year			SRIS		Engagement		Need		Insight	
Reflection	Score	n (%)	M	SD	M	SD	M	SD	M	SD
Critical	A	15 (33%)	3.00	0.54	2.87	0.88	2.92	0.68	***3.15***	***0.60***
	B	21 (47%)	3.42	0.52	3.29	0.77	3.13	0.81	***3.74***	***0.52***
	C	9 (20%)	3.25	0.58	3.11	0.89	3.22	0.56	3.38	0.66
Concrete	A	15 (33%)	3.09	0.55	3.00	0.81	3.02	0.65	***3.21***	***0.59***
	B	21 (47%)	3.41	0.56	3.28	0.86	3.13	0.85	***3.71***	***0.58***
	C	9 (20%)	3.13	0.53	2.93	0.83	3.04	0.52	3.35	0.62

First-year students' self-regulation shows significant differences, with large effect sizes, on the Insight scale for both the Critical and Concrete score of students' self-reflection. Students with a Critical score B (n=21, M=3.74, SD=0.52) report significant higher Insight competencies (p=.013, Cohen's d=1.09) compared to students with a Critical score A (n=15, M=3.15, SD=0.60). The same significant difference (p= .05, Cohen's d=0.88) is found between students with a Concrete score B (n= 21, M=3.71, SD=0.58) and a Concrete score A (n=15, M=3.21, SD=0.59).

Second-year students' self-regulation shows significant differences, with large effect sizes, on the Engagement scale for the Concrete score of students' self-reflection. Students with a Concrete score A (n=15, M=3.48, SD=0.56) report significant higher Engagement competencies (p=.025, Cohen's d=1.17) compared to students with a Concrete score B (n=12, M=2.74, SD=0.77). A similar significant difference (p=.016, Cohen's d=1.24) is also found between students with a Concrete score C (n=8, M=3.77, SD=1.03) and Concrete score B.

Table 2. Second-year engineering students' self-regulation competencies

Second-year			SRIS		Engagement		Need		Insight	
Reflection	Score	n (%)	M	SD	M	SD	M	SD	M	SD
Critical	A	18 (51%)	3.22	0.43	3.14	0.76	3.19	0.68	3.3	0.69

	B	8 (23%)	3.79	0.55	3.73	0.84	3.88	0.75	3.78	0.64
	C	9 (26%)	3.42	0.69	3.2	0.97	3.35	0.93	3.64	0.81
Concrete	A	15 (43%)	3.34	0.37	***3.48***	***0.56***	3.41	0.64	3.18	0.59
	B	12 (34%)	3.23	0.46	***2.74***	***0.77***	3.15	0.74	3.67	0.77
	C	8 (23%)	3.77	0.87	**3.77**	**1.03**	3.69	1.09	3.83	0.74

No significant differences in SRIS scores were found between the first-year and second-year students, grouped by A, B, or C scores (e.g. no significant differences were found between the SRIS mean scores of first-year students with a critical score A and SRIS mean scores of second-year students with a critical score A).

The Chi² test found that the relation between year of study programme and the summative scores on self-reflection reports (A/B/C score) was not significant for both the Critical score (X^2 (2, N=80)= 1.28, p= .5263) and the Concrete score (X^2(2, N=80)=4.93, p=.0851).

DISCUSSION

A growing emphasis on and more explicit attention towards professional competencies in engineering curricula in good and much needed (Passow & Passow, 2017). This raises, however, questions about assessing all these professional competencies in an objective manner. Research about competency measurement in higher education is therefore evolving, but not yet completed (Zlatkin-Troitschanskaia et al., 2015). In their systematic review, Cruz et al. (2020), provide an overview of the existing methods to assess competencies. They discuss seven different methods: questionnaires, rubrics, tests, observations, interviews, portfolios, and reflections. Questionnaires and rubrics were used in the majority of the included studies. This study uses both a validated questionnaire (SRIS) and a rubric to assess the quality of students' self-reflection reports.

It can be hypothesized that a positive relationship exists between students' summative scores on their self-reflection reports and their self-reported self-regulation competencies, i.e. that students with a higher summative score report a higher level of mastery for these competencies. It turns out that this is not the case, as students with the highest summative score (i.e. score A) do not have the highest self-reported level of competencies.

If the aim is to assess students' self-regulation competencies after implementing interventions focusing on the development of these competencies, it will be important to select proper assessment methods. Currently, the use of the SRIS is questionable, since the Dunning-Kruger effect is present. An example is shown in Figure 1, which represents second-year students' mean score on Engagement for the three summative Concrete scores on their self-reflection reports. The low achievers, i.e. students who received a Concrete score C, report the highest level of self-regulation competencies. The high achievers, i.e. students with a Concrete score A, report higher level of self-regulation competencies than the moderate achievers, i.e. students with a Concrete score B, but still lower than the ones with a Concrete score C.

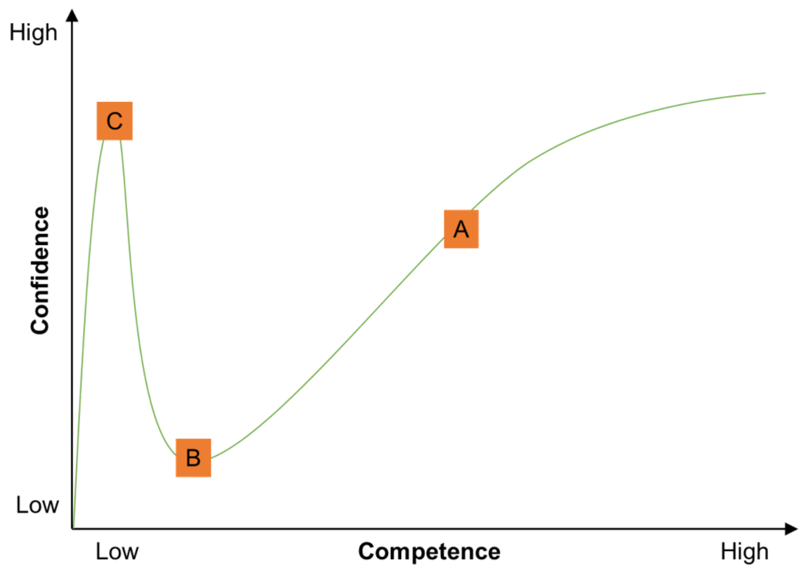

Figure 1. Dunning-Kruger effect: Second-year students' mean scores on the Engagement scale & self-reflection Concrete scores

Kruger & Dunning (1999) stated that the competencies required to achieve a particular competence level are the same competencies needed for an accurate assessment of that specific competence. To tackle this, it would be interesting to explore which statistical methods can be used to control for this effect (Gignac & Zajenkowski, 2020).

With competency development being a continuous process (OECD, 2018), it is expected that students' competencies develop throughout the study programme. In general, second-year engineering students report a higher level of self-regulation competencies. However, no significant differences were found. There is a higher percentage of second-year students with an A-score on their self-reflection reports, but no significant differences were found when the distributions of scores were compared across cohorts. At this time, it is not possible to make hard conclusions about the presence of a natural growth, nor about changes in population. Nevertheless, it will be interesting to collect more data and gain more insight into students' self-regulation competencies development. In addition, to really grasp competency development, there is a need for longitudinal research (Van den Broeck et al., 2022).

In the next steps, interventions will be piloted and their effectiveness will be measured, with both quantitative and qualitative measurements. This mixed-method approach is crucial to put the effectiveness of interventions into perspective and thus not only rely on self-reporting methods.

CONCLUSION

If HEIs aim to develop interventions to improve students' lifelong leaning competencies, it is important to define which measurement methods can be used to properly assess students' competencies. This study examined two measurements methods: a self-reported validated questionnaire and the use of a rubric resulting in summative scores. Analysing the self-reported competencies of the students shows that the Dunning-Kruger effect is present. Analysing the summative scores shows that there is possibly natural growth present or that maybe the population has changed. All in all, both methods have their limitations and therefore the use of a mixed-method approach is crucial when determining the effectiveness of interventions.

FINANCIAL SUPPORT ACKNOWLEDGEMENTS

The author(s) received no financial support for this work.

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BIOGRAPHICAL INFORMATION

Dr. Lynn Van den Broeck holds a master's degree in Chemical Engineering Technology and a PhD in Engineering Education Research. Her PhD research focused on improving the guidance and support of transfer students in Engineering via the development of a validated diagnostic test and effective interventions. Currently, she is a postdoc in the research group ETHER (Engineering Technology Education Research) and her research interests focus on study guidance, effectiveness and efficiency of educational interventions, LLL and professional competencies, and feedback.

Rani Dujardin is a PhD researcher and holds a MSc in Theoretical and Experimental Psychology. During her Master's at UGhent, Rani conducted several research projects with the common theme of the role of personality in school performance. After graduating in 2022, she started as a PhD student at KU Leuven in the research group ETHER (Engineering Technology Education Research). Currently, she dedicates her time to the TRAINeng-PDP project on the subject of lifelong learning and the personal development of engineering students.

Shandris Tuyaerts joined the ETHER research group as a PhD candidate in October 2022. She combines her background in Engineering Science (Computer Science) with her passion for education in the topic of engineering education. In context of the REFL³ECT project, she researches lifelong learning for engineers, with a focus on self-regulation.

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