UDC 37.016:004

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INTERACTIVE ONLINE SURVEYS AS A TOOL FOR IMPROVING THE EFFECTIVENESS OF FORMATIVE AND SUMMATIVE ASSESSMENT IN HYBRID LEARNING ENVIRONMENTS

Abstract. Using a mixed-methods case study at Odesa Polytechnic National University, this article examines the impact of online interactive polling (using Vevox) on academic performance during summative assessments in a hybrid learning context. Using a mixed-methods case study approach, we analysed performance trends before and after Vevox implementation, situating findings within prior studies on engagement. The study addressed an identified gap in the literature regarding the pedagogical impact of ARS beyond student satisfaction metrics. We established quantitative changes in performance (up to 5% improvement). Moreover, we established qualitative perceptions of students and lecturers. Previous ARS studies primarily focus on engagement in diverse learning environments but rarely explore its pedagogical impact. Our study addresses this gap by examining how polling supports formative and summative assessment practices, facilitates active learning, and contributes to students' understanding of complex topics. By contextualising these findings within educational technology research, we highlight the tool's significance for scalable pedagogy. Based on our findings, we recommend the following pedagogical guidelines: (1) incorporate polling as a regular formative assessment tool to reinforce key concepts; (2) design questions that progressively challenge students, supporting cognitive development; (3) use polling to facilitate peer discussion and collaborative learning; and (4) combine polling with reflective activities to deepen understanding and encourage metacognition. The research purpose is to evaluate quantitatively and qualitatively the effect of Vevox on student outcomes in hybrid tertiary education, thereby informing best practices for technology-enhanced assessment systems.

Keywords: interactive polling; academic performance; Vevox; formative assessment; active learning.

1. INTRODUCTION

Statement of the problem. With the current tendency of tertiary education provision to shift from a face-to-face delivery focus to an online or hybrid learning environment, there is a clear need for the implementation and analysis of new innovative teaching and learning methods supported by technology. This shift underscores the critical importance of exploring how interactive polling can address challenges of engagement, retention, and assessment in digital and hybrid learning environments, thereby contributing to the broader discourse on technology-enhanced pedagogy in tertiary education. Naturally, ARS platforms like Vevox and Mentimeter are widely considered in higher education.

Analysis of recent research and publications. Previous studies have ranged from using ARS in large lecture settings [1], [2], [3], in smaller seminars [4], [5], for solely online delivery [6] or in a hybrid mode [7], [8]. While these investigations demonstrate various benefits of ARS

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in fostering student engagement across contexts, there remains an insufficient articulation of the pedagogical significance and scalability of these tools within the overarching domain of educational technology research.

Recent cognitive science research highlights *retrieval practice* as a key mechanism underpinning the efficacy of polling in learning: systematic reviews show that repeatedly recalling information reinforces memory retention and comprehension, suggesting ARS can support long-term learning gains [9]. In particular, the review contains the results of more than 50 empirical studies that confirm that regular use of extraction practices in the learning process leads to a significant improvement in long-term memorization of material. The researchers emphasize the importance of studying this approach in online environments, which makes our study, conducted in a virtual format, a relevant contribution to the development of this topic.

Furthermore, studies on *metacognition* underscore the value of coupling polling with reflective activities: prompting students to analyse their own thinking after each poll enhances their ability to monitor and regulate their understanding, deepening conceptual mastery. In his article [10], Tanner presents a structured approach to developing students' metacognition through self-reflection questions and the integration of reflective practices into the classroom. This is in line with our recommendations on the use of post-questionnaire tasks as a tool for developing critical thinking and self-assessment of knowledge by students.

Critical examinations of technology integration, such as critiques of the SAMR model, warn that *technology alone is insufficient* – it is the design of post-polling discussions, progressive question difficulty, and contextualisation that determine learning impact, rather than the polling platform itself [11]. The authors criticize the SAMR model, which is often used to describe the introduction of digital technologies, and note that superficial integration of technologies does not lead to significant educational change. In the context of our study, this confirms the importance of a pedagogical approach: we analyzed not only the use of a polling as a tool, but also its combination with discussion and explanation, which goes beyond simply "supplementing" traditional methods.

Broader reviews of *ICT adoption* in higher education emphasize that student satisfaction and performance improvements depend on awareness of tool capabilities and instructional design; our qualitative findings on student and lecturer perceptions align with these insights, highlighting the importance of effective orientation and support when implementing Vevox [12]. Researchers have found that students' satisfaction with online learning is largely dependent on their familiarity with digital tools and understanding of their capabilities. This suggests that the positive perception of Vevox by students in our experiment could be partly due to their familiarization with the platform as part of the course.

In study [13], undergraduate students (44 in total) enrolled in an information technology education course were divided into two groups during the lectures: one used ARS, as mentioned earlier, for multiple choice style questions, whereas the other answered those orally. Results were mixed, showing minor performance differences across assessments. The author emphasised the likely short-term effect of ARS and the instrumental role of discussion and brainstorming in classrooms, with ARS' role/effect on students' performance identified as additional. Similarly, in another study at Loyola University, an internally designed ARS was used to determine whether students performed better in examinations following exposure to similar interactive polling in a large lecture format [14]. ARS was used throughout seven lectures in one module and included two intakes of students. The authors concluded that ARS usage did not dramatically enhance overall student performance in the module exam, but observed improvement among lower-quartile students which may be attributed to the scaffolding provided by interactive polling. Polling helped less-prepared students build confidence through immediate feedback.

Mohin, Kunzwa, and Patel [15] reported a study concerning formative assessment that was conducted at the University of Hertfordshire. In this study, Mentimeter was used in a lecture-style environment for engineering students to generate multiple-choice and open-ended questions based on the lecture content as a formative assessment. Most students indicated that the online polling tool was beneficial to their performance. However, the study had some important limitations, such as conducting only one 60-minute lecture in one module and seemingly without further discussion following or underpinning the quiz. Moreover, only 25 out of 262 students who attended the lecture eventually completed the distributed survey.

These findings resonate with Voelkel and Bennett's [16] observations on the nuanced benefits of ARS, where targeted implementation in specific contexts can yield measurable performance gains. Furthermore, the student engagement improvements align with theories of active learning, underscoring Vevox's potential as a scalable educational intervention.

Hence, some common limitations of those as mentioned above and other studies on ARS and interactive polling include:

- Limited time of study sessions when online polling/ARS is used, which usually involves just one or two sessions;
- Limited number of disciplines, which generally includes only one module;
- Small pool of student responses;
- Limited number of tutors running polling sessions (usually just one or two);
- Predominate focus on satisfaction rather than the performance of students.

With these results of previous studies on the topic and acknowledging their limitations, we designed our study as follows. By situating our investigation within this identified research gap, we aim to contribute a comprehensive analysis of both quantitative performance outcomes and qualitative perceptions, thereby advancing the scientific dialogue on the pedagogical impact of interactive polling tools.

Research purpose. The goal of this article is to evaluate the impact of implementing Vevox as an online interactive polling system on university students' academic performance during summative assessments and to identify how polling practices can enhance formative and summative assessment processes in hybrid learning contexts.

2. RESEARCH METHODOLOGY

We conducted the study during a term (March-June 2023) at Odesa Polytechnic National University in Ukraine. Our project was aimed specifically at the virtual environment for teaching, which was necessitated by ongoing military actions in Ukraine resulting from the invasion by Russia. Even after the war, many institutions in Ukraine, specifically from the most heavily affected regions of the country, are likely to have to function fully online or in a hybrid mode.

The study explored whether Vevox improves summative performance and collected student and lecturer perceptions. To address these questions, we adopted a case study approach that evaluated the structured use of Vevox. The main objective of this study was to evaluate the impact of the introduction of Vevox as an interactive polling tool to improve academic performance.

We assembled a team of ten lecturers from a variety of disciplines, including such subjects as economic theory, management, software architecture and design, mathematical statistics, psychological diagnosis, social work, strategic analysis, and innovative entrepreneurship, psychology of criminal behaviour, etc. Each was instructed to use Vevox as an interactive online polling system in regular online seminars with undergraduate students throughout one semester. The important conditions were the following.

1. Each new seminar session included polling activities of around 20-30 minutes long to deal with three to five questions. The polling questions reinforced active learning. They targeted key concepts from previous sessions to promote retrieval practice and critical thinking. For example, the questions encouraged students to recall, apply, and analyse concepts, consistent with Bloom's taxonomy. This approach aligns with research advocating for formative assessments to strengthen long-term retention and comprehension [17].
2. The lecturers facilitated post-polling discussions to scaffold student learning by explaining correct answers, addressing misconceptions, and contextualising the results within broader course objectives. This aligns with constructivist pedagogy, which emphasises active student participation and reflection as critical components of meaningful learning.

This approach includes establishing clear goals in advance, emphasising critical-thinking tasks and appropriate instructional methods.

We divided the students into two cohorts: one before the integration of interactive polling and the other after it was conducted. The cohorts spanned multiple years and disciplines. Each academic group consisted of 10-15 students, or 144 in general. At the end of the semester, but before the final grades were released, students and lecturers involved in the process received a questionnaire with a series of Likert-style questions. These aimed to understand the impact of using Vevox on their perceived final performance and, generally, for a more enhanced learning process (67 students and 10 lecturers completed this survey). Statistical analysis revealed that students in the Vevox cohort performed significantly better, with an average score increase of up to 5%. Polling may enhance academic performance; however, further investigation is required. This integrated approach allowed us to study the impact of interactive polling technology on student performance in summative assessments. Performance improvements in cohorts using Vevox can be attributed to the integration of formative assessment strategies. Polling supports retention through retrieval practice and feedback [8].

Consequently, our study differs from those previously discussed. This study evaluates the pedagogical effectiveness of interactive online polling as a tool to enhance formative feedback, encourage collaborative learning, and foster student engagement. Interactive polling leverages the principle of retrieval practice, where the recall of information strengthens memory retention and understanding. By embedding polling into revision sessions, we provided students with opportunities to rehearse and consolidate their knowledge, which has been shown to significantly improve long-term learning outcomes [18], [19].

3. RESULTS OF THE STUDY

Data distribution and normality check. Our initial consideration was to ensure that the collected data did not skew towards high or low scores. This allowed us to determine whether the data is biased and whether the two cohorts of students are similar in academic performance. Prior to conducting parametric analyses, the normality of the data was assessed using the Shapiro–Wilk test; all variables met the assumption of normality ($p > 0.05$), thereby justifying the use of t-tests.

Fig. 1 illustrates the academic performance distribution of two cohorts of students before and after the introduction of interactive polling. Blue represents the cohort using polling, while orange represents the control group. The balanced distribution suggests comparability between the groups, with a slight positive correlation between polling use and performance. These results indicate that the data are unbiased and that the two cohorts of students are comparable according to the indicators of their academic performance.

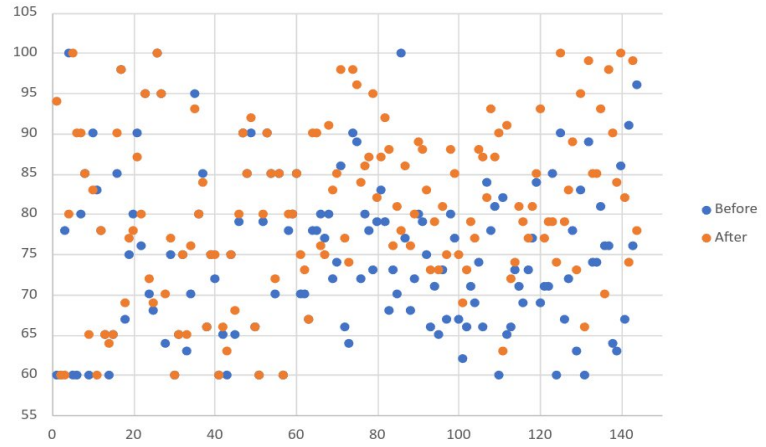

Fig 1. Distribution of Academic Scores Across Two Cohorts of Students Before and After Implementation of Interactive Polling

At the same time, the scatter plot also visually shows a slight positive correlation between the use of interactive polling and academic grades. This suggests that students who used interactive polling tended to show slightly higher academic performance than students who did not have such activities implemented. However, it is important to note that correlation does not equal causation, especially since such a correlation is not very pronounced.

Data distribution and normality check ensured methodological rigor. These scatter plots provide insight into each data set's distribution and potential deviations from normality.

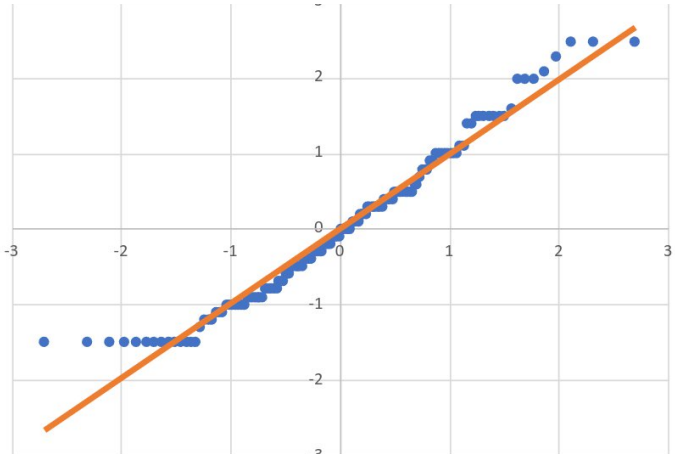

Fig 2. Normality Check of Academic Scores Prior to Interactive Polling Implementation

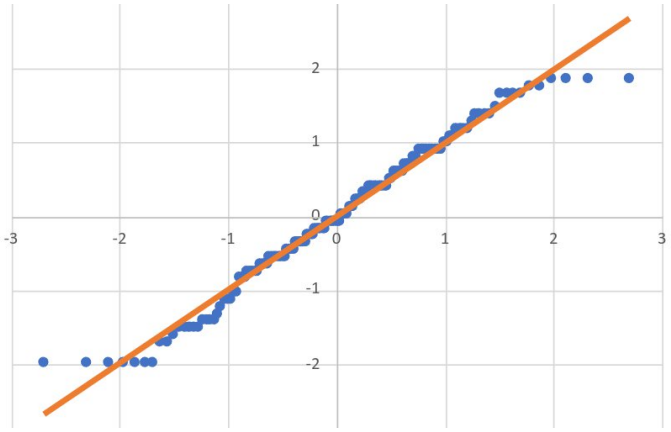

Fig 3. Normality Check of Academic Scores Following Interactive Polling Implementation

This suggests that the normality assumptions for the analysed datasets of academic grades are being reasonably met.

Student's T-test. Since the normality assumptions for the analysed datasets of academic degrees are being reasonably met, we performed a student's T-test to compare the means of the two groups of students. Thus, in this manner, we further investigated the relationship between interactive polling and academic performance.

The two-sample T-test allows comparison of the mean values of two data sets by the calculation of the test statistic:

$$T = \frac{\underline{y_1} - \underline{y_2}}{\sqrt{s_p^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

in which $\underline{y_1}$ and $\underline{y_2}$ are the mean values from groups 1 and 2, s_p is an estimate of the pooled s of the measurements, and n_1 and n_2 are the number of observations for each group. The s_p of replicate sets of measurements is:

$$s_p = \sqrt{\frac{(n_1 - 1)\, s_1^2 + (n_2 - 1)\, s_2^2}{n_1 + n_2 - 2}}$$

in which s_1 and $s_2$are the estimated s values for each set of measurements. The absolute value of the calculated T-value is then compared with the critical t-value for the selected significance level. If the absolute value of the calculated T-value is greater than or equal to the critical t-value, then the data sets are declared statistically different. This test can also be performed by constructing a $100(1 - \alpha)\%$ confidence interval for the difference between two means using:

$$\left(\underline{y_1} - \underline{y_2}\right) \pm t_{\left(1-\alpha/2, n_1+n_2-2\right)} \cdot \sqrt{s_p^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}$$

If the confidence interval does not contain 0, then the means are declared unequal.

In this study, the null hypothesis (H0) was that the two cohorts had no difference in performance. In other words, the average academic scores and performance are the same. At the same time, the alternative hypothesis (H1) was that interactive polling improves academic performance. In other words, the average academic scores and performance of the cohort using interactive polling are higher than those of the cohort not using them.

Since we had data from two cohorts (current and previous) and wanted to evaluate the impact of interactive polling on student performance, at the first stage, we treated them as separate groups and analysed them separately. We therefore analysed each lecturer's data as a separate dataset, conducting a T-test for each cohort to compare the academic performance of students in the current cohort with and without the online polling.

The following table presents the results of a paired student's T-test conducted to analyse the impact of interactive polling on improving academic performance and, as a result, the effectiveness of student learning in a sample of all ten lecturers involved. The T-test assessed the statistical significance of differences in average academic performance between two groups of students, i.e., the one that used interactive polling during the study process and the other that did not have such activities implemented.

Table 1

T-test results for cohort 1 and cohort 2 (before and after the interactive polling) distributed by each individual lecturer

	Mean (before)	Mean (after)	t-statistics	p-value one tail	t critical one tail	p-value two tail	t critical two tail	Conclusion
L1	74.182	78.818	-0.245	0.404	1.706	0.808	2.056	No significant

								difference in means (do not reject null hypothesis)
L2	76.571	77.643	-0.269	0.395	1.691	0.789	2.032	No significant difference in means (do not reject null hypothesis)
L3	73.611	74.722	-0.269	0.395	1.691	0.789	2.032	No significant difference in means (do not reject null hypothesis)
L4	76.450	77.400	-0.307	0.380	1.686	0.761	2.024	No significant difference in means (do not reject null hypothesis)
L5	77.385	85.923	-2.613	0.008	1.711	0.015	2.064	There is a significant difference in the means (reject the null hypothesis)
L6	76.167	83.667	-3.261	0.001	1.691	0.003	2.032	There is a significant difference in the means (reject the null hypothesis)
L7	71.357	80.357	-3.501	0.001	1.706	0.002	2.056	There is a significant difference in the means (reject the null hypothesis)
L8	73.133	80.533	-2.661	0.006	1.701	0.013	2.048	There is a significant difference in the means (reject the null hypothesis)
L9	73.600	84.300	-2.098	0.025	1.734	0.050	2.101	There is a significant difference in the means (reject the null hypothesis)
L10	77.273	86.636	-2.101	0.024	1.725	0.049	2.086	There is a significant difference in the means (reject the null hypothesis)

The data in the table labelled L1-L10 corresponds to the individual lecturers concerned. The P-values associated with academic achievement indicate the statistical significance of the observed differences between the two cohorts. A P-value less than the given significance level ($\alpha = 0.05$) suggests a significant difference in academic achievement between the cohorts.

The results of the T-test show the effect of polling on academic performance. The P-values indicate whether the observed differences in mean scores are statistically significant, contributing to a comprehensive understanding of the impact of interactive polling on teaching practice and student experience.

Upon conducting a paired T-test, we were able to record the following relationships between the sample size of students, the calculated average value expressed as a percentage, and the results of the paired T-test:

- for a small sample of students: no significant difference in mean values up to 10%, but a significant difference in mean values from 10% or more;
- for a large sample of students: no significant differences in mean values up to 5%, but a significant difference in mean values of 5% or more.

These observations can be explained by the statistical concept of statistical power, which represents the probability of correctly rejecting the null hypothesis when it is indeed false. In other words, it measures the sensitivity of the test to detect a true difference between the means of two groups.

With a small sample size, the variability within each group tends to be greater, making it more difficult to detect a true difference between the groups. This results in lower statistical power and a higher probability of failing to reject the null hypothesis, even if there is a real difference between the means. As the sample size increases, the variability within each group decreases, and the power of the paired T-test increases. This means that the test becomes more sensitive to detecting true differences between the means, and the probability of correctly rejecting the null hypothesis increases.

The specific thresholds that we observed (10% for small samples and 5% for large samples) are likely due to the specific characteristics of our data and the significance level we chose for our T-tests. However, with the general principle that larger sample sizes lead to greater statistical power in most situations, the observations we recorded are consistent with statistical theory. A larger sample size provides more information on the underlying population, allowing the paired T-test to better distinguish between true and false differences in the means of two groups. Taking this into consideration, the outcome of our analysis suggests that consistent and structured interactive online polling for revision purposes can potentially enhance student academic performance in summative assessments by around 5%, though other factors need to be evaluated, too (see below sections).

Significance and variability of observed differences. In addition to providing numerical data, the histograms offer a visual representation of the statistical significance of the differences observed in mean academic performance scores between the two cohorts. Below are three histograms representing the statistical parameters obtained from the results of the student's T-test for ten participant lecturers. These charts provide an overview of the significance and variability of observed differences in mean academic performance scores between the two cohorts.

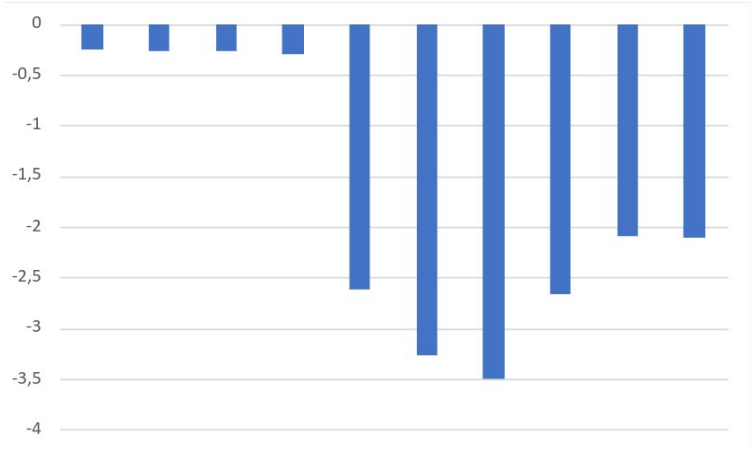

Fig 4. Distribution of the T-statistics for Student's T-test Results

Student statistics quantify the standardised difference in means between two cohorts and measure the size of improvement in academic achievement. A lecturer with a higher T-statistic

shows more significant differences in student academic performance between the groups that used interactive polling and those that did not.

Fig. 4 shows low T-statistics for four lecturers, suggesting limited Vevox impact. However, the T-statistic values for the other six lecturers were very high, indicating a significant difference between their Vevox use and student performance. The observed differences in the T-statistic values suggest that the implementation of the interactive polling may not have a uniform effect on student performance and that other factors could influence the results.

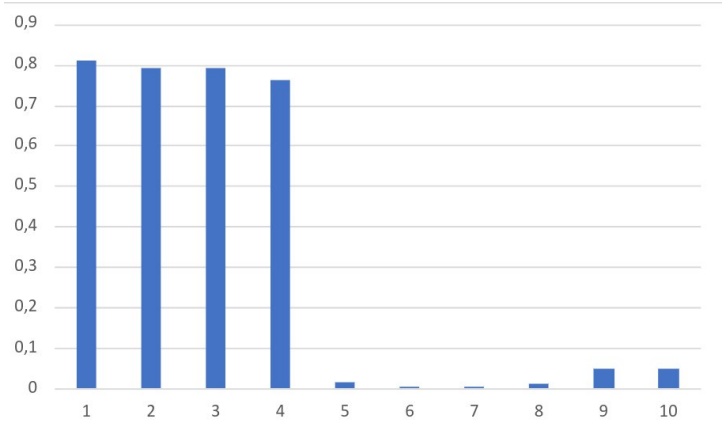

Fig 5. Distribution of the two-tailed P-values for Student's T-test Results

Fig. 5 shows two-tailed P-values corresponding to the T-test scores for each participant lecturer. The P-value is the probability of obtaining the observed results under the null hypothesis of no cohort differences. Instructors with lower P-values indicate a higher likelihood of significant differences in grade point averages, while higher P-values suggest less evidence favouring deviation from the null hypothesis.

The diagram (Fig. 5) shows that the P-values for the first four reported lecturers are all greater than 0.05, indicating that the observed difference between their Vevox usage and student academic performance was more likely due to chance [20]. However, the P-values for the other six lecturers were all less than 0.05, indicating that the observed difference is real [20].

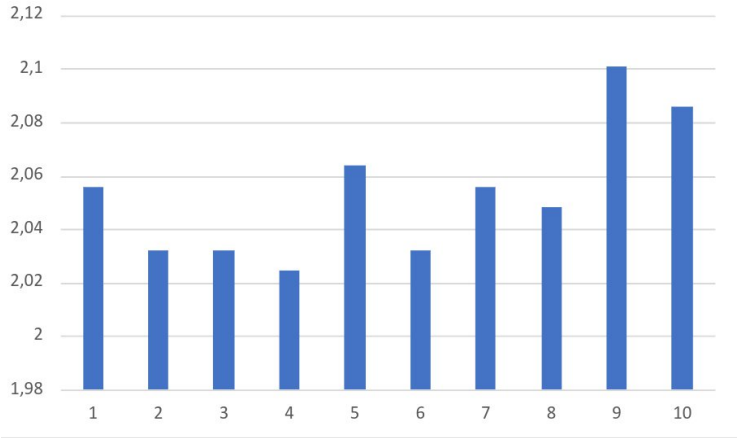

Fig 6. Distribution of the two-tailed T-critical Values for Student's T-test Results

Fig. 6 shows the two-tailed T-critical values for each lecturer, reflecting the threshold above which the T-statistic is considered statistically significant [20]. These critical values are based on the chosen significance level ($\alpha = 0.05$) and degrees of freedom, determining whether the observed T-statistics was large enough to reject the null hypothesis [20].

In each histogram, lecturers can be visually identified based on their relation to the null hypothesis. The lecturers whose scores were lower or higher than the average represented the instances where differences in academic performance were statistically significant or noteworthy. On the contrary, lecturers whose bars were more in line with the means could indicate less pronounced differences that are not statistically significant.

Although histograms provide a valuable overview of the statistical significance of observed differences, they do not explicitly quantify the magnitude of these variations or account for the uncertainty associated with sample assessments. To address these limitations and gain a more precise understanding of the impact of interactive polling on student performance, we resorted to the use of forest plots.

Forest plots. Forest plots provide a comprehensive visual representation of the statistical significance and magnitude of observed differences in student performance between the two cohorts. They also allow for the assessment of uncertainty associated with sample estimates, as indicated by the width of confidence intervals. Additionally, forest plots facilitate the identification of significant average changes in student performance after introducing interactive polling. This is accomplished through examining the relative positions and overlap of the confidence intervals for the two cohorts. Suppose that the confidence intervals for the post-polling cohort consistently lie above or below those for the pre-polling cohort. In that case, it suggests a significant average change in student performance after the implementation of interactive polling.

Below are two forest plots (Fig. 7 and Fig. 8) illustrating the confidence intervals for the mean of the student population before and after the implementation of the interactive polling. These plots show the estimated means of academic performance, accompanied by their respective confidence intervals, providing information on the accuracy and uncertainty of the sample estimates.

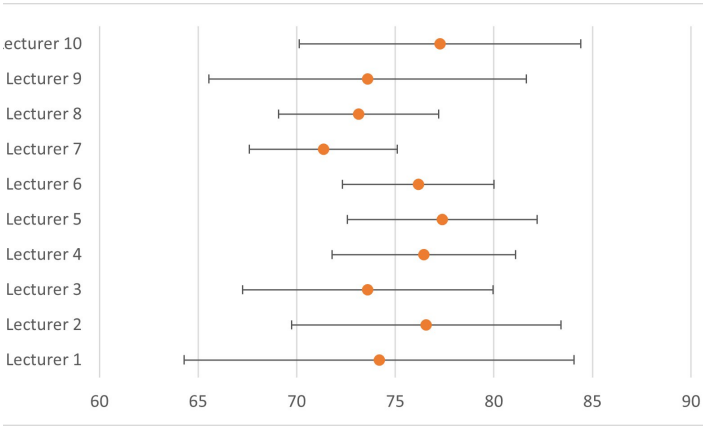

Fig 7. Confidence Intervals Prior to Interactive Polling Implementation

Fig. 7 shows the estimated average academic performance scores of the cohort population of students who did not use interactive polling during their classes. The graph shows point estimates of the mean scores, indicated by circles and horizontal lines extending to the confidence intervals. The confidence intervals represent values that are likely to fall within the population mean with a given confidence level.

The confidence intervals in Fig. 7 indicate the precision of the estimate of the average academic performance score for students who did not use interactive polling. The width of the confidence interval indicates the range of values within which the true population mean is likely to lie with a given level of confidence.

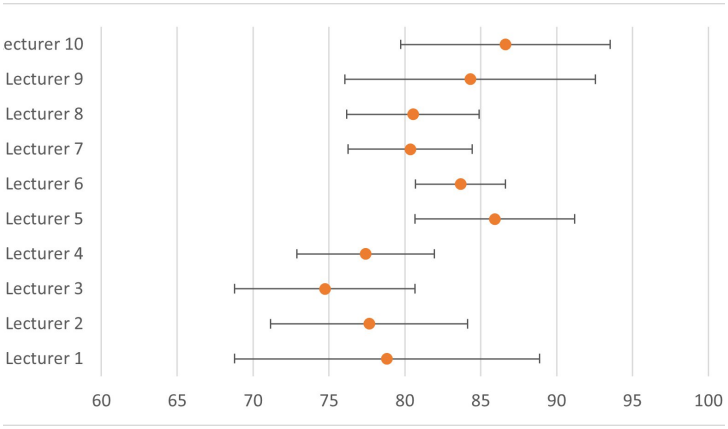

Fig 8. Confidence Intervals Following Interactive Polling Implementation

Fig. 8 provides a similar representation of the estimated average academic performance score and confidence interval for students who used interactive polling. By comparing the confidence intervals in Fig. 7 and Fig. 8, the graphical representation reveals whether there has been a significant change in student performance following the implementation of interactive polling.

Previously, we conducted a primary analysis of each lecturer separately, as it provided valuable information and helped to avoid potential pitfalls associated with combining data from different sources. Subsequently, we conduct a pooled analysis among lecturers to provide an overview of the impact of interactive tests on the entire project team. Therefore, we combined data from different lecturers into two separate datasets: current and previous cohorts. Information about the performance of the most recent cohort, provided by the ten participant lecturers, was collected into one standard data set.

There are several reasons behind this choice, namely:

- Even though the data from each lecturer is a different sample, all of these samples measure the same aspect. In our study, all lecturers considered the data on each of their students' academic success;
- Combining the data gives a larger sample size, allowing more opportunity to detect differences in means between groups;
- Combining data allowed us to control the influence of various factors on different lecturers. For example, if one lecturer had a more challenging class than another, the pooled data would help average these effects.

Table 2

Pooled t-test results for cohort 1 and cohort 2 (before and after online polling)

Mean (before)	75.007
Mean (after)	80.549
T-statistics	-4.594
P-value one tail	0.000
T critical one tail	1.650
P-value two tail	0.000
T critical two tail	1.968
Conclusion	There is a significant difference in the means (reject the null hypothesis)

Regression analysis. As an additional step, an ANCOVA (Analysis of Covariance) was performed to assess whether there is an influence of the individual lecturer and his individual teaching style on the final grades.

The results of the regression analysis ($F = 9.48, p < 0.0001, R^2 = 0.416$) showed that students' PreScore (PreScore, $p < 0.0001$) is a significant predictor of final results, while the influence of instructors is statistically insignificant ($p = 0.00094$). This confirms that the new method probably has an overall positive effect, but the differences between the instructors do not play a key role (Fig. 9).

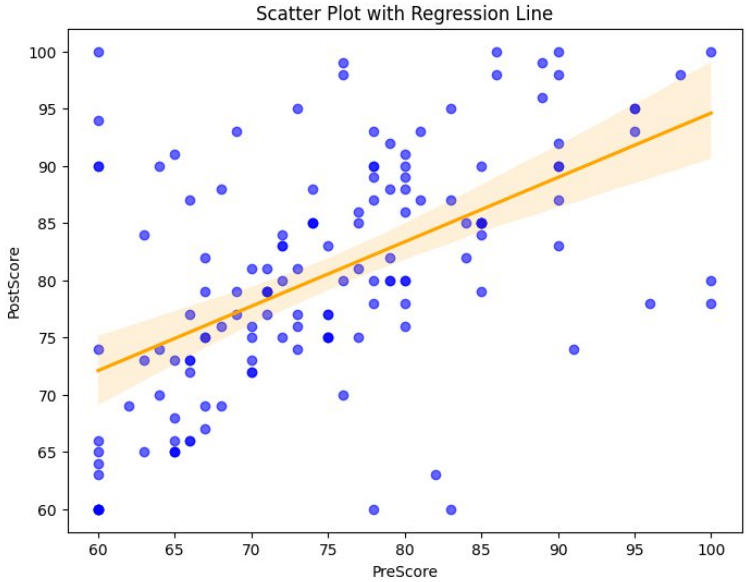

Fig 9. Scatter plot with regression line.

Fig. 9 shows the relationship between students' grades before the new method (PreScore) and grades after its implementation (PostScore). Each blue point corresponds to the average of a particular instructor working with different cohorts of students in different semesters. The red regression line shows the general trend of the relationship between PreScore and PostScore, and the shaded area around the line represents the 95% confidence interval. Visualisation indicates a statistically significant positive correlation between initial and final grades, which emphasises the role of the students' initial level of preparation, even when a new teaching method is introduced.

If we draw conclusions from these two independent tests, we can say that the application of the new method (using Vevox) probably increases scores overall. However, the question remains: Is the increase due to the method or to the different levels of preparation of the cohorts of students? For this, it is worth considering the level of students in different cohorts (for example, their GPAs or prior grades in other courses). Additional control variables could also be added to the regression (e.g., characterisation of course difficulty in different years). We can say that the new method is effective, but there are likely to be biases when changing the students' background levels.

Likert scale survey. In addition to the statistical analysis of the final grades of the students, we also conducted a Likert scale survey to assess student perceptions of interactive polling and its impact on their engagement and learning outcomes. This survey provides valuable information on the subjective experiences of students and complements the objective data obtained from the analysis of the final grades.

The Likert scale survey revealed that 83% of students perceived polling to improve their engagement and understanding. These findings suggest that interactive polling can motivate

students by creating an active learning environment in which they feel more involved in their education. Additionally, the immediate feedback provided by polling supports formative assessment by helping students identify gaps in their knowledge and adjust their learning strategies. This iterative process reinforces a growth mindset, encouraging students to view challenges as opportunities for improvement rather than as barriers to success [21], [22], fostering self-regulated learning behaviours. Although final grades serve as a measure of overall academic achievement, the Likert scale survey captures student perceptions of interactive polling's effectiveness in enhancing engagement, understanding, learning, and confidence. By combining these two approaches, we gain a more comprehensive understanding of the impact of interactive polling on student learning.

Additionally, the Likert scale survey provides valuable insights into the student experience, which can inform future iterations of interactive polling implementation and instructional design. Understanding how students perceive the impact of interactive polling on their engagement and learning can help educators refine their use of this technology to maximise its effectiveness.

The following diagram (Fig. 10) shows the results of the Likert scale analysis of student engagement with and perception of Vevox/interactive polling. In particular, students were asked to rate and evaluate the impact of using Vevox on their engagement with the course material (Question 8), understanding of the topics covered (Q9), learning and academic performance (Q10), promoting equal learning and collaboration (Q14), achieving learning objectives of a course (Q21), improving critical thinking and problem-solving skills (Q22), etc. (the full list of questions is on file with the authors). All of these aspects are relevant to the student experience of interactive polling and can be used to assess how well Vevox is meeting its goal of improving student engagement and, accordingly, and more importantly for our study, academic performance.

Fig 10. Likert-scale Analysis of Student Engagement and Perception of Vevox

The results indicate that over 80% of students reported improved engagement and understanding of course material due to polling, highlighting its perceived effectiveness. This

aligns with broader research on the positive influence of active learning strategies in digital settings.

In addition, we also performed the analysis of the Vevox/interactive polling perception from the lecturers' perspective (Fig. 11). Specifically, we asked the ten participant lecturers to evaluate their experience of using interactive polling and its effects on their student groups. Thus, the following diagram shows the results of our analysis with the questions relating to how lecturers felt about using Vevox and how they perceived its impact on student engagement (Q8), student performance (Q10), teaching experience (Q12), identification of areas of confusion and misunderstanding (Q20), improvement of students' critical thinking and problem-solving skills (Q25), etc (full list of questions is on file with the authors). All of these questions are relevant to the lecturer's experience using Vevox, and they can be used to assess how well Vevox is meeting its goal of supporting lecturers and improving student learning.

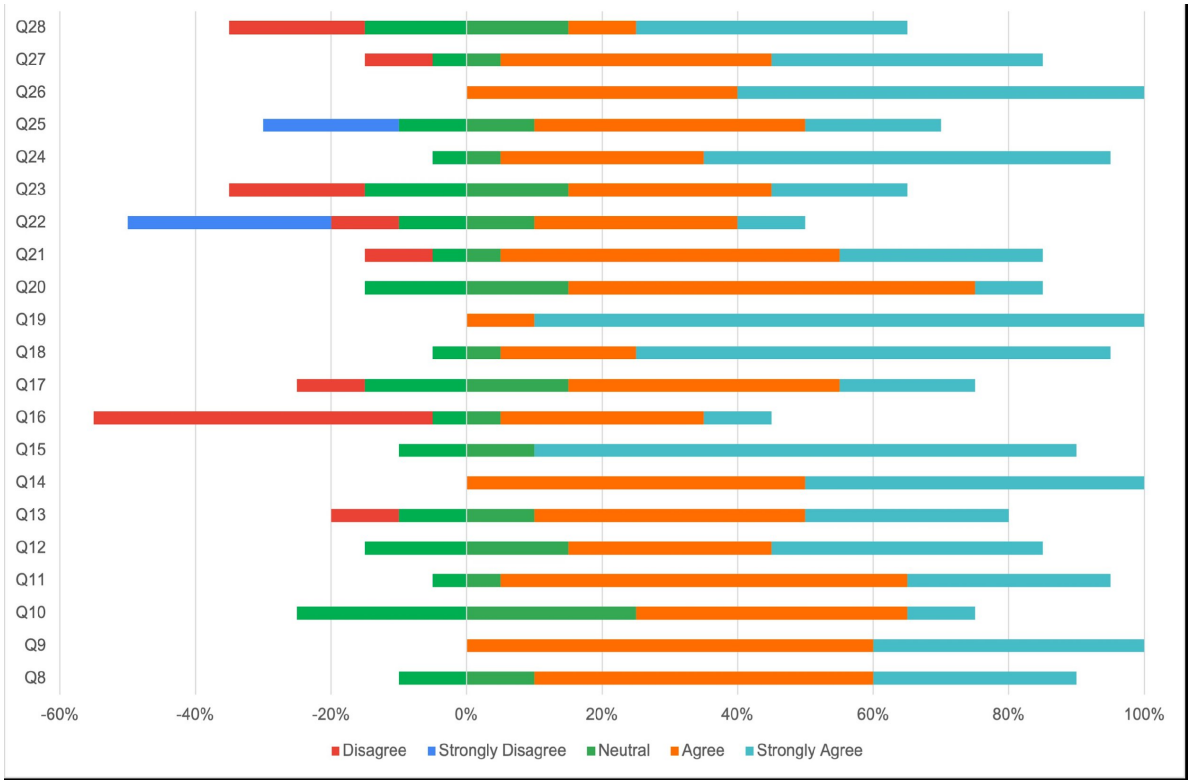

Fig 11. Likert-scale Analysis of Tutor Engagement with and Perception of Interactive Polling

This suggests that Vevox is having a very positive impact on both student and lecturer perceptions of academic learning and performance across a wide range of areas.

As can be seen from these two diagrams, the percentage of students and lecturers who agree with the statement is significantly higher than the percentage who disagree in all cases. This is apart from just a couple of questions in the lecturers' survey. There are some possible pedagogical reasons why lecturers partially or completely disagreed with the concern. For example, in Q16 lecturers were asked whether implementation of Vevox changed their approach to student feedback and assessment, but it seems that many of the participant tutors did not record any significant change from the methods of student feedback and assessment they were already using. Similarly, in Q22 tutors were asked whether Vevox helped them in personalisation of the learning process for each student, but a substantial degree of disagreement with this statement may suggest that lecturers did not believe that Vevox provides the required flexibility and tailoring for the needs of each individual student or that such personalisation is simply unnecessary.

4. CONCLUSIONS AND FUTURE RESEARCH PERSPECTIVES

Our findings suggest that educators should consider integrating structured interactive polling, such as Vevox, into their teaching strategies to improve student engagement and performance. Recommended practices include using polling regularly for revision, aligning questions with learning objectives, and fostering active discussions around poll results to deepen understanding.

Our analysis revealed a statistically significant increase in student performance in summative assessments among cohorts using interactive polling. A further pooled analysis among all participating lecturers demonstrated a consistent pattern of improvement in the mean average grade of students. Polling promotes active participation in online settings. By encouraging students to interact with the course material in real time, polling reduces passivity and fosters a more dynamic and inclusive learning environment. This conclusion is further supported by the results of the Likert scale analysis, which indicated that both students and lecturers perceived online polling as a valuable and impactful component of the learning process.

Paired T-tests conducted on a large sample of students revealed that an increase of around 5% in average student performance was associated with a statistically significant difference in mean values. This 5% improvement corresponds to, on average, a shift from a 'C' to a 'B-' grade on conventional grading scales, underscoring its practical significance for student mastery and confidence. This suggests that the observed improvement in student performance is not attributable to chance alone and that interactive polling can contribute to improved academic outcomes.

However, the observed increase of up to 5% is a meaningful and educationally relevant result. In practical terms, such a gain can translate into higher retention rates and reduced remediation, offering tangible benefits for curriculum design and institutional learning outcomes. This finding aligns with the positive perceptions of both students and lecturers, further strengthening the overall conclusion that interactive polling can be an effective tool for enhancing student learning.

Prospects for further research. As an additional step, an ANCOVA was used to assess whether there was an effect of individual lecturers and their individual teaching style on the final grades, which suggested that the new method probably had an overall positive effect, but that differences between lecturers did not play a key role. Combining the findings of these two independent tests, it can be said that the use of the new method (using Vevox) probably increases overall scores, but there will likely be bias when the background levels of the students change. These findings highlight the importance of combining polling with other pedagogical supports (such as pre-assessment diagnostics and scaffolding activities) to maximize equitable learning gains across diverse student cohorts.

Integration of quantitative and qualitative findings highlights the value of interactive polling as a scalable tool to improve teaching and learning in higher education, particularly in online and hybrid environments. As educational institutions increasingly adopt technology-driven methods, tools such as Vevox can play a crucial role in improving academic results and fostering active learning.

The study was limited by sample size and duration. Additionally, due to the small sample sizes of individual lecturers, the results should be interpreted with caution, as statistical power may be limited. Future research should examine the use of polling in other pedagogical models. Furthermore, examining the long-term effects of polling on student motivation, metacognition, and collaborative learning could provide a more holistic understanding of its educational impact.

It is illustrative that even when operating with limited available data, we encountered significant differences in T-statistics and P-values in different groups (as reported, four out of the ten participant lecturers did not see any significant differences in the academic performance of their respective students/groups).

There are a few possible explanations for these considerable differences. It may be that the four lecturers referred to above did not use Vevox effectively and engagingly for the students but only used it for low-level activities that did not require students to think critically or creatively. Alternatively, the other six lecturers may have used Vevox in a more effective way to engage their students, such as facilitating discussions, creating collaborative learning activities, or providing students with instant feedback on their work. On top of that, a mediation analysis could be employed to investigate whether other factors, such as student motivation, self-regulation, or prior knowledge, mediate the relationship between interactive polling and academic performance. Understanding these mediating factors, coupled with a holistic view of student learning, could provide valuable insight into how interactive polling influences student learning outcomes. HLM would allow for a more nuanced analysis of the factors that influence student performance, considering individual student characteristics and lecturer-level effects.

T-statistical differences may result from small sample sizes. Although our study is more extensive than the vast majority of previous interactive polling studies, it is recommended that any similar future studies include a more significant number of student participants (ideally from diverse backgrounds and institutions) over a longer period. Hence, more data are needed to increase sample size and reduce the influence of random fluctuations, including but not limited t

- Demographic characteristics of the participants, such as sex, race, ethnicity, and marital status;
- External influences that could affect the data, such as changes in economic conditions or political situations;
- Data collection methods, control, and time variables;
- Face-to-face method of teaching delivery instead of an online format;
- Introduction of an additional control group.

Additionally, it may be necessary to use and compare other platforms that allow for interactive polling that control for potential confounding variables, thus including other factors that may affect academic performance, other than interactive polling. A deeper and more robust understanding of the specific interactive polling activities used by the lecturers would be necessary for investigation of the significant difference in T-statistic values.

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Text of the article was accepted by Editorial Team 09.04.2025.

ІНТЕРАКТИВНІ ОНЛАЙН-ОПИТУВАННЯ ЯК ІНСТРУМЕНТ ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ ФОРМУВАЛЬНОГО ТА ПІДСУМКОВОГО ОЦІНЮВАННЯ В УМОВАХ ГІБРИДНОГО НАВЧАННЯ

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Анотація. У цій статті на прикладі змішаного дослідження Національного університету «Одеська політехніка», досліджується вплив інтерактивного онлайн-опитування (з використанням Vevox) на академічну успішність під час підсумкового оцінювання в контексті гібридного навчання. Використовуючи змішаний підхід до тематичного дослідження, ми проаналізували тенденції успішності до і після впровадження Vevox, розмістивши результати в контексті попередніх досліджень щодо залучення. Дослідження заповнило виявлену прогалину в літературі щодо педагогічного впливу ARS за межами показників задоволеності студентів. Ми встановили кількісні зміни в успішності (до 5% покращення). Крім того, ми визначили якісні зміни в сприйнятті студентів та викладачів. Попередні дослідження ARS в основному зосереджувались на залученні до різноманітних навчальних середовищ, але рідко досліджували його педагогічний вплив. Наше дослідження заповнює цю прогалину, вивчаючи, як опитування підтримує практики формувального та підсумкового оцінювання, сприяє активному навчанню та сприяє розумінню студентами складних тем. Контекстуалізуючи ці висновки в межах дослідження освітніх технологій, ми підкреслюємо важливість цього інструменту для масштабованої педагогіки. На основі наших висновків ми рекомендуємо такі педагогічні рекомендації: (1) використовувати опитування як регулярний інструмент формувального оцінювання для закріплення ключових понять; (2) розробляти питання, які поступово ставлять перед учнями складні завдання, підтримуючи когнітивний розвиток; (3) використовувати опитування для сприяння обговоренню з однолітками та спільному навчанню; (4) поєднувати опитування з рефлексивними вправами для поглиблення розуміння та заохочення до метапізнання. Мета дослідження – кількісно та якісно оцінити вплив Vevox на результати навчання студентів у гібридній вищій освіті, у такий спосіб інформуючи про найкращі практики для технологічно вдосконалених систем оцінювання.

Ключові слова: інтерактивне опитування; академічна успішність; Vevox; формувальне оцінювання; активне навчання.

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