

Students' Self-Evaluation of Learning Outcomes in Control Engineering Courses of the Post-Bologna Reform at the University of Ljubljana

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Abstract. The paper analyses the students' self-evaluation of learning outcomes for the Control Engineering (academic level program) and Fundamentals of Control Engineering (professional level program) courses at the University of Ljubljana, Faculty of Electrical Engineering, after the implementation of the Bologna reform. The students predicted their written exam and colloquium results before and after each assessment, rounded to 10 percentage points. The data for the 2011/2012 to 2024/2025 study period reveal the presence of the Dunning-Kruger effect with the lower-performing students overestimating and the high-performing students underestimating their results. The study compares three periods: the early post-Bologna (2011/2012–2014/2015), pre-pandemic (2015/2016–2018/2019), and post-pandemic (2019/2020–2024/2025) period. The self-evaluation accuracy improved over time, particularly in the post-pandemic period, despite fewer self-evaluation instances due to the increased project-based assessments. The academic program students outperformed the professional program students in the achieved results, likely due to their stronger mathematical skills, and demonstrated more accurate self-evaluations, possibly due to their broader educational background. The findings highlight the self-evaluation role in enhancing learning outcomes and provide guidance for improving the engineering education.

Keywords: Self-evaluation, assessment, students, learning outcomes, control engineering, Dunning-Kruger effect, Bologna reform

Študentska samoevalvacija učnih izidov pri predmetih s področja regulacijske tehnike po bolonjski prenovi na Univerzi v Ljubljani

Prispevek obravnava študentsko samoevalvacijo učnih izidov na Univerzi v Ljubljani, Fakulteti za elektrotehniko, za predmet Regulacijska tehnika (RT) v 3. letniku na dodiplomskem univerzitetnem študijskem programu prve stopnje Elektrotehnika, na smeri Energetika in mehatronika, in za predmet Osnove regulacijske tehnike (ORT) na dodiplomskem visokošolskem strokovnem študijskem programu prve stopnje Aplikativna elektrotehnika, na smeri Energetska tehnika in avtomatizacija postrojev. Samoevalvacija pri navedenih predmetih se izvaja tako, da študenti predvidijo svoj pisni izpitni in kolokvijski rezultat tik pred izpitom in takoj po njem, zaokroženo na 10 odstotnih točk. Pri študentski samoevalvaciji je sicer Dunning-Krugerjev učinek [1-5] zaznala že prva tovrstna raziskava na predbolonjskih študijskih programih [6], njeno nadaljevanje [7] pa je pokazalo, da so rezultati samoevalvacije po bolonjski prenovi boljši, kar pomeni, da so s strani študentov napovedani rezultati manj odstopali od njihovih dejanskih dosežkov. V prispevku so predstavljeni podatki o samoevalvaciji od 2011/2012 do 2024/2025, ki prav tako razkrivajo Dunning-Krugerjev učinek, pri čemer študenti s slabšim uspehom precenjujejo svoje dosežene rezultate, študenti z boljšim uspehom pa jih podcenjujejo. Študija primerja tri zaporedna obdobja: zgodnje postbolonjsko (2011/2012–2014/2015), predpandemsko (2015/2016–

2018/2019) in postpandemsko (2019/2020–2024/2025).

Rezultati kažejo, da se je natančnost samoevalvacije sčasoma izboljšala, zlasti po pandemiji, čeprav v tem obdobju opazamo nekaj anomalij. Študenti univerzitetnega programa so v vseh treh obdobjih dosegali boljše rezultate od študentov visokošolskega strokovnega programa, kljub temu da so vsebine na visokošolskem strokovnem programu manj poglobljene, kar je mogoče pripisati razlikam v njihovih matematičnih spretnostih.

Prehod na ocenjevanje projektnega dela študentov v obdobju po pandemiji je zmanjšal število pisnih izpitov in kolokvijev ter posledično opravljenih samoevalvacij, zato bi morale prihodnje raziskave najti možnost integriranja samoevalvacije in ocenjevanja projektnega dela, s čimer bi še izboljšali natančnost samoevalvacije in podprli prilagojene izobraževalne pristope v inženirskih študijskih programih.

Ključne besede: Samoevalvacija, ocenjevanje, študenti, učni izidi, regulacijska tehnika, Dunning-Krugerjev učinek, bolonjska reforma

1 INTRODUCTION

In education, self-evaluation is an important component of quality assurance systems. Numerous processes are assessed by applying the classical control engineering principle: detection of the actual value, its comparison with the reference value (set point), and based on the

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difference between the reference value and the actual value, the system is affected in the way to reduce this difference (error). However, in engineering, systems and their requirements are typically well-defined, making the negative feedback loops a common solution. On the other hand, the “controlled variables” in the field of education (and also in many other non-engineering fields) are much more complex and interlaced. Besides the multiple – sometimes conflicting – set points, measuring the “actual values” through regular institutional meetings or mass surveys is a time-consuming process, prone to delays, “noise”, and “disturbances”. Despite these obstacles, the feedback loops are an efficient tool in the quality assurance.

Among the self-evaluations commonly conducted in education [1], the students' self-evaluation of the knowledge tests verifies their achievement of the desired learning outcomes. At the tertiary level of education, the students are expected to objectively evaluate their learning outcomes due to an appropriate prior training [2, 3]. Nevertheless, in this type of the self-evaluation, the so-called Dunning-Kruger effect [4] is often noticed. Namely, the students who are assessed by evaluators as below average usually give themselves a higher grade than their actual grade. The same applies to the students who achieve above-average results. They rate themselves worse than the evaluator. This effect cannot be avoided even in the self-evaluations of the students who are studying to become teaching professionals, although their assessment competencies are already quite well developed and certainly better than those of the students from non-educational study programs [5].

The author of the paper is in charge of the courses that cover the field of the control engineering for the students of the Power Engineering options at the University of Ljubljana, Faculty of Electrical Engineering. A noticeable decline in the average written exam and colloquium results, coupled with weaker student preparedness for oral examinations, indicated declining learning outcomes in these courses. With the upcoming Bologna reform, we were in a search for measures that could systematically improve the situation, especially in the forthcoming new study programs. A small step taken in this direction was the introduction of the students' self-evaluation at written examinations and colloquia. The first self-evaluation gave a clear indication of the Dunning-Kruger effect that was more pronounced for the students of the professional study programs compared to the students of the academic level study programs [6]. Continued research led to a comparison between the self-evaluation results for the students before and after the significant change in study programs introduced by the Bologna reform [7]. The students' self-evaluation after the Bologna reform has been significantly better than for the students of the older study programs. Their self-evaluation results differ less from their achieved results

than of their predecessors. This can be attributed to a significant reduction in the number of enrolment places for the electrical engineering study programs after the implementation of the Bologna reform, because the students who only needed their status were no longer enrolling.

In this paper, further results of the self-evaluation are presented, taking into account the students of both the academic and the professional level first cycle Electrical Engineering study programs after the implementation of the Bologna reform. The following three consecutive time intervals are considered: early study years after the Bologna reform implementation (2011/2012–2014/2015), pre-pandemic study years (2015/2016–2018/2019), and post-pandemic study years (2019/2020–2024/2025).

2 METHODOLOGY OF STUDENTS' SELF-EVALUATION

Before their written exam or colloquium, the students are asked to take one minute to estimate their anticipated results based on their preparedness, rounded to 10 percentage points. Before the implementation of the Bologna reform, the students were required to forecast their results rounded to 5 percentage points. As the most of the predictions were rounded to 10 percentage points, the rounding requirement was changed to 10 percentage points.

After completing their written exam or colloquium, the students are asked to take another one minute to reestimate their results based on their actual experience, rounded to 10 percentage points.

Before the Bologna reform, the third phase of the self-evaluation followed. Namely, after reviewing and scoring the examination papers, the students were invited to see the unexamined and unscored copies of their examination papers. They were given a detailed scoring plan with correct answers and solutions. They were then asked to evaluate their own examination papers according to the scoring plan and compare their originally revised exam sheet with their self-evaluation [6]. Unfortunately, due to the time constraints, this procedure was discontinued after the introduction of the revised study programs. Regardless of their written examination results, the students are still invited to attend the oral exams. They are given the scoring plan so that they can thoroughly check how their performance in the written part of the exam is evaluated. The discussion with the student while viewing the written exam results continues into the oral part of the examination. This process also helps students in developing their broader communication competence. A direct impact of this insight to the written exam and the following discussion provides an in-depth and consistent correction of possible errors in the assessment of the student's written examination. The experience helps developing more appropriate exam

questions and tasks and makes the scoring plans properly balanced.

3 SELF-EVALUATION RESULTS AND DISCUSSION

At the University of Ljubljana, Faculty of Electrical Engineering, there are two first-cycle study programs of electrical engineering following the implementation of the Bologna reform: the academic level program and the professional level program, each lasting three years with the total of 180 credit points, compliant with the European Credit Transfer and Accumulation System (ECTS). The students of the *Power Engineering and Mechatronics* option within the first-cycle academic level program have the compulsory Control Engineering (CE) course in the 5th semester. On the other hand, the students of the *Power Engineering and Plant Automation* option within the first-cycle professional level program have the compulsory Fundamentals of Control Engineering (FCE) course in the fourth semester. For the observed study years (2011/2012–2024/2025), the number of the students enrolling the Control Engineering course for the first time, varied from 22 to 45 per year (on average 30), and the number of students that enrolled the Fundamentals of Control Engineering course for the first time, varied from 16 to 51 per year (on average 29).

The research takes into account the students' self-evaluation of all written exams and colloquia for the Control Engineering and Fundamentals of Control Engineering courses after the adoption of the Bologna reform, i.e., from the 2011/2012–2024/2025 study years. Exceptions that could distort the overall picture, for example, the students who registered for the exam but did not take it without providing a justifiable reason are not taken into account; they received a 0% score in the written exam record.

Table 1 presents the achieved exam results, the students' self-evaluation prior to the written exam, and the students' self-evaluation after taking the written exam, for the Control Engineering and Fundamentals of Control Engineering courses for the 2011/2012–2024/2025 study years. The achieved results for the Fundamentals of Control Engineering course in the professional level study program are approximately 15% lower than for the Control Engineering course in the academic level study program. Although the knowledge required for Fundamentals of Control Engineering course is less in-depth than for Control Engineering course, professional program students' weaker mathematical skills – due to taking only two mathematics courses compared to four in the academic program – contribute to their lower results. Also, more

students of the professional level program take their exam without a proper preparation. This can be seen from Figures 1 and 2, where the self-evaluation results prior and after the exam are shown together with the achieved exam results for the Control Engineering and Fundamentals of Control Engineering courses, respectively.

On average, the difference between the self-evaluation and the achieved results (rows B–A and C–A in Table 1) is significantly lower for the Control Engineering course students (1.39% and 1.86%) than for the Fundamentals of Control Engineering course students (8.90% and 3.16%). This could be due to the wider educational background of the students of the academic level program, so they can carry out a more accurate self-evaluation. However, the Dunning-Kruger effect has to be considered, as it is evident that the students of the professional level program have much higher expectations prior to the exam. This particularly applies to the students who are not well prepared, as they rarely set their self-evaluation prior to the exam below 50% (Figure 2, left side). If there is an overestimation in the self-evaluation prior to the exam for the students achieving the exam results below the average or even negative (below 50%), the Dunning-Kruger effect is also noticed for the students with the best achieved results, but in the opposite direction. They quite frequently underestimate themselves not only prior to the exam, but also after the exam. Moreover, the phenomenon is more pronounced for the students of the Control Engineering course (see Figure 1, right side).

The distribution of the self-evaluation (prior and after the exam) and the achieved exam results for the Control Engineering (Figure 3, left) and for the Fundamentals of Control Engineering course (Figure 3, right) is shown for all the written examinations and colloquia in the 2011/2012–2024/2025 study years.

As the time after the adoption of the Bologna reform is quite long, the paper reviews separate results for three consecutive time intervals: early study years after the adoption of the Bologna reform (2011/2012–2014/2015), pre-pandemic study years (2015/2016–2018/2019), and post-pandemic study years (2019/2020–2024/2025). Despite it may be seen that these three time intervals are determined arbitrarily, the pandemic period lead to some major changes in the teaching and learning process and the necessity of using new approaches to the assessment of the students learning outcomes, e.g., by evaluating their work on project tasks. Consequently, the number of the self-evaluations for the written exams and the colloquia is reduced for the post-pandemic interval.

Table 1: Achieved and self-evaluation results for written exams and colloquia in Control Engineering (academic) and Fundamentals of Control Engineering (professional) courses, 2011/2012–2024/2025. Note: STD = Standard Deviation.

		Control Engineering			Fundamentals of Control Engineering		
		Number of students	Average (%)	STD	Number of students	Average (%)	STD
Achieved result	A	744	72.82	20.33	808	57.53	26.01
Self-evaluation prior to the exam	B	744	74.21	11.75	808	66.44	13.29
Self-evaluation after the exam	C	744	74.68	17.25	808	60.69	20.10
Difference of self-evaluation prior	B–A	744	1.39	18.76	808	8.90	24.31
Difference of self-evaluation after	C–A	744	1.86	16.02	808	3.16	18.11

Table 2: Achieved and self-evaluation results for written exams and colloquia in Control Engineering (academic) and Fundamentals of Control Engineering (professional) courses, 2011/2012–2014/2015. Note: STD = Standard Deviation.

		Control Engineering			Fundamentals of Control Engineering		
		Number of students	Average (%)	STD	Number of students	Average (%)	STD
Achieved result	A	284	72.28	20.56	395	53.08	24.60
Self-evaluation prior to the exam	B	284	75.28	11.61	395	66.20	14.13
Self-evaluation after the exam	C	284	75.88	17.06	395	58.84	19.70
Difference of self-evaluation prior	B–A	284	3.00	18.06	395	13.12	23.50
Difference of self-evaluation after	C–A	284	3.60	15.27	395	5.75	16.85

Table 3: Achieved and self-evaluation results for written exams and colloquia in Control Engineering (academic) and Fundamentals of Control Engineering (professional) courses, 2015/2016–2018/2019. Note: STD = Standard Deviation.

		Control Engineering			Fundamentals of Control Engineering		
		Number of students	Average (%)	STD	Number of students	Average (%)	STD
Achieved result	A	257	70.60	20.63	170	61.04	26.86
Self-evaluation prior to the exam	B	257	74.94	11.51	170	70.29	9.54
Self-evaluation after the exam	C	257	73.46	18.10	170	64.71	19.74
Difference of self-evaluation prior	B–A	257	4.34	18.24	170	9.25	24.62
Difference of self-evaluation after	C–A	257	2.86	16.58	170	3.66	17.35

Table 4: Achieved and self-evaluation results for written exams and colloquia in Control Engineering (academic) and Fundamentals of Control Engineering (professional) courses, 2019/2020–2024/2025. Note: STD = Standard Deviation.

		Control Engineering			Fundamentals of Control Engineering		
		Number of students	Average (%)	STD	Number of students	Average (%)	STD
Achieved result	A	203	76.37	19.09	243	62.32	26.42
Self-evaluation prior to the exam	B	203	71.77	11.90	243	64.12	13.53
Self-evaluation after the exam	C	203	74.53	16.25	243	60.91	20.57
Difference of self-evaluation prior	B–A	203	-4.60	19.02	243	1.80	23.73
Difference of self-evaluation after	C–A	203	-1.84	15.72	243	-1.41	19.65

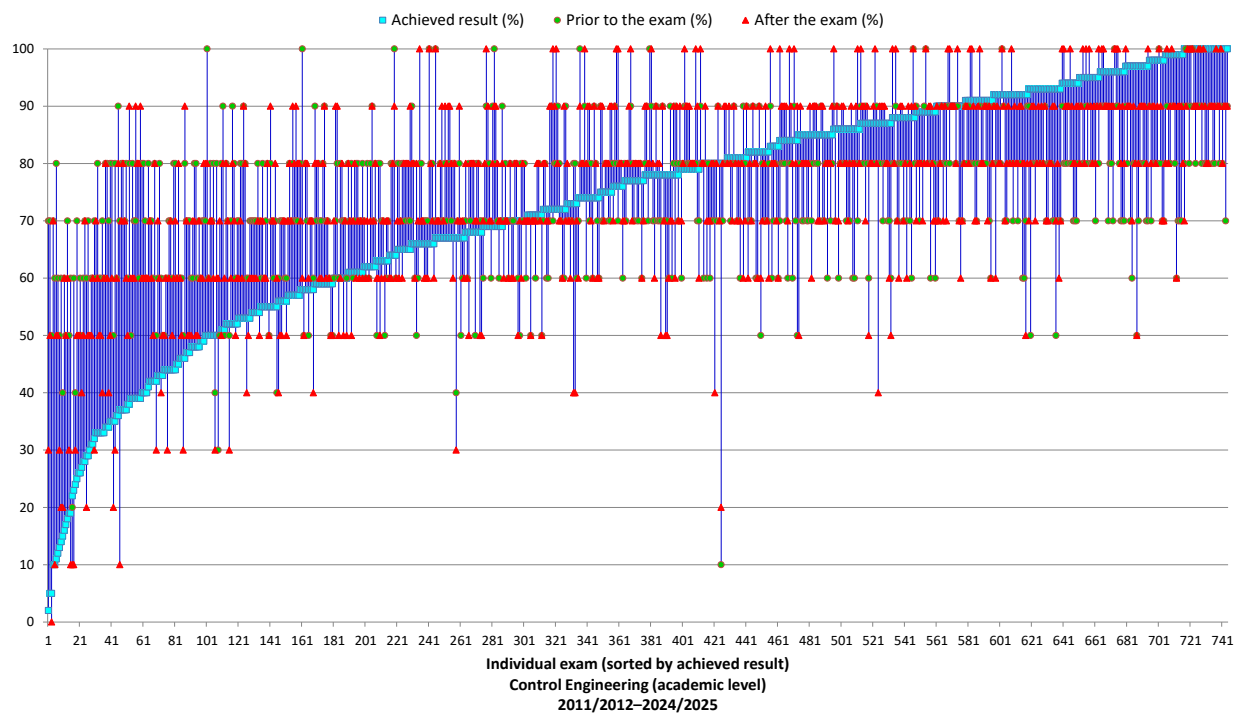


Figure 1. Self-evaluation and achieved exam results for the Control Engineering course (academic level), 2011/2012–2024/2025.

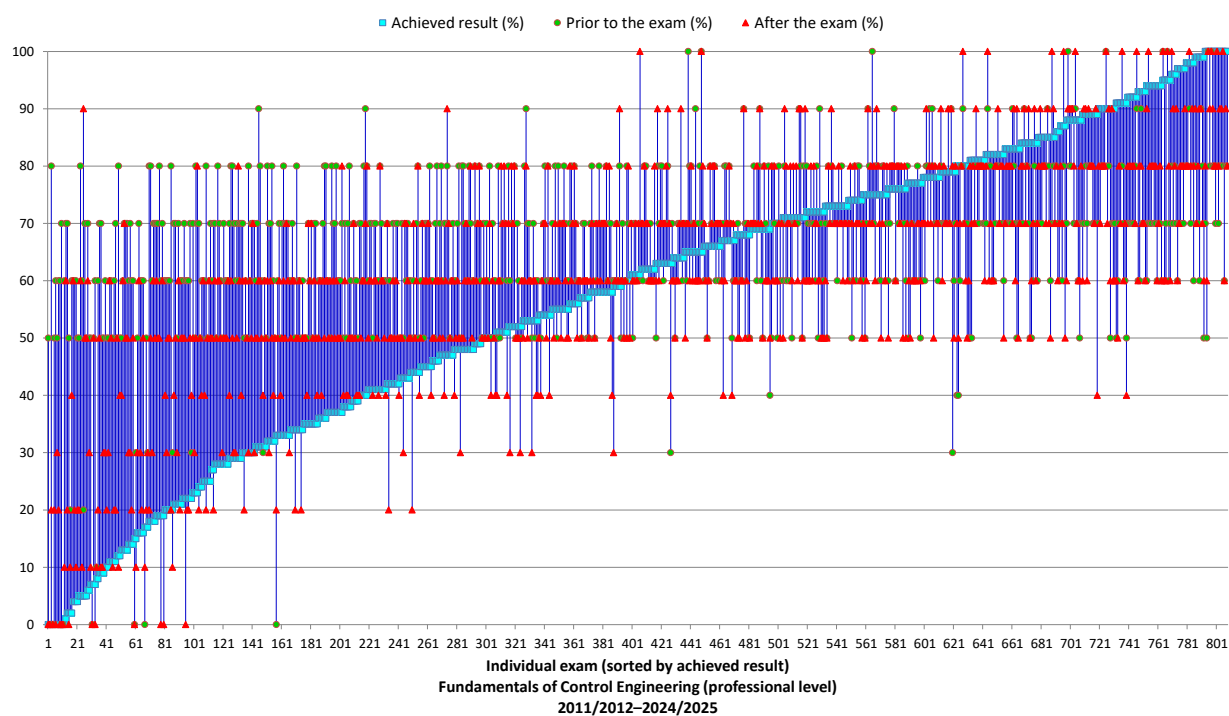


Figure 2. Self-evaluation and achieved exam results for the Fundamentals of Control Engineering course (professional level), 2011/2012–2024/2025.

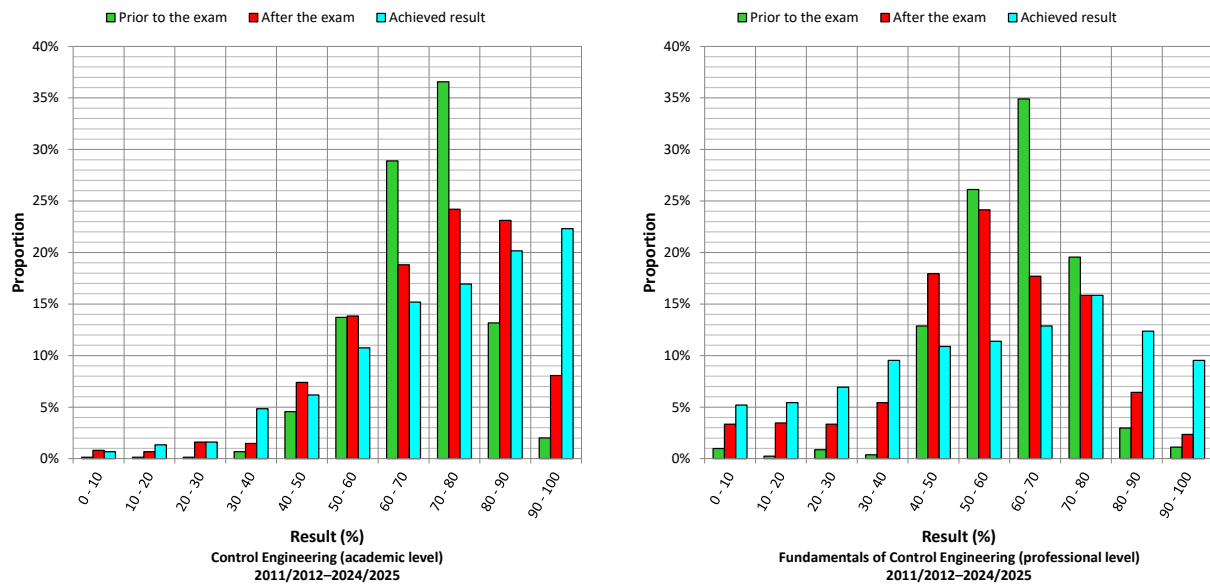


Figure 3. Distribution of self-evaluation and achieved exam results for the Control Engineering course (academic level, left) and for the Fundamentals of Control Engineering course (professional level, right), 2011/2012–2024/2025.

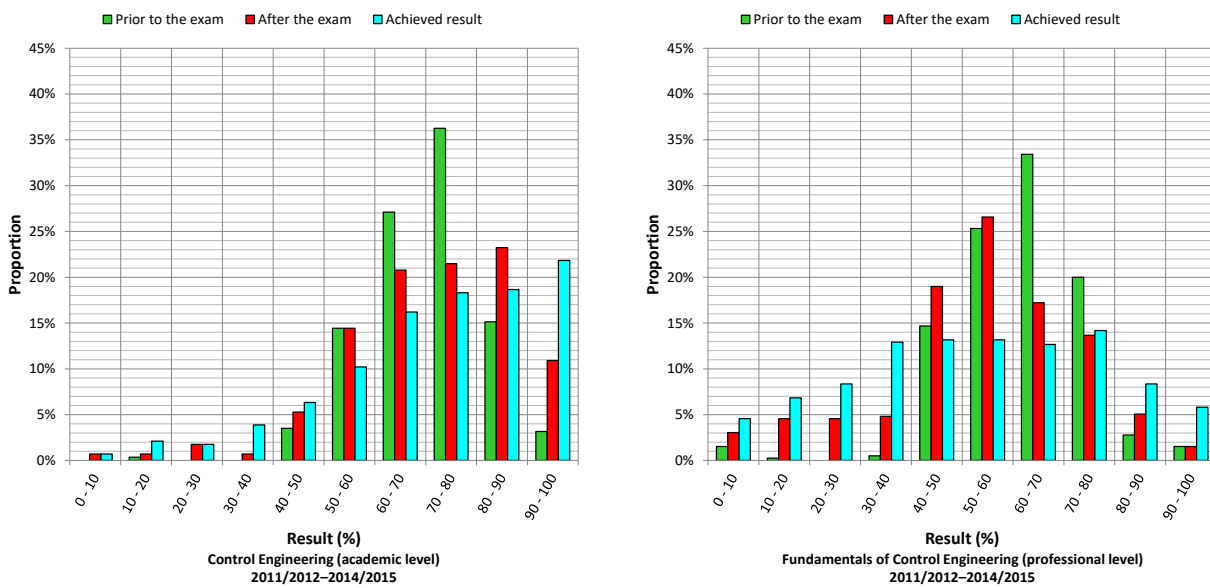


Figure 4. Distribution of self-evaluation and achieved exam results for the Control Engineering course (academic level, left) and for the Fundamentals of Control Engineering course (professional level, right), 2011/2012–2014/2015.

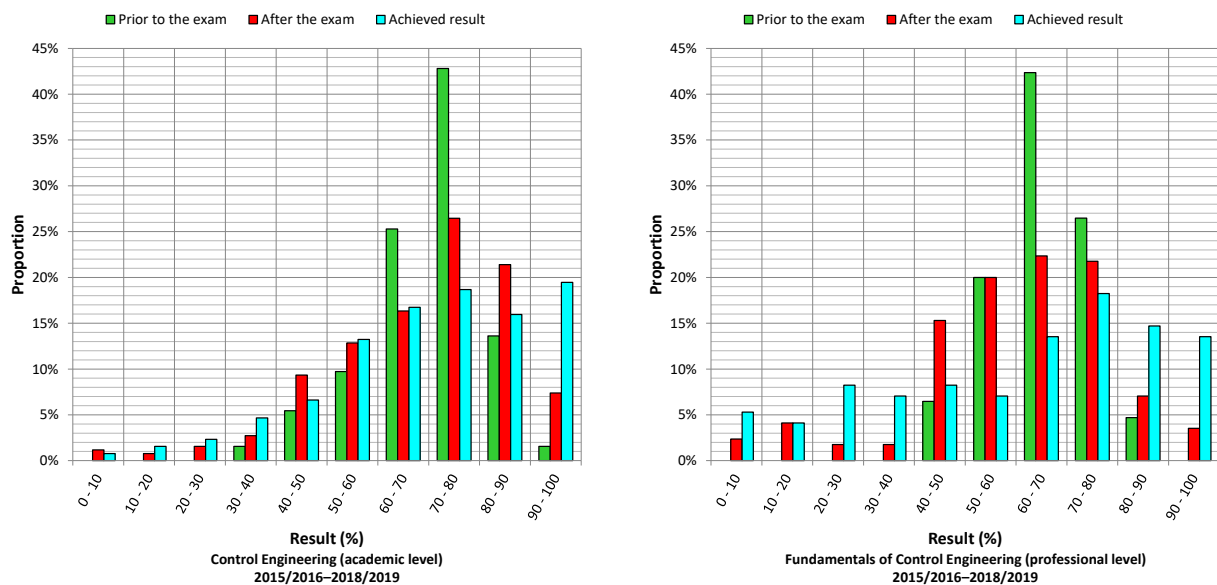


Figure 5. Distribution of self-evaluation and achieved exam results for the Control Engineering course (academic level, left) and for the Fundamentals of Control Engineering course (professional level, right), 2015/2016–2018/2019.

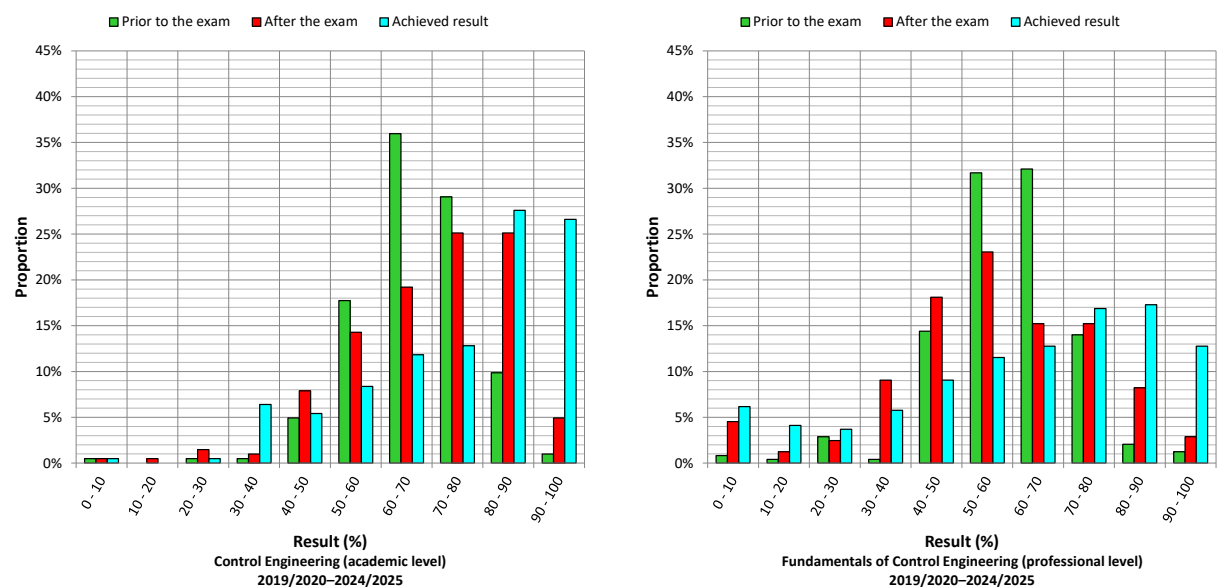


Figure 6. Distribution of self-evaluation and achieved exam results for the Control Engineering course (academic level, left) and for the Fundamentals of Control Engineering course (professional level, right), 2019/2020–2024/2025.

3.1 Students' Self-evaluation Results for the 2011/2012–2014/2015 Study Years

Table 2 shows the written exam results and the students' self-evaluations for the Control Engineering and Fundamentals of Control Engineering courses for the 2011/2012–2014/2015 study years. These early years after the adoption of the Bologna reform show a larger difference in the achieved results between the academic and the professional program students (19%) than for the entire post-Bologna period average (15%, Table 1). The difference between the self-evaluation and the achieved results (rows B–A and C–A in Table 2) is lower for the students of the academic level program

(3.00% and 3.60%) than for the students of the professional level program (13.12% and 5.75%). These figures are higher than average for the entire 2011/2012–2024/2025 period (Table 1). Distribution of the self-evaluation (prior to the exam and after it) and the achieved exam results for both courses for the 2011/2012–2014/2015 study years is shown in Figure 4. Again, the Dunning-Kruger effect is pronounced.

3.2 Students' Self-evaluation Results for the 2015/2016–2018/2019 Study Years

In later years after the implementation of the Bologna reform (2015/2016–2018/2019; Table 3), the difference in the achieved results between the students of the

academic level and the professional level program (10%) is lower than in the previous interval (2011/2012–2014/2015; Table 2). The difference between the self-evaluation and the achieved results (rows B–A and C–A in Table 3) is again lower for the students of the academic level program (4.34% and 2.86%) than for the students of the professional level program (9.25% and 3.66%). Compared to the previous interval (2011/2012–2014/2015; Table 2), the self-evaluation accuracy improves, with the majority of the differences reduced. In Figure 5, where the Dunning-Kruger effect is evident, no students of the professional level program set their self-evaluation prior to the exam below 50%.

3.3 Students' Self-evaluation Results for the 2019/2020–2024/2025 Study Years

During the pandemic period, some major adaptations of the teaching and learning process were required, as well as for the assessment (examinations). Those changes which bring certain advantages to the students learning outcomes are continued even after the pandemic period. In the assessment of the students' knowledge, more emphasis is given to the students' achievements in project tasks. Consequently, the number of the written exams and colloquia has been reduced, thus contributing to a lower number of self-evaluations in the post-pandemic years, especially for the students of the academic level program.

The achieved results of the written exams in the post-pandemic period (Table 4) show a slight increase compared to the previous interval (Table 3). It is interesting to note that the difference between the self-evaluation and the achieved results (rows B–A and C–A in Table 4) is now lower for the professional program students (1.80% and –1.41%) than for the academic program students (–4.60% and –1.84%). These negative numbers indicate that all the students on average underestimated themselves in their self-evaluation before or after the exam. From Figure 6, it can be concluded that the main reason for this underestimation is the Dunning-Kruger effect, as the students with the best achieved results are very self-critical in their self-evaluations.

4 CONCLUSION

The analysis of the students' self-evaluation in the Control Engineering (academic level program) and Fundamentals of Control Engineering (professional level program) courses at the University of Ljubljana, Faculty of Electrical Engineering in the period from 2011/2012 to 2024/2025 highlights the persistence of the Dunning-Kruger effect. The lower-performing students overestimate their outcomes, while the higher-performing students underestimate theirs. The analysis of the three consecutive post-Bologna periods shows an improvement in the self-evaluation accuracy, particularly in the post-pandemic period, but with some

anomalies. The academic program students demonstrate a more accurate self-evaluation than the professional program students, likely due to their broader educational background. This suggests that a structured self-evaluation, combined with a transparent scoring and oral exam discussions that follow the written exam, enhances reflective learning and improves teaching practices. The shift towards a project-based assessment in the post-pandemic period reduces the number of the written exams and the corresponding self-evaluations, so the future research should explore the integration of the self-evaluation with the project-based assessment to further enhance the self-evaluation accuracy and to support tailored educational approaches in the engineering study programs.

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