Online Peer Assessment in Undergraduate Electrical Engineering Course

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Abstract*—*Contribution: **This research presents a case study of an online peer assessment (PA) implementation in a random processes course. Students were required to submit simulation assignments, and then to evaluate their peers' submissions. The research explored the students' perception of the activity throughout the course using surveys, and their behavior and academic performance using data obtained in the course.**

Background: **With decreased resources and larger class sizes, the obligatory theoretical random processes course in the electrical engineering program presents a challenge with regard to students' motivation and assimilation of the academic material.**

Intended Outcomes: **In preceding research, PA was found to provide benefits for students' learning, without significantly burdening teaching staff resources. The implementation was directed at achieving these benefits.**

Application Design: **Simulation exercises were designed to provide illustrations of relatively abstract material, and PA was instituted to facilitate better learning of the material without imposing greater resource requirements on the teaching staff.**

Findings: **Results indicated that PA, although executed in accordance with the best practices presented in the literature, failed to achieve the benefits expected, and might even have contributed to lower grades in the course.**

***Index Terms*—Electrical engineering education, higher education, peer assessment, student assessment.**

I. INTRODUCTION

THE INTRODUCTORY random processes course is an obligatory fundamental course in the advanced undergraduate electrical engineering program. It is often considered by students to be abstruse, irrelevant, and hard, resulting in low motivation and a high percentage of students' failure.

Seeking a remedy for this situation, it was decided to shape a more practical and illustrative course and, thus, a simulation-based pedagogical approach, as proposed by Kay's [1] textbook was adopted. For example, the result of a very simple simulation of a random walk process that illustrates the central limit theorem and results in an odd-integer-valued $\{\pm 1, \pm 3, \ldots\}$ Gaussian-like distribution is presented in Fig. 1 (simulation details are presented in Appendix A). While simulations are an excellent tool for illustrating the studied material, active learning via hands-on practice facilitates reinforcement of the theoretical material [2].

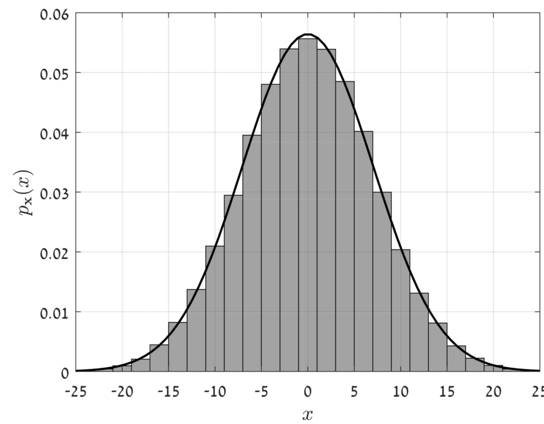

Fig. 1. Random walk simulation example with the odd-integer-valued Gaussian-like distribution result.

One of the common approaches adopted to encourage students to become familiar with simulations is to give illustrative assignments that relate between the theory and the simulation results. Providing feedback to the students and grading the assignments is an important pedagogic tool that has been found to be the most valuable [3]. Both automatic and "manual" feedback in this field are challenging and time consuming and require considerable resources.

One possible approach for providing feedback for numerous assignments is to use peer assessment (PA). In this technique, each student provides feedback and grades to a few assignments of his peers in the course. It was decided to adopt this technique due to its reported benefits in the literature (see Section II).

Two approaches were experimentally applied in the course: 1) numerical simulations and 2) PA, anticipating a synergy that will promote students' motivation and understanding while requiring no extra resources from the teaching staff.

The remainder of this article is organized as follows. The next section presents relevant research, highlighting the benefits of PA as found in the previous literature. The methodology used in the course and its evaluation is presented in Section III. Next, the results of the evaluation are presented (Section IV) and finally, these are discussed in Section V.

II. RELATED WORK

PA, a process in which individuals are rated by their peers [4], has been increasingly used in teaching, following

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the notion that multiple assessment methods, specifically those that involve the students, support the development of a more responsible and reflective student [5]. PA may be performed in numerous ways: assessment of groups or individuals, of written or oral assignments, by peers with the same or with different capabilities, performed anonymously or nonanonymously, etc. [6].

PA has been the focus of numerous studies but the use of PA in higher education has received limited attention [7]. Research on PA in engineering higher education is even scarcer [8]. Furthermore, some of the published research in the context of science and engineering is focused on assignments that are of a social science nature, such as writing reports or an essay (e.g., [9] and [10]). For example, Calibrated Peer Review, a Web-based, instructional tool for PA of writing assignments, used in hundreds of courses and discussed in tens of research studies, originated from science disciplines, but is focused on writing assignments; this is an important skill in all disciplines, but is, nevertheless, different in its nature from most assignments in engineering courses.

PA in higher education is used for two main reasons [11]. One is the reduction in teaching resources and the increase in class size, which poses unrealistic demands on instructors who wish to provide feedback to their students (e.g., [12] and [13]). The other is the advantages this pedagogy was found to provide in the previous research, such as increased motivation and involvement [14], promotion of the development of soft skills, such as self-management and communication [15, and references therein], a greater sense of accountability and greater volume, immediacy, and quality of feedback [16], [17], more time spent on the assignment (and thus more practice), enhanced learning [10], and improved learning outcomes [18]. Furthermore, some researchers claimed that PA contributes to the development of teamwork skills and is a unique setting that facilitates individual feedback in a collaborative effort (e.g., [19]–[22]).

The findings regarding the benefits above are mixed, with some negative results of PA with regard to feedback and mark accuracy and students' attitudes toward the process. Exploring the validity and reliability of grades received by peers produces inconsistent results. For example, Topping [23] found more (18) research studies that provide evidence of the reliability of PA than those (7) that found that the pedagogy produced marks significantly different from those given by instructors. Similarly, some research studies found students' attitudes toward PA to be positive, while others reported negative perceptions [5]. Furthermore, some research studies found these mixed results in the same research. For example, Cassidy [24] surveyed 41 second-year students immediately after performing PA and asked them about their feelings regarding giving and receiving assessment to and from peers. Results show that 61% of them reported they enjoyed assessing their peers and 51% felt uncomfortable with the task. Instructors have additional concerns, such as the time required for the implementation of the pedagogy [25], the motivation of students in performing the task, and the adequacy of the online platforms that support online PA [15].

In fact, it is not clear which factors best facilitate the success of an implementation of the PA pedagogy. A relatively consistent factor found in the literature addresses the competence of the assessors; specifically, training and practice are found to improve the reliability and validity of PA and positively affect student attitudes [26]. With regard to desirable matching between the assessors and the assessees, the findings are mixed and complex [27]. Findings regarding the preferable form of feedback, revealed by Strijbos *et al.* [28], drew an even more complex picture. They found that detailed feedback from competent peers was perceived to be beneficial, despite other negative effects, while concise feedback was perceived to be more effective overall. Cho and MacArthur [29] also focused on the form of feedback in PA and found that nondirective feedback was more supportive in improving the quality of the task performed. Seeking a generic approach, Topping [6] integrated results from several research studies and suggested a list of over 50 variables that should be explored in further research. Li *et al.* [30] performed meta-analysis of 69 papers regarding the accuracy of peer marks and their correlation with teacher grading and, based on Topping's earlier work and others, identified 17 variables that might affect the procedure's outcomes. They found nine variables that might enhance student's grading accuracy: 1) using paper based (not online PA); 2) nonmedical/clinical subject matter; 3) graduate-level courses; 4) addressing individual (rather than group) work; 5) randomly matching assessors and assessees; 6) making the PA voluntary; 7) nonanonymous; 8) supplying qualitative comments as well as scores; and 9) involving the students in the preparation of the rubric. Some of these findings are contrary to other research findings; for example, Panadero and Alqassab [31] performed a narrative review and found that anonymity, among other aspects, elevated students' perceptions of the learning value of PA, improved feedback, and slightly improved performance. Indeed, performing PA with a minimal negative effect, on the one hand, and making a meaningful contribution to students' learning and skill development, on the other hand, seems to be complex and clear conclusions are elusive [19]. These findings suggest that PA has several benefits to offer if incorporated into a course, but achieving these benefits is not straightforward.

III. Methodology

In this section, the methodology employed in the course is presented, followed by a description of the methodology used to evaluate the results of PA implementation in the course.

A. Peer Assessment Context and Process

The PA approach was introduced in the fall semester of the 2018–2019 academic year in a random processes course, a mandatory third-year course in the Department of Electrical Engineering in an engineering college. In order to recruit the cooperation of the students, the idea and its benefits, as well as details of the process, were presented to them at the beginning of the course. With the aim of focusing the introduction to the assignment given to the students on its pedagogical benefit, the presentation was conducted by a member of the college's

Center for Promotion of Learning and Teaching (and one of the authors of this article). Close to an hour in the lecture was devoted to answering students' questions and concerns regarding the process and the requirements.

Students were required to submit six MATLAB simulation exercises from a pool of seven exercises and provide feedback and grading to three other students for each exercise (total of 18 feedbacks). The goal of the simulation was to illustrate course material. The assignments required 10–15 lines of MATLAB code accompanied by a brief theoretical explanation. The PA was double blind, i.e., students did not know who they are assessing and who is assessing them, in order to minimize bias stemming from relationships among students [17], [32]. Students were provided with a solution and a grading rubric to guide them through the assessment. In order to keep the task short and simple, students were asked to grade and comment on their peers' work with regard to only two criteria—the theoretical calculation and the simulation itself. For each aspect, they were required to indicate their evaluation in accordance with four alternatives: 1) answer is missing; 2) answer is wrong; 3) generally correct but not completely accurate/full; and 4) completely correct and accurate. Only students that submitted an assignment were eligible to assess their peers.

A MATLAB personal-use license was provided for all students. The learning management system (LMS) used in the course was Moodle, with PA implemented using workshop activity in the module (some technical comments regarding the Moodle application for PA are presented in Appendix B). The grades of the exercises, calculated for each student as the average of the three assessments he or she received for each exercise, were 10% of the final grade in the course (6% for the exercise and 4% for the PA), while the remaining 90% were assigned to a midterm (15%) and the final exam (75%).

B. Evaluation

Three aspects of the process were examined. One was concerned with the students' perception of the process and its outcomes, the second focused on the way they conducted the PA, and the third examined the impact on academic performance.

In order to evaluate the students' perception, they were asked to fill out questionnaires three times.

1) At the beginning of the semester, after the idea of PA was introduced.
2) After submitting four assignments, performing PAs for these assignments and receiving their peer evaluation for these assignments.
3) After the final exam in the course.

The questions in the three questionnaires were identical other than the tense used (future, present, and past, respectively). The last questionnaire contained additional questions regarding the simulations, demographics of respondents (age and gender), and some reflective questions on the process. In the questionnaire, students were asked to indicate their level of agreement on a five-point Likert scale [33] ranging between 1 (totally disagree) and 5 (agree completely) regarding statements concerning the impact of the PA on learning and motivation to learn, as well as the cognitive and emotional efforts required, and their general satisfaction with the pedagogy. Students were offered compensation for the time devoted to filling out the survey in the form of two bonus points to their final grade in the course if they filled out all three questionnaires. Students were asked, but not required, to provide identifying information to facilitate the analysis of paired responses.

Next, the behavior of students as they performed the PA was examined. Specifically, the percentage of the students performing PA out of those submitting the assignment was computed and the frequency of grades assigned for each assignment was calculated.

Student performance, the third dimension of the evaluation that was explored, was evaluated compared to the previous year, as the course was being taught by the same instructor, using the same pedagogies (apart from the assignments and the PA), and covering the same material. Specifically, the correlation between the grades in the assignments (given by the teaching assistant in the previous year and by peers in the discussed semester) and the other grades in the course (midterm and final exams) were examined. Another examination explored students' general academic performance in the course compared to the performance in previous years.

IV. Results

Following the methodology presented in the previous section, students' perception of the process is presented, followed by the results of the analysis of their behavior and academic performance.

A. Students' Perception of Peer Assessment

Out of 105 students enrolled in the two cohorts of the course, 93 (88.6%) students filled out the first survey, 70 (66.7%) filled out the second, and 80 (76.2%) filled out the last survey. Students' attitudes toward the PA were generally not favorable (see Table I). The first five statements (#1– 5) that had the highest score are concerned with the negative effect of the process—the effort and resources it requires and the cognitive and emotional burden it presents. The lowest average ratings were assigned to the expected positive effect of the pedagogy—its contribution to learning and motivation, as well as general satisfaction (statements #10– 17). In between the highest scores assigned to the negative effects and the lowest scores assigned to the positive effects and general satisfaction, lie the statements regarding the students' ability to perform the PA and its quality (statements #6– 9). The average scores of these groups of statements for all three surveys and their standard deviation are detailed in Table I.

Fig. 2 presents the changes in students' perception of the contribution of PA to learning and motivation (statements #10– 12) throughout the surveys (width of objects represents the relative number of responses). Trend lines clearly indicate that students found the PA activity to have a less positive effect

TABLE I
AVERAGE SCORE AND STANDARD DEVIATION OF STATEMENTS REGARDING PEER ASSESSMENT

#	Group of statements	Statement	Average Score (std)* Survey 1	Survey 2	Survey 3	Group
1	Negative factors and effects of peer-assessment	Performing peer-assessment requires effort on my side	3.946	4.000	3.950	3.755 (0.929)
2		Performing peer-assessment is time consuming	3.903	3.843	3.913	
3		Performing peer-assessment makes me uncomfortable	3.613	3.800	3.769	
4		Performing peer-assessment is a difficult task	3.570	3.657	3.613	
5		Getting feedback and grades from my peers makes me feel uncomfortable	3.559	3.657	3.525	
6	Quality of peer-assessment performed	I think my peer-assessment is of high quality	3.613	3.386	3.532	3.214 (0.883)
7		I have the skills to perform peer-assessment	3.301	3.257	3.625	
8		The feedbacks I receive are correct	2.914	2.871	3.150	
9		The feedbacks I receive are clear	2.957	2.957	3.000	
10	Contribution to learning and motivation	Performing peer-assessment helps me understand the material better	3.086	2.743	2.650	2.694 (1.088)
11		Preforming peer-assessment helps me learn better	2.957	2.586	2.625	
12		Peer-assessment elevates my motivation to learn	2.688	2.514	2.400	
13	General satisfaction	Using peer-assessment is a good idea	2.699	2.529	2.544	2.430 (1.044)
14		Using peer-assessment makes the course better	2.624	2.343	2.500	
15		Performing peer-assessment is fun	2.720	2.214	2.392	
16		I am satisfied with the use of peer-assessment in the course	2.624	2.386	2.304	
17		I would like peer-assessment to be used in other courses	-	2.143	2.234	

* Between 1 (totally disagree) and 5 (agree completely)

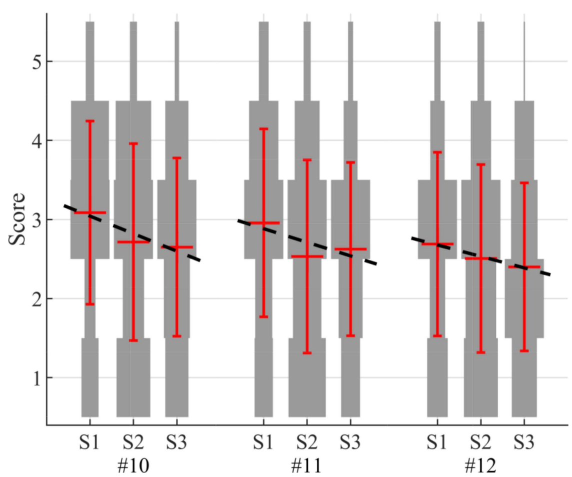

Fig. 2. Change in the perception of the negative effect of PA (Statements #10– 12, S1: Survey 1, S2: Survey 2, and S3: Survey 3).

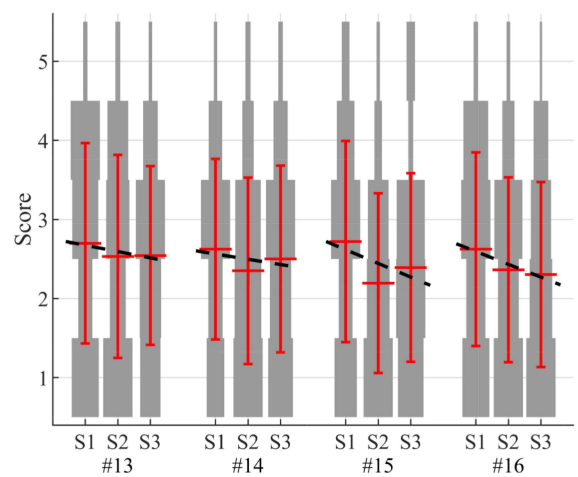

Fig. 3. Change in the perception of the general satisfaction from PA (Statements #13– 16, S1: Survey 1, S2: Survey 2, and S3: Survey 3).

on motivation and learning after performing it than before performing it. Fig. 3 presents respondents' perception on general satisfaction from PA (statements #13– 16). These results also indicate a negative change of these perceptions at the end of the semester compared to their perception prior to performing the task.

Thirteen students provided identifying information and filled out two or three surveys, enabling a more accurate exploration of the shift in their perception of the pedagogy during the course. Comparing these students' responses to the different surveys supports the previous finding of a negative shift in students' perception, but reveals a slightly more complicated picture. Students changed their perception on some items for the better and reported a more negative approach on others. Counting the negative changes (e.g., lower agreement in a later survey to the statement "peer assessment makes the course better") and the positive changes (e.g., higher agreement in a later survey on such statements) reveals that most students (62%) had more negative changes in the opinion they expressed on the statements presented to them (see Fig. 4). The shift for the students with more negative changes was also stronger, as overall 52 statements' responses got a more

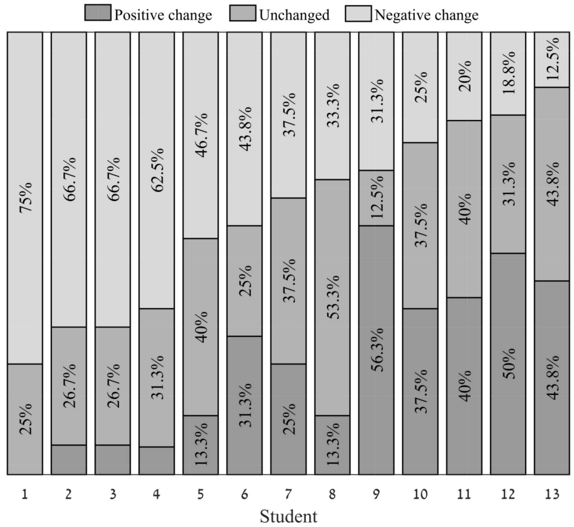

Fig. 4. Perception shift of self-identified students.

positive response over time while 84 got a more negative response over time. Furthermore, on 13 out of 16 statements, more students expressed a less favorable opinion on the pedagogy in a later survey than those whose opinions shifted for the better. The shift concerning the contribution of PA to learning is most preponderant. On those three statements (#10– 12), the number of students whose opinion improved was between 1 and 3, and the number of students whose opinion diminished was between 7 and 9 (the rest of the students had no change in their perception of the contribution of PA to learning).

Students' responses to a final open question focused on the previously identified factors, such as social and emotional concerns, the resources demanded (mainly time), and the skills required to perform PA. Very few students indicated a very positive approach; for example, one student wrote "clear and worthwhile" and another "excellent, highly recommended."

B. Students' Peer-Assessment Behavior

Analysis of students' conduct in the PA revealed two main findings. The first concerns the relatively high percentage of students choosing not to perform the PA at all. As shown in Fig. 5, between 10% and 20% of the students submitting the assignment chose not to perform the assessment.

The second finding is the students' tendency to give disproportionally high grades (see Fig. 6). Between close to 70% (in the first assignment) and above 95% (in the last assignment) of students graded their peers with (only) the highest grade. A random check by the instructor of some assignments graded with the highest grade found some of them to be extremely poor.

C. Students' Academic Performance

In order to explore the true value of PA, the correlations between the three components of the grades in the course (homework assignments, midterm, and final exams) were explored both in the discussed semester (fall semester of 2018–2019 academic year) and in the previous one (fall

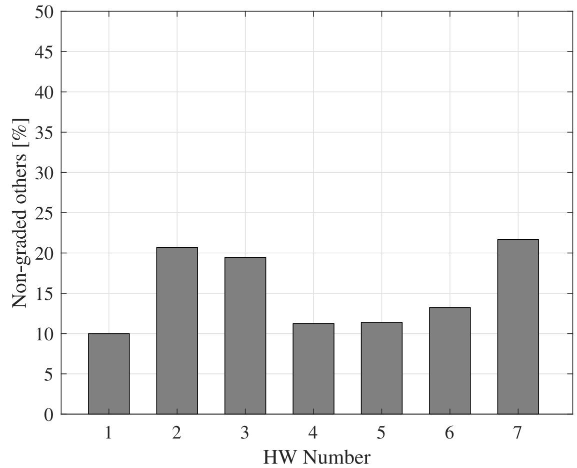

Fig. 5. Percentage of students who did not grade others (among those that submitted the assignments) for each homework assignment.

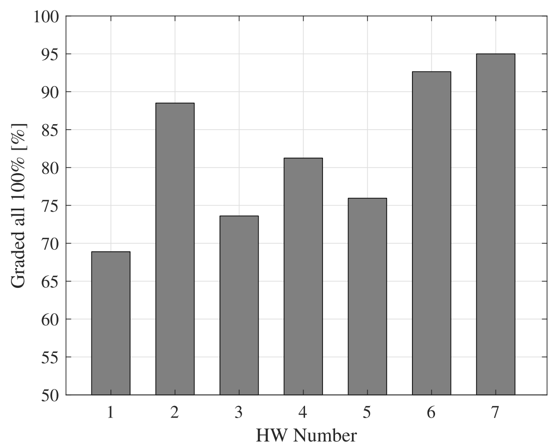

Fig. 6. Percentage of students who graded others with the highest grade for each homework assignment.

semester of 2017–2018 academic year), where assignments were randomly checked by the teaching assistant in the course. The correlations are outlined in Table II (students who were exempted from a homework assignment or the midterm exam due to special personal circumstances were excluded). The results indicate a similar correlation between the grade components with both grading approaches. A comparison between the correlations was tested using Fisher's test statistic [34]. The test result indicates that the interyear difference between correlations is not significant (the null hypothesis is not rejected).

Students' grades in the course were examined and compared to previous years in order to get some indication of the effect that the new pedagogy had on academic performance (Table III). This effect is also visualized in Fig. 7. It can be noted that the lower average grade is mostly attributed to students who failed the course. This fact also explains the higher difference between the median and the average in the 2018–2019 academic year compared to previous years. Moreover, the percentages of failures in the final exam and a second-chance final exam (to which students enrolled in the course are entitled) were approximately 20% in previous years and

TABLE II
CORRELATIONS BETWEEN GRADE FACTORS
(YEARS 2017–2018 AND 2018–2019)

	2017-8 (n=91)		2018-9 (n=101)	
	Midterm	Final	Midterm	Final
Midterm	1.00		1.00	
Final	0.47**	1.00	0.52**	1.00
HW	0.33**	0.43**	0.51**	0.37**

** Correlation significant at 0.01 level.

TABLE III
ACADEMIC PERFORMANCE OF THE STUDENTS IN THE COURSE IN THREE YEARS

Academic Year	2016-7	2017-8	2018-9
Number of students	71	91	101
Average grade*	77.72	78.19	69.04
Median grade*	78	78	73
Std*	14.65	13.90	22.71
Failed first final exam (<56), [%]	23.88 (N=67)	18.39 (N=87)	36.9 (N=84)
Failed second final exam (<56), [%]	20.00 (N=20)	16.67 (N=18)	47.83 (N=46)
Failed the course (<56), [%]	1.41	2.20	14.85

* Grades are between 0 and 100.

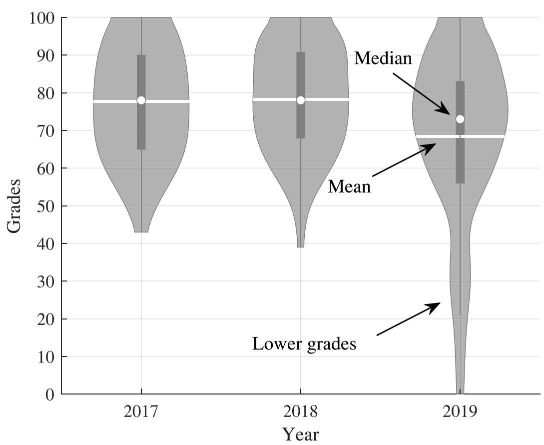

Fig. 7. Visualization of the grades during the preceding three years (width represents the frequency of the grade).

close to 40% in the course deploying PA pedagogy (taught by the same instructor).

V. DISCUSSION AND CONCLUSION

The results indicated that none of the objectives of the implementation of PA were attained. First, students' initial perception of the pedagogy was not positive and did not improve after experiencing it, as was hoped. Their view of the contribution of PA to their learning and motivation, as well as their general satisfaction, declined slightly over the course. Furthermore, a considerable percentage of the students chose not to perform the PA at all, and as the semester progressed, more chose to give their peers the highest mark, regardless of the assessed student's performance. This behavior may be both the source and the effect of students' perception of the pedagogy. It is possible that due to their negative approach some chose not to perform the PA and some of them who did assess their peers chose to give them the highest mark, regardless of the quality of the work being assessed. It is also possible that as the semester progressed, students found that not performing the PA or assigning the highest grade regardless of the work quality was easier and had little effect on their grade, which, in turn, generated a decline in their perception of PA. Students' behavior might also stem from their perception of student and instructor roles and their belief that assignment assessment by students was inappropriate. An additional possible consideration on the part of the students that might have contributed to their behavior was the weight assigned to the homework assignments and their assessment—the six assignments (and their 18 corresponding PA) comprised only 10% of the final grade.

Another interesting change that might be attributed to the simulation and their PA was a lower academic performance in the course compared to previous years. As the instructor, other teaching approaches and the material remained unchanged, it is reasonable to consider that the pedagogy deployed did not promote students' learning for, and performance in, the final exam, when compared with the previous pedagogy—assignments assessed randomly by the teaching assistant. Surprisingly, a correlation between the assignments grade and the other grading components in the course (midterm and final exams) was found, similar to the preceding year when PA was not deployed. Again, both cause and effect may explain these results. On the one hand, it is possible that students who worked on the assignment learned from the process, regardless of the way they performed the PA. On the other hand, it is possible that high achieving students were the ones submitting the assignments and receiving higher grades on the assignment and on the exam.

The results of the PA implementation in the course suggested that the teaching staff was unable to convey and implement the benefits of the pedagogy in this course, despite devoting time and thought to the procedure [16], [17] and deploying some best practices suggested in the literature, such as providing examples and a grading rubric to the students, using double-blind PA [23], assessing individual work, matching assessors and assessees randomly, and including marks and feedback in the assessment [30].

Furthermore, it is possible that some minor changes would make a significant difference, as suggested by Boud and Holmes [16], and/or that the effort was just not sufficient to shift the students' mindset and support them in performing the PA task, as demonstrated by Keeney-Kennicutt *et al.* [9] who made effective changes and refinements to their pedagogy over seven semesters. This notion is supported by Duzer and McMartin [19], who found that student's experience and further training improved their attitude. Hopefully, such efforts would result in a better level of perception and grading reliability than observed in this study, perhaps with the support of some quality control of the grading (with the students being notified of the control in advance). In such a case, the use of an alternative tool to the Moodle workshop (e.g., Calibrated Peer Review), which has been proved to be useful in supporting the instructor's supervision, may be used.

The disappointing outcomes of PA integration in this research, along with the relatively small body of knowledge regarding PA in engineering higher education and mixed results with PA in education, in general, suggested that further exploration regarding critical success factors of PA in education is required. Following some of the dimensions identified by Topping [6] and Li *et al.* [30] and focusing on assignments of a methodological and quantitative nature common in engineering, may shed some light on this complex issue and perhaps support the formulation of simpler guidelines for instructors interested in gaining the benefits PA can offer for engineering education. Additionally, the findings of this research raise some interesting questions regarding students' motivation when performing PA. Specifically, exploration of the degree of internalization and integration of motivation for students' involvement in PA could make a significant contribution to the body of knowledge. It seems that Keeney-Kennicutt *et al.* [9] achieved higher internalization and integration of motivation by repeatedly discussing the teaching philosophy with the students (among other actions taken). In contrast, Wang *et al.* [35] suggested that students' marking strategy may be regarded as gaming behavior, and deploying a dynamic game theory model with awards and punishments might improve the process by harnessing students' external motivation to improve PA outcomes. Exploring this spectrum of motivation may support the development of best practices since it is apparent that internal motivation is more powerful than external motivation in the context of learning, yet is harder to achieve by instructors [36].

The main contribution of this article lies in providing a detailed case study that demonstrated the complexity of the implementation of PA in engineering education. Although best practices were employed, the usage of PA generated negative effects on students' perceived learning and motivation. Moreover, it seems that the use of PA may have contributed to lower average grades and a higher percentage of student failure in the course.

The research's main limitation is its methodology—it is a case study and in order to be able to make some generalization of its findings, numerous case studies in similar settings should be done. Alternatively, experiments isolating a specific variable (i.e., the nature of the assignment being peer assessed) may facilitate a more generalized understanding.

Appendix A
Random Walk

Consider a random walk process of the form

$$\mathbf{x}[n] = \sum_{k=0}^{n} \mathbf{w}[n]$$

where $\mathbf{w}[n]$ gets ± 1 values with equal probability, and $\mathbf{w}[n]$ and $\mathbf{w}[m]$ are identically and independently distributed. It can be easily shown that

$$E[\mathbf{x}[n]] = 0$$
$$\mathrm{Var}\,[\mathbf{x}[n]] = n + 1.$$

Moreover, for a sufficiently high n, the distribution of $\mathbf{x}[n]$ is Gaussian, following the central limit theorem, i.e., $\mathbf{x}[n] \sim N(0, n+1)$.

An example of the distribution of $\mathbf{x}[50]$ that is the outcome of 10^5 process realizations is presented in Fig. 1. While the presented result is mathematically straightforward, its simulation is a neat example since the resulting Gaussian distribution is odd-integer valued. Moreover, a basic MATLAB realization of this process simulation requires only a *few* lines of code (Fig. 8).

```
N = 1e5;% number of realizations
n = 50; % n=50
w = (randi([0 1],[n N])-1/2)*2;
x = sum(w); %x[50] values
```

Fig. 8. MATLAB code for the simulation $\mathbf{x}[50]$ that is the outcome of 10^5 process realizations.

Appendix B
Notes on Workshop Module of Moodle for Implementation of PA

The "workshop" activity of Moodle was used for the implementation of the PA activity. In the following, some technical difficulties related to this module and its suitability for further research on the subject are pointed out.

Currently, workshop activity does not offer the possibility of the bulk download of students' submissions (issues MDL-40879 "bulk download submissions" and MDL-43542 "need to be able to export entire contents of workshop activity") [37]. This feature is essential for both convenient grading by the staff and the effective application of plagiarism cross-check. Moreover, an export of student responses feature is also missing (issue MDL-20149 "export workshop responses to a spreadsheet" [37]). Since these features are essential for efficient and convenient research on the subject, a researcher may want to consider alternative tools for the purpose of PA until these issues are resolved.

References

[1] S. Kay, *Intuitive Probability and Random Processes using MATLAB*. Boston, MA, USA: Springer-Verlag, 2006. [Online]. Available: https://link.springer.com/book/10.1007/b104645#about
[2] C. Meyers and T. B. Jones, *Promoting Active Learning College: Strategies for the College Classroom*. Hoboken, NJ, USA: Wiley, 1993.
[3] D. Hounsell, "Student feedback, learning and development," in *Higher Education and the Lifecourse*. San Francisco, CA, USA: McGraw-Hill Educ., 2003, pp. 67–78.
[4] N. Falchikov, "Peer feedback marking: Developing peer assessment," *Innov. Educ. Train. Int.*, vol. 32, no. 2, pp. 175–187, May 1995.
[5] F. Dochy, M. Segers, and D. Sluijsmans, "The use of self-, peer and co-assessment in higher education: A review," *Stud. High. Educ.*, vol. 24, no. 3, pp. 331–350, Jan. 1999.
[6] K. J. Topping, "Methodological quandaries in studying process and outcomes in peer assessment," *Learn. Instruct.*, vol. 20, no. 4, pp. 339–343, Aug. 2010.
[7] D. D. Nulty, "Peer and self-assessment in the first year of university," *Assess. Eval. High. Educ.*, vol. 36, no. 5, pp. 493–507, Aug. 2011.

[8] E. Trengove, "Peer interaction as mechanism for providing timely and accessible feedback to a large undergraduate class," *Int. J. Elect. Eng. Educ.*, vol. 54, no. 2, pp. 119–130, Jan. 2017.
[9] W. Keeney-Kennicutt, B. Gunersel, and N. Simpson, "Overcoming student resistance to a teaching innovation." *Int. J. Scholarship Teach. Learn.*, vol. 2, no. 1, p. 1, 2008.
[10] D. Reinholz, "The assessment cycle: A model for learning through peer assessment," *Assess. Eval. Higher Educ.*, vol. 41, pp. 301–315, Feb. 2016.
[11] L. B. Nilson, "Improving student peer feedback," *College Teach.*, vol. 51, no. 1, pp. 34–38, Jan. 2003.
[12] L. Bouzidi and A. Jaillet, "Can online peer assessment be trusted?" *J. Educ. Technol. Soc.*, vol. 12, no. 4, pp. 257–268, 2009.
[13] R. Ballantyne, K. Hughes, and A. Mylonas, "Developing procedures for implementing peer assessment in large classes using an action research process," *Assess. Eval. Higher Educ.*, vol. 27, no. 5, pp. 427–441, Sep. 2002.
[14] C. Brindley and S. Scoffield, "Peer assessment in undergraduate programmes," *Teach. High. Educ.*, vol. 3, no. 1, pp. 79–90, Mar. 1998.
[15] C. Adachi, J. H.-M. Tai, and P. Dawson, "Academics perceptions of the benefits and challenges of self and peer assessment in higher education," *Assess. Eval. High. Educ.*, vol. 43, no. 2, pp. 294–306, 2018.
[16] D. J. Boud and W. H. Holmes, "Self and peer marking in an undergraduate engineering course," *IEEE Trans. Educ.*, vol. E-24, no. 4, pp. 267–274, Nov. 1981.
[17] K. J. Topping, "Peer assessment," *Theory Into Pract.*, vol. 48, no. 1, pp. 20–27, Jan. 2009.
[18] L. R. Murillo-Zamorano and M. Montanero, "Oral presentations in higher education: A comparison of the impact of peer and teacher feedback," *Assess. Eval. High. Educ.*, vol. 43, no. 1, pp. 138–150, Mar. 2017.
[19] E. V. Duzer and F. McMartin, "Methods to improve the validity and sensitivity of a self/peer assessment instrument," *IEEE Trans. Educ.*, vol. 43, no. 2, pp. 153–158, May 2000.
[20] B. Baruah, T. Ward, and N. Jackson, "Is reflective writing an effective peer assessment tool for students in higher education?" in *Proc. IEEE 16th Int. Conf. Inf. Technol. Based High. Educ. Train. (ITHET)*, Jul. 2017, pp. 1–6.
[21] B. Sridharan, M. B. Muttakin, and D. G. Mihret, "Students' perceptions of peer assessment effectiveness: an explorative study," *Account. Educ.*, vol. 27, no. 3, pp. 259–285, May 2018.
[22] F. Ahammed, "Peer assessment using SPARKPLUS for engineering students," in *Proc. Int. Joint Conf. Inf. Media Eng. (IJCIME)*, Osaka, Japan, 2019, pp. 112–115, doi: 10.1109/IJCIME49369.2019.00031.
[23] K. Topping, "Peer assessment between students in colleges and universities," *Rev. Educ. Res.*, vol. 68, no. 3, pp. 249–276, Sep. 1998.
[24] S. Cassidy, "Developing employability skills: Peer assessment in higher education," *Educ. Train.*, vol. 48, no. 7, pp. 508–517, Aug. 2006.
[25] N.-F. Liu and D. Carless, "Peer feedback: The learning element of peer assessment," *Teach. High. Educ.*, vol. 11, no. 3, pp. 279–290, Jul. 2006.
[26] M. van Zundert, D. Sluijsmans, and J. van Merriënboer, "Effective peer assessment processes: Research findings and future directions," *Learn. Instruct.*, vol. 20, no. 4, pp. 270–279, Aug. 2010.
[27] B. Huisman, W. Admiraal, O. Pilli, M. van de Ven, and N. Saab, "Peer assessment in MOOCs: The relationship between peer reviewers' ability and authors' essay performance," *Brit. J. Educ. Technol.*, vol. 49, no. 1, pp. 101–110, Dec. 2016.
[28] J.-W. Strijbos, S. Narciss, and K. Dünnebier, "Peer feedback content and sender's competence level in academic writing revision tasks: Are they critical for feedback perceptions and efficiency?" *Learn. Instruct.*, vol. 20, no. 4, pp. 291–303, Aug. 2010.
[29] K. Cho and C. MacArthur, "Student revision with peer and expert reviewing," *Learn. Instruct.*, vol. 20, no. 4, pp. 328–338, Aug. 2010.
[30] H. Li *et al.*, "Peer assessment in the digital age: A meta-analysis comparing peer and teacher ratings," *Assess. Eval. High. Educ.*, vol. 41, no. 2, pp. 245–264, Feb. 2016.
[31] E. Panadero and M. Alqassab, "An empirical review of anonymity effects in peer assessment, peer feedback, peer review, peer evaluation and peer grading," *Assess. Eval. High. Educ.*, vol. 44, no. 8, pp. 1253–1278, Apr. 2019.
[32] M. L. Wen and C.-C. Tsai, "University students' perceptions of and attitudes toward (online) peer assessment," *Higher Educ.*, vol. 51, no. 1, pp. 27–44, Jan. 2006. [Online]. Available: https://doi.org/10.1007/s10734-004-6375-8
[33] R. Likert, "A technique for the measurement of attitudes," in *Archives of Psychology*, vol. 140. New York, NY, USA: Columbia Univ. Press, 1932, pp. 1–55.
[34] B. Diedenhofen and J. Musch, "Cocor: A comprehensive solution for the statistical comparison of correlations," *PLoS ONE*, vol. 10, no. 4, pp. 1–12, Apr. 2015. [Online]. Available: https://doi.org/10.1371/journal.pone.0121945
[35] Y. Wang, H. Li, Y. Feng, Y. Jiang, and Y. Liu, "Assessment of programming language learning based on peer code review model: Implementation and experience report," *Comput. Educ.*, vol. 59, no. 2, pp. 412–422, Sep. 2012.
[36] R. M. Ryan and E. L. Deci, "Intrinsic and extrinsic motivations: Classic definitions and new directions," *Contemp. Educ. Psychol.*, vol. 25, no. 1, pp. 54–67, Jan. 2000.
[37] *Moodle Tracker*. Accessed: Dec. 23, 2019. [Online]. Available: http://tracker.moodle.org/