Investigating Students' Experience with Peer Assessment in Two Computer Science Courses - A Longitudinal Study

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***Abstract* — The effects of peer assessment on students' learning experience over time are scarcely examined in the literature. The current research performs a longitudinal study that explores the use of LearnEval, a comprehensive peer assessment platform, in two computer science courses in two consecutive years. Both courses followed a Project-Based Learning (PBL) approach, allowing a peer assessment component to be easily integrated. In 2020-2021 academic year, 78 students participated in the process in a 3rd year Web Applications Design course. In the following year, a subset of the same students (54) participated in the activity in a 4th year Human-Computer Interaction course. A quantitative analysis of the outcomes in the two years was performed and the results were compared. Furthermore, the LearnEval usability was assessed. Therefore, the current work addresses two research questions: (1) How do the outcomes of the peer assessment activity in the 4th year course compare to the previous year when the students attended the process for the first time? (2) How did the students perceive LearnEval usability in the two years? The main findings show that the results were slightly improved in the second year of attending the peer assessment process in terms of involvement, reviewing skills, grades assigned and quality of the feedback provided.**

Keywords — peer assessment; longitudinal study; project-based learning; quantitative analysis

I. Introduction

Evaluation has a core role in the educational process. Over time, the evaluation approaches have adapted to the evolving requirements of the novel learning methods, such as active learning. Peer assessment represents an effective alternative approach for evaluation and it has been employed in various contexts, particularly in the last decade [1, 8, 14]. Its application leads to several important benefits for the students, such as: better understanding of the topic [7], improved collaboration between the learners and the instructor [12], or development of higher-level competencies [17].

Different systems dedicated for the peer assessment process have been proposed in the literature in recent years [9, 11, 19]. One such system is our in-house solution called LearnEval, a fully-fledged peer assessment platform that has been employed in the context of various courses over the years [4]. The system offers a highly configurable peer assessment workflow, providing various effective features for both student and teacher. Several important affordances enhance the student experience, such as the options to perform calibration tasks, access comprehensive statistics and reports, examine personal scores, visualize an open learner model representation, or automatic delivery of notifications. On the other hand, the teacher experience is also enhanced by features such as high control over the peer assessment settings, automatic identification of the rogue evaluations, or dynamic allocation of the submitted artifacts to reviewers.

The platform has been mainly applied in Project-Based Learning (PBL) settings. PBL is an educational approach where students learn by performing intricate tasks associated with challenging projects [16]. Joint employment of peer assessment and PBL can lead to an increase in the learners' reviewing abilities and critical thinking [10].

In general, the students have a positive view on the peer assessment contribution to their learning [1, 14, 15, 18]. Although various works report on the students' experience with peer assessment, to the best of our knowledge, no investigation was carried out comparing the learners' experience with the process in a longitudinal study, over the course of several years.

The current work adds to the literature by carrying out such an investigation and comparing the students' peer assessment experience in two consecutive years in two distinct Computer Science courses: a 3rd year Web Applications Design course and a 4th year Human-Computer Interaction course. In particular, we address the following research questions: (1) How do the outcomes of the peer assessment activity in the 4th year course compare to the previous year when the students attended the process for the first time? (2) How did the students perceive LearnEval usability in the two years?

The following section reports on several works that investigate the students' peer assessment experience. Next, the context of the two studies where the peer assessment activity was employed and the methodology of our research are introduced (section III). Following, the results of the two studies are presented and compared (section IV). Subsequently, a discussion about the main outcomes of the research is provided (section V). Finally, the findings are summarized, limitations are presented, and future analysis and research directions are stated (section VI).

II. Related Work

In the literature, several works investigate the students' experience with the peer assessment process. The findings are in general positive and the students are open to the activity.

In the following we present several such papers and the results obtained regarding the learners' experience.

Three facets of the peer assessment activity were analyzed in [1]: a) the validity of the grades assigned by the students, b) the dissimilarities between the reviews performed by students following a college major and the ones performed by students following a college minor, and c) the learners' experience with the evaluation process. The activity was applied in a Bioscience class involving 79 learners at the University of Helsinki, Finland. Each student had to review two peers at the end of an exam. Various methods, such as descriptive statistics or Pearson correlation coefficient, were used to assess the degree of agreement between the instructor's evaluations and the peer grades. No statistically significant difference was found between the means of the grades. Different analyses compared the grades assigned by the major students with the ones assigned by the minor students for the same solution. The disagreement between the grades assigned by the two groups of reviewers was assessed using one-way ANOVA. An anonymous survey was used to gather the learners' experience with the activity. The comments provided to the open-ended items were analyzed using inductive content analysis. The results showed that the students' experience was mainly positive. The negative experiences were related to time management, difficulty in reviewing peers' solutions, or skepticism about their peers' abilities to evaluate. The outcomes revealed that the major and the minor students are similarly proficient in reviewing.

In [15] is examined the type of peer assessment feedback the learners recall months or years after the activity. The paper also investigates the reactions and the changes that the students experience due to the evaluation. The study took place at University of Rochester (USA) in 2005 and involved 101 second-year students and 83 fourth-year students. Each student was required to assess 10 peers. The assessment form consisted in 15 items related to work habits and interpersonal attributes that needed to be scored on a scale from 1 to 5. Additionally, the reviewer was required to provide comments about the peer's strengths and weaknesses. The learners offered narratives about the ways the peer assessment activity influenced their professional and personal advancement. The content of the resulting 138 narratives was analyzed by a mix of both qualitative and quantitative methods. The narratives were coded by two members of the team and frequency counts were provided. In many cases, the students considered the peer assessment process as helpful. Many learners also stated significant improvements in behaviors and awareness due to participating in the activity. The improvement was clearer in the cases where the feedback was precise and mentioned the exact sections requiring changes. In rare cases, the students provided negative feedback regarding the activity. The paper concludes that peer assessment can be used to appraise and support the improvement of professional behavior.

In [18] is presented a case study that examines the practice of the peer assessment process in a media professional course. The case study involved nine out of the 11 second-year students following a Bachelor of Social Science Degree at the University of Queensland, Australia. The students had to deliver a viva voce as one of the course requirements. Following the viva voce, the reviewers had five minutes to assign grades and leave comments on their peers' performance. The research addresses aspects such as methods for carrying out peer assessment, factors affecting the activity, or the students' experience. Several different methods were employed to gather data to perform the study: a questionnaire concerning the students' views on peer assessment, focus-group interviews with the learners regarding their assessment experience, or interviews with the coordinator of the course about the evaluation process. Half of the learners concurred that the activity fosters interaction. The learners appreciated the benefits of attending the process, such as improving understanding and learning. On the other hand, some of the students were worried about their peers' abilities to review and doubtful about the worthiness of the process. Two important issues stated were the insufficient amount of time to evaluate and the low quality of the comments provided. The students' ratings regarding the process prior and following the activity were relatively similar. Noteworthy, the answers provided in the focus-group interviews supported the findings from the questionnaires.

The experience of peer assessment applied to second-year undergraduate accounting students at a university from South Africa in 2016 is reported in [14]. The research investigates how the process fosters the development of skills related to lifelong learning. The activity took place in a tutorial class and it was conducted using a marking grid. The students were allowed to revise their solutions according to the received feedback. The investigation applied concurrent triangulation, a design method where the data coming from quantitative analysis is compared and aggregated with the data coming from qualitative analysis. A web-based survey consisting of both closed-ended and open-ended questions was delivered to the students. The survey featured questions related to different aspects: effectiveness of the peer assessment process, learners' views on self-regulated learning, skills required to be a lifelong learner, or ways to improve the assessment activity. A thematic analysis was performed on the narrative section. The majority of the learners agreed that they used the feedback received to enhance their solutions and they allocated time to reflect on their own work after being reviewed. Following, the quantitative and qualitative data were aggregated and several outcomes were inferred. The results showed that students valued the contribution of peer assessment in allowing them to learn more independently, assuming more responsibility for learning, improving understanding about the evaluation process, or fostering collaborative learning.

To sum up, the students' experience with the peer assessment process was examined in various areas, such as bioscience, medical education, media, or accounting. The process was analyzed from different perspectives, both quantitatively and qualitatively. Different statistical measures were applied to assess the outcomes of the process. The present work contributes to the literature by exploring the outcomes of applying the peer assessment process in two distinct courses in two consecutive years with the same students.

III. Context of Studies and Methodology

The current research is based on a longitudinal study where students enrolled at the University of Craiova, Romania, performed peer assessment activities in two different courses. In 2020-2021 academic year, 78 3rd year

learners participated in the peer assessment process for the first time in the context of a Web Applications Design course (we will refer to it as Study A for the rest of the paper). In the following academic year, a subset of the same learners (i.e., 54 students) participated again in the peer assessment process, this time in the context of a Human-Computer Interaction course (we will refer to it as Study B for the rest of the paper). Both courses applied a PBL approach. Next, we summarize the requirements of each project.

A. Web Applications Design Project (Study A)

In Study A the project required students to follow the entire life cycle of developing a web application. The first assignment demanded learners to develop the user interface. The second assignment involved the design of the database. The third assignment entailed the delivery of the main business logic of the application. The fourth assignment involved the integration of the authentication and authorization features for the users. Lastly, the fifth assignment required the delivery of the fully functional application. Some excerpts from the student deliverables are included in Figures 1 and 2.

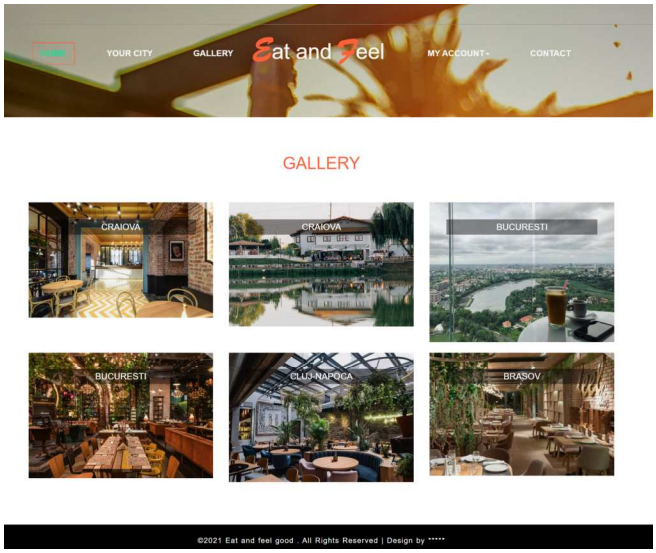

Figure 1. Web Applications Design sample deliverable – user interface (first assignment)

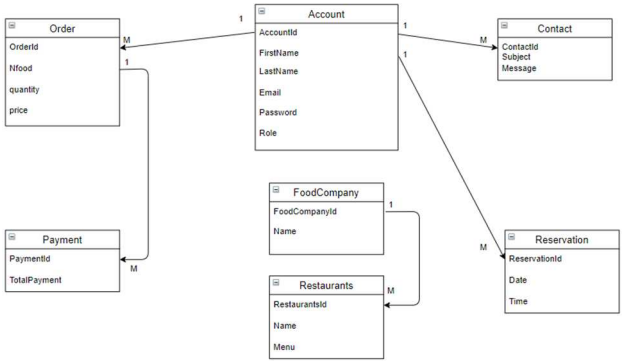

Figure 2. Web Applications Design sample deliverable – database diagram (second assignment)

B. Human-Computer Interaction Project (Study B)

In Study B the project required students to design, implement and evaluate the user interface for a web application. The first assignment solicited learners to conceptualize the requirements of the application and conduct user modeling. The second assignment entailed the design of wireframes, mockups, and user interface. Lastly, the third assignment demanded the appraisal of the user interface by developing a usability test plan and performing qualitative and heuristic evaluation. Some excerpts from the student deliverables are included in Figures 3 and 4.

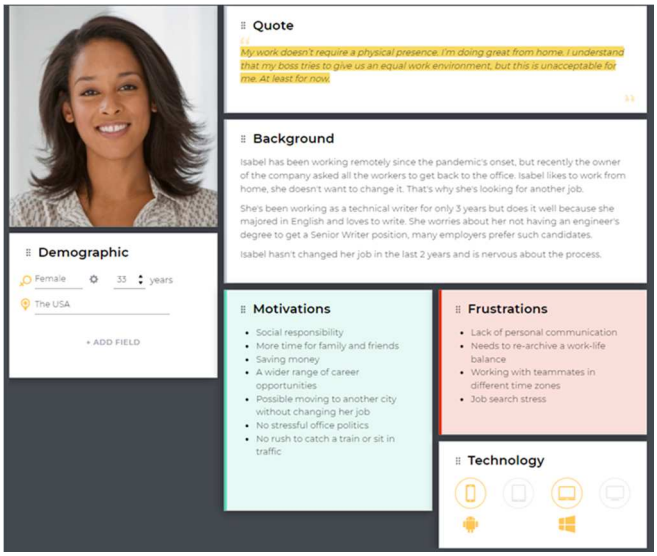

Figure 3. Human-Computer Interaction sample deliverable – persona (first assignment)

Figure 4. Human-Computer Interaction sample deliverable – wireframe (second assignment)

C. Peer Assessment Activity

Both courses featured a peer assessment process that complemented the development of the project. The peer assessment activities were carried out using LearnEval platform. The students submitted solutions into the system and then reviewed their peers by means of an evaluation form. At the end of the process, both the students and the teacher could examine various statistics and scores. The complete peer assessment workflow supported by the LearnEval system is presented in [4].

An evaluation session was conceived for each assignment. The applied settings were mainly the same in both scenarios. A dynamic review allocation mechanism was

used to allocate the submissions to reviewers. The approach splits the evaluation period in two stages: a mandatory review phase and an extra review phase. The procedure applied for allocating an artifact to a reviewer considers the number of submitted assessments for the artifact and the evaluation proficiency of the already assigned reviewers, as detailed in [3]. Each stage lasted approximately one week. The process was double-blind and each learner had to assess three solutions in the mandatory review phase, and optionally, three additional ones in the extra review phase. The review criteria were devised based on the requirements of the assignments and ranged between two and six in Study A, and between three and seven in Study B. The assessment was both summative and formative, requiring learners to provide a grade on a scale from 1 to 10 and leave argumentative feedback for each review criterion.

Applying the same peer assessment settings allowed us to compare the outcomes from the two studies.

IV. Results

In this section we analyze the collected data and try to answer the two research questions stated in the Introduction. The first subsection addresses the first research question and provides a quantitative analysis and comparison of the peer assessment data, by examining aspects such as students' involvement, quality of the reviews, or validity of the grades assigned. The second subsection addresses the second research question and assesses LearnEval usability based on the learners' answers to a questionnaire.

A. Quantitative Analysis of the Peer Assessment Data from the Two Studies

The percentages and numbers of deliverables submitted by the students in each assignment for both studies are displayed in Table I. The students were more involved in Study B as the submission rate was higher. The *Overall* column depicts the values achieved when aggregating the submissions from all the sessions. Similarly, a higher overall submission rate was attained in Study B.

TABLE I. Percentages and Numbers of Deliverables Submitted for each Assignment in Study A and Study B

Assignment	A1	A2	A3	A4	A5	Overall
Study A	85% (66)	81% (63)	73% (57)	65% (51)	67% (52)	74% (289)
Study B	91% (49)	81% (44)	89% (48)	-	-	87% (141)

The average number of reviews submitted per student and the total number of reviews submitted in each assignment for both studies are displayed in Table II. Again, the students were more involved in Study B as the reviewing rate was higher. The *Overall* column depicts the values achieved when aggregating the reviews from all the sessions. Similarly, a higher overall reviewing rate was attained in Study B.

TABLE II. Average Number of Reviews Submitted per Student and Total Number of Reviews Submitted for each Assignment in Study A and Study B

Assignment	A1	A2	A3	A4	A5	Overall
Study A	3.1 (242)	2.76 (215)	2.6 (203)	2.49 (194)	2.46 (192)	2.68 (1046)
Study B	3 (162)	3.44 (186)	3.19 (172)	-	-	3.21 (520)

Descriptive statistics about the final grades assigned to the submitted solutions are displayed in Table III. The final grade assigned to a submission aggregates the assessments received from both the students and the instructor [2]. In both scenarios, the review provided by the instructor represented 70% of the final grade. The quality of the submissions was slightly higher in Study B as a slightly higher mean of the grades was attained. Noteworthy, the spread of the grades, as depicted by the standard deviation, was relatively similar in both settings. Moreover, many submissions had high grades, with a few underperformers, as outlined by the negative skewness.

TABLE III. Descriptive Statistics About The Final Grades Assigned to the Submissions

	Mean	Standard Deviation	Skewness
Study A	8.33	1.44	-0.7
Study B	8.61	1.35	-0.87

LearnEval models the student based on various capabilities, such as: involvement, reviewing, and competence [2]. *Involvement Score* represents the student's participation to the activity. *Reviewing Score* portrays the learner's assessment skills. *Competence Score* summarizes the quality of the student's solutions. Additionally, *Overall Score* describes the general capabilities of the learner.

The average figures of the scores achieved by the students in the two studies are displayed in Table IV. Higher values were attained in Study B: the students were more involved, they assigned more accurate grades, and the quality of the solutions submitted was higher. Furthermore, the *Overall Score* figure was also higher.

TABLE IV. Average Figures of the Scores Achieved by the Students in the Two Studies

	Involvement Score	Reviewing Score	Competence Score	Overall Score
Study A	6.08	8.03	7.21	7.21
Study B	7.21	8.54	7.90	7.96

The percentage of comments according to their length (i.e., number of characters) in different bin intervals for the two studies is displayed in Table V. Noteworthy, the percentage is higher in Study B for the [200, 300) interval, while higher values were attained in Study A for [0, 100) and [100, 200) intervals. In the rest of the intervals the percentages were relatively similar. Therefore, in Study B the length of the comments was higher, so the feedback provided was more substantial.

TABLE V. Feedback Length Bins with the Percentage and Number of Comments in the Two Studies

Length	[0, 100)	[100, 200)	[200, 300)	[300, 400)	>= 400	Total
Study A	4% (184)	21.4% (929)	57.9% (2508)	10.9% (473)	5.5% (236)	4330
Study B	0% (0)	0.2% (5)	85.5% (1888)	9.8% (217)	4.4% (98)	2208

LearnEval allows students to rate the reviews received by assigning a grade ranging from 1 to 10 and providing feedback. The mean and standard deviation of the grades assigned by the students to the reviews received are displayed in Table VI. Noteworthy, in Study B a slightly higher mean was attained denoting a slightly better quality of the reviews

compared with Study A, as perceived by the students. However, these results should be interpreted with caution as the assigned back-review grades were very high.

TABLE VI. AVERAGE BACK-REVIEW GRADES IN THE TWO STUDIES

	Mean	Standard Deviation
Study A	9.52	1.26
Study B	9.78	0.64

Finally, the validity of the grades assigned in the two studies was assessed by employing Pearson Correlation coefficient, which is widely used in the literature [13]. The correlation coefficients between the grades assigned by the students and the ones assigned by the teacher are displayed in Table VII. Statistically significant values were achieved in both studies. However, a slightly higher correlation was attained in Study B.

TABLE VII. PEARSON CORRELATION COEFFICIENTS BETWEEN THE GRADES ASSIGNED BY THE STUDENTS AND THE GRADES ASSIGNED BY THE TEACHER IN THE TWO STUDIES

	Coefficient	p-value
Study A	0.53	< .01
Study B	0.56	< .01

B. LearnEval Usability

In addition to the quantitative analysis of the peer assessment data, we were also interested in evaluating the usability of the LearnEval platform. Therefore, in both studies the System Usability Scale (SUS) questionnaire [6] was applied to the learners at the end of the semester. SUS survey provides an easy-to-apply and reliable tool for evaluating the usability of a platform. The survey comprises 10 Likert items, having values which span from "strongly disagree" to "strongly agree". The items refer to various aspects, such as whether the user would like to use the system more frequently, the user finds the system unnecessarily complex, or the user considers the system easy to use. A higher completion rate was attained in Study B as 56% (or 30 learners) filled in the questionnaire compared to 46% (or 36 learners) in Study A.

The SUS Score values computed using the algorithm proposed by [6] are displayed in Table VIII. As we can see, the score was slightly higher in Study B. However, both values categorized the system usability as "*good"* according to [5].

TABLE VIII. SUS SCORE IN THE TWO STUDIES

	SUS Score
Study A	74.17
Study B	74.67

V. DISCUSSION

Although the mean of the final grades assigned to the submissions was slightly higher in Study B, the difference is not statistically significant. Therefore, the complexity of the requirements from the two courses was relatively similar, allowing various comparisons to be performed.

When it comes to the first research question, several findings can be mentioned. As shown in subsection IV.A, in the second year of participation to the peer assessment activity the outcomes were slightly better. The higher involvement, as outlined by the larger *Involvement Score* and submission and reviewing rates, could be due to the increased interest of the students and clearer perspective on the advantages of the process.

The reviewing skills of the students, as revealed by the higher *Reviewing Score* average value and higher back-review grades, were also improved, possibly as a result of the assessment experience gathered in the previous year. In addition, the evaluations performed were more substantial, as highlighted by the longer feedback, but also by the slightly higher correlation between the grades assigned by the students and the grades assigned by the teacher.

The second research question was addressed in subsection IV.B. Findings show that in both years the usability of the system was categorized as "*good"* by the students, meaning that LearnEval effectively supported the peer assessment process.

Even though no major and significant differences were found between the outcomes of the two studies, overall, slightly better results were obtained in the second installment of the peer assessment activity; this suggests the conclusion that repeating the experience may lead to an improvement in the involvement and reviewing skills of the learners.

VI. CONCLUSIONS

The current study analyzed and compared the students' peer assessment experience in two consecutive years in two different courses.

The findings show that the outcomes were slightly improved in the second year of applying the activity: the submission rate and reviewing rate were higher, the quality of the solutions delivered was slightly increased, the students' reviewing and competence skills were improved, the feedback provided was more substantial, the quality of the reviews was increased, and the correlation between peer assessments and teacher's evaluations was a bit higher. In addition, LearnEval SUS score was marginally higher in the second year, reaching the "*good*" usability category in both studies.

The main limitation of the current study represents the relatively low number of students involved and the fact that only two courses were compared, which limits the generalizability of the results. Furthermore, the particularities of the courses could also have an impact on students' experience (e.g., the fact that Study B took place in the final semester of the bachelor program, when students were more focused on the graduation project). However, the present work can still be considered a stepping-stone in understanding the effect of peer assessment on students' learning activity over time.

Additional analyses to further develop the understanding of peer assessment role on students' learning are needed. In the future, a larger study over the course of multiple years and in the context of several courses is envisaged. Moreover, an additional qualitative analysis would allow us to assess other aspects of the students' experience, such as their subjective satisfaction with the learning activity.

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