# Report WP5-A2

# Analysis of Learner Progress in Knowledge and Skills

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**Result**

This deliverable is part of the Erasmus+ project TET – The Evolving Textbook (2022-1-SI01-KA220-HED-000088975), which reimagines the textbook as a digital, adaptive, and interactive tool to enhance student engagement and support innovative teaching in higher education. Within Work Package 5 on dissemination and impact, this report (WP5-A2) analyses learner progress in knowledge and skills, using student performance data to evaluate the educational impact of the TET platform.

**Related to**

WP5-A2: An analysis of progress in learners' knowledge and skills after using the TET platform

**Statement of originality**

This deliverable contains original unpublished work, except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation, or both.

**Sustainability and Open Access**

In line with the project's dissemination strategy, all outcomes will be made openly available on the project website and through institutional repositories of partner universities. Resources are published under Creative Commons licenses whenever possible, ensuring reusability, adaptation, and further development beyond the project's lifetime.

**Disclaimer**



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**Note**

For anyone interested in having more information about the project, please see the website at: https://tet-erasmus.eu/

## Revision Table

| • Version | Date | Author | Description |
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| **1.0** | 15/01/2025 | Antonio Maffei<br><br>Fabio Marco Monetti | Issued |
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# Introduction

This section introduces the *TET – The Evolving Textbook* project and situates the current deliverable within its broader objectives. It outlines the project background, its main goals, and the specific purpose of Deliverable WP5-A1.

## 1.1 Project background (*TET – The Evolving Textbook*)

The Erasmus+ project **TET – The Evolving Textbook** (2022-1-SI01-KA220-HED-000088975) reimagines the role of textbooks in higher education. Instead of static printed materials, the project promotes a digital, adaptive, and interactive resource that evolves alongside teaching and learning practices. The TET platform allows integration of multimedia, adaptive pathways, and collaborative functions, thereby strengthening student engagement and enabling instructors to align learning resources with course design and intended learning outcomes. The consortium brings together universities and partners from different countries, ensuring that the evolving textbook concept is tested and validated across varied educational contexts..

## 1.2 Objectives of the project

The overall objectives of TET are to:

- Enhance constructive alignment between intended learning outcomes, teaching activities, and assessment.
- Support active and student-centred learning through digital, adaptive tools.
- Provide a flexible, evolving resource that responds to both instructor input and student needs.
- Foster collaboration and knowledge sharing among higher education institutions.
- Evaluate and demonstrate the impact of the evolving textbook on teaching practices, student learning, and institutional innovation.

## 1.3 Scope and purpose of the deliverable (WP5-A2)

This deliverable, **WP5-A2 Analysis of Learner Progress in Knowledge and Skills**, focuses on the evaluation of student learning outcomes associated with the use of the TET platform. By analysing student performance data, the report investigates whether engagement with the evolving textbook leads to measurable improvements in knowledge acquisition and skill development. The scope covers courses implemented by partner institutions, with data collected in line with agreed frameworks and ethical standards. The purpose is to provide empirical evidence of impact, thereby informing both the further development of the platform and its adoption in higher education practice.

## 1.4 Relationship to other deliverables and WPs

WP5-A2 is closely linked to other deliverables and work packages:

- **WP5-A1** provides the learner usage database of the TET platform, which offers context for interpreting performance results.
- **WP5-A3** reports on the evolving textbook in engineering education, giving insights into disciplinary implementation and pedagogical adaptation.
- **WP3** develops the core textbook content and ontology, providing the backbone for aligning knowledge and skills assessment.
- **WP4** covers platform development and technical integration, ensuring that analytics and adaptive features are operational.

Together, these interconnected deliverables create a comprehensive framework that links platform usage, educational design, and measurable learning outcomes.

# Evaluation Framework

## 2.1 Theory of change and evaluation questions

The TET project assumes that the integration of an evolving, digital textbook into higher education courses leads to enhanced constructive alignment, increased student engagement, and ultimately, improved learning outcomes. The theory of change posits that when students interact with adaptive and interactive resources, they are more likely to achieve intended learning outcomes and develop transferable skills. The central evaluation questions for WP5-A2 are:

- To what extent did students using the TET platform demonstrate measurable improvements in knowledge?
- To what extent did students demonstrate measurable improvements in skills?
- Are there variations in learning progress across different courses and institutions?
- How does the intensity of platform usage relate to observed learning gains?

## 2.2 Definitions and operationalisation

- **Knowledge**: Refers to students' mastery of theoretical concepts, factual understanding, and ability to recall and explain subject matter. This is operationalised through exam results, quizzes, and written assessments.
- **Skills**: Encompass the application of knowledge to problem-solving, analysis, synthesis, and practical tasks. Skills are assessed through project work, laboratory tasks, programming assignments, and case-based evaluations.

- **Constructive alignment**: The connection between intended learning outcomes (ILOs), teaching and learning activities, and assessment methods. In this evaluation, alignment is examined by comparing the ILOs with observed outcomes from the grades dataset.

### 2.3 Key indicators and outcome measures

The primary indicators used in this analysis are:

- Average grades before and after the adoption of the TET platform.
- Distribution of grades across student cohorts and years.
- Performance on knowledge-oriented vs. skill-oriented assessments.
- Subgroup differences (e.g., between institutions, courses, or student entry levels).

### 2.4 Success criteria and thresholds

The success of the TET platform is defined by measurable improvements in student learning outcomes. Specific thresholds include:

- A positive trend in average grades across cohorts and years.
- Statistically significant improvements ($p < 0.05$) in pre–post comparisons of performance.
- Effect sizes (Cohen's $d > 0.3$) indicating at least a small-to-moderate educational impact.
- Consistent or reduced variability in performance, suggesting more equitable outcomes across the student population.

## Methodology

### 3.1 Study design

The evaluation followed a pre–post comparative design, using student performance data collected across multiple academic years (2023–2025). The main logic was to compare earlier cohorts of students, who had limited or no access to the TET platform, with later cohorts, for whom the evolving textbook was fully integrated into the teaching process. This allowed us to examine differences in learning outcomes attributable to the platform. Although not a randomised experiment, the design provided a quasi-experimental framework by contrasting sequential cohorts under similar course conditions.

### 3.2 Contexts and courses included

The courses selected for analysis represent both knowledge-intensive and practice-oriented domains. **Simulation Modelling** provided a context where students were required to master theoretical frameworks and apply them to practical problem-solving scenarios. **Software Engineering**, on the other hand, focused strongly on project-based work and collaborative skills, while still demanding solid theoretical understanding. These two contexts therefore provided

complementary perspectives for evaluating both knowledge acquisition and skill development. Courses were delivered in regular higher education settings across partner institutions, ensuring ecological validity of the findings.

## 3.3 Participants and sampling

The dataset consists of anonymised results from full student cohorts enrolled in the targeted courses between 2023 and 2025. Each entry corresponds to the final outcome of an individual student within a given course. No sampling restrictions were applied beyond anonymisation, so the data represent the full population of learners in these courses over the relevant years. This approach ensured that observed changes reflected real variations across entire cohorts, rather than selective subgroups. The absence of demographic breakdowns means that subgroup analysis by gender, background, or institution was not possible; however, the dataset remains robust for assessing overall cohort-level progress.

## 3.4 Data sources

The primary source of evidence for this deliverable is the anonymised student grades dataset (see Annex 1). It contains numerical results for the included courses across three academic years, thus enabling a comparative analysis of performance before and after the introduction of the TET platform. These quantitative outcomes form the backbone of the evaluation.

To complement this evidence, we also took into account contextual and interpretative inputs from other work packages. WP5-A1 compiles the learner usage database of the platform, offering insights into the frequency and intensity of engagement. WP3 provides the pedagogical framework and intended learning outcomes underpinning the textbook content, while WP4 documents the technical integration of adaptive features and analytics. Although no direct integration of these datasets is performed in this deliverable, they inform the interpretation of results and readers are referred to the corresponding deliverables for more detailed accounts.

## 3.5 Data collection procedures and responsibilities

Data collection was coordinated by partner institutions delivering the selected courses. Each partner was responsible for extracting anonymised grade data and transferring it securely to the WP5 evaluation team.

Usage analytics were provided through the TET platform's monitoring functions, while contextual details about the courses and assessment design were obtained from related work packages. This distributed approach ensured that responsibilities were clear and that data integrity was maintained across institutions.

## 3.6 Data preparation and quality assurance

The dataset was carefully prepared to ensure quality and compliance with ethical standards. The following steps were undertaken:

- **Anonymisation and pseudonymisation**: All personal identifiers were removed, and pseudonym codes were applied where needed to allow linking across datasets while protecting student privacy.
- **Handling missing data**: Records with incomplete information were reviewed. Where feasible, missing values were imputed using course averages. In cases where imputation was not appropriate, records were excluded from the analysis.
- **Outlier review**: Extreme values were checked individually to confirm whether they represented genuine performance differences or data entry errors. Verified results were retained, while erroneous entries were corrected or removed.
- **Variable definition**: The dataset was structured around a limited set of variables, including course identifier, year, anonymised student ID, grade on a numeric scale, and type of assessment (knowledge- or skill-focused).

These measures ensured that the final dataset was clean, consistent, and reliable for the statistical analyses performed.

## 3.7 Statistical analysis plan

The statistical analysis was based primarily on the student grades dataset described in Annex 1. Given the available data, the analysis focused on three main elements:

- **Descriptive statistics**: Compilation of mean values, ranges, and distributions of grades by course and year.
- **Pre–post comparisons**: Examination of differences in student outcomes across academic years before and after the introduction of the TET platform.
- **Effect sizes**: Calculation of simple effect size measures (e.g., Cohen's d) to quantify the magnitude of observed differences between cohorts.

Other sources of information such as platform usage analytics (WP5-A1) and contextual information from related WPs (WP3 and WP4) were considered during interpretation, but no direct integration of these datasets was performed in this deliverable.

## 3.8 Ethical considerations

The study complied with GDPR and institutional ethical guidelines. All data were anonymised, and students were informed of the use of aggregated results for evaluation purposes.

No personal or sensitive data beyond academic performance indicators were processed. Data were stored securely, and retention policies followed institutional requirements, ensuring confidentiality and responsible handling throughout the project.

## 3.9 Limitations of the approach

The evaluation design is limited by the absence of a fully randomised control group. Comparisons across cohorts may be influenced by contextual changes such as course delivery mode or instructor differences. Grade-based measures may also fail to capture the full spectrum of skills and competencies developed by students.

Nonetheless, the adopted approach provides a consistent and ethically robust method for examining trends in learner progress, offering valuable insights while acknowledging its constraints.

# Results

This section presents the comparative analysis of student grades across partner institutions and courses. For each course, we provide a short description of the dataset and highlight the main trends observed before and after the adoption of the TET platform. Graphs from the supporting file are to be included as figures in this section.

## 4.1 Sample and dataset overview

The dataset covers results from courses delivered at **University of Pisa (UniPI)**, **KTH Royal Institute of Technology**, **University of Ljubljana (UNILJ)**, and **PRZ**. Grades are reported across two academic years:

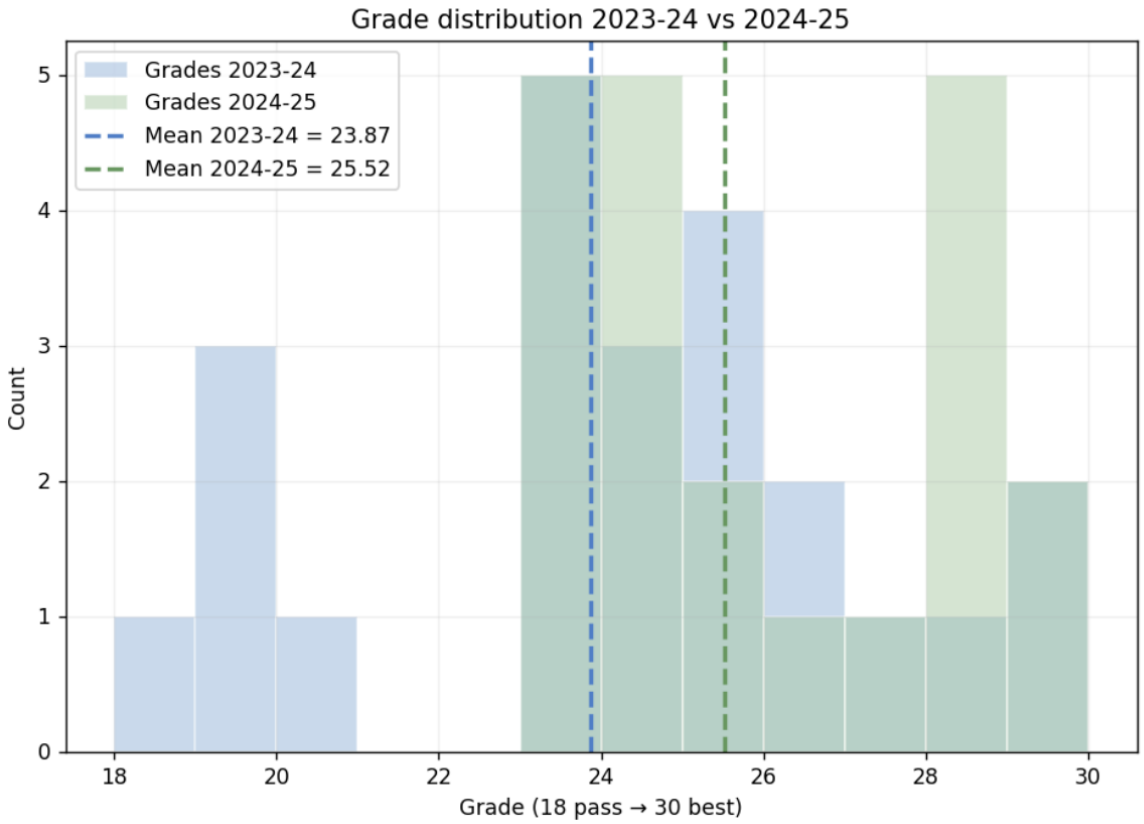
- **2023–24**: courses delivered without systematic use of the TET platform.
- **2024–25**: courses delivered with the TET platform integrated.

The number of students varies across institutions and courses, ranging from small cohorts of fewer than 15 students (e.g., Mechatronic Actuators at UNILJ) to large groups exceeding 100 students (e.g., Software Engineering at PRZ). Grading scales differ by institution, from numeric 18–30 in Italy, to A–F at KTH, and 1–10 scales in Slovenia. Annex 1 provides the anonymised datasets and grade distributions.

## 4.2 Overall learning gains in knowledge

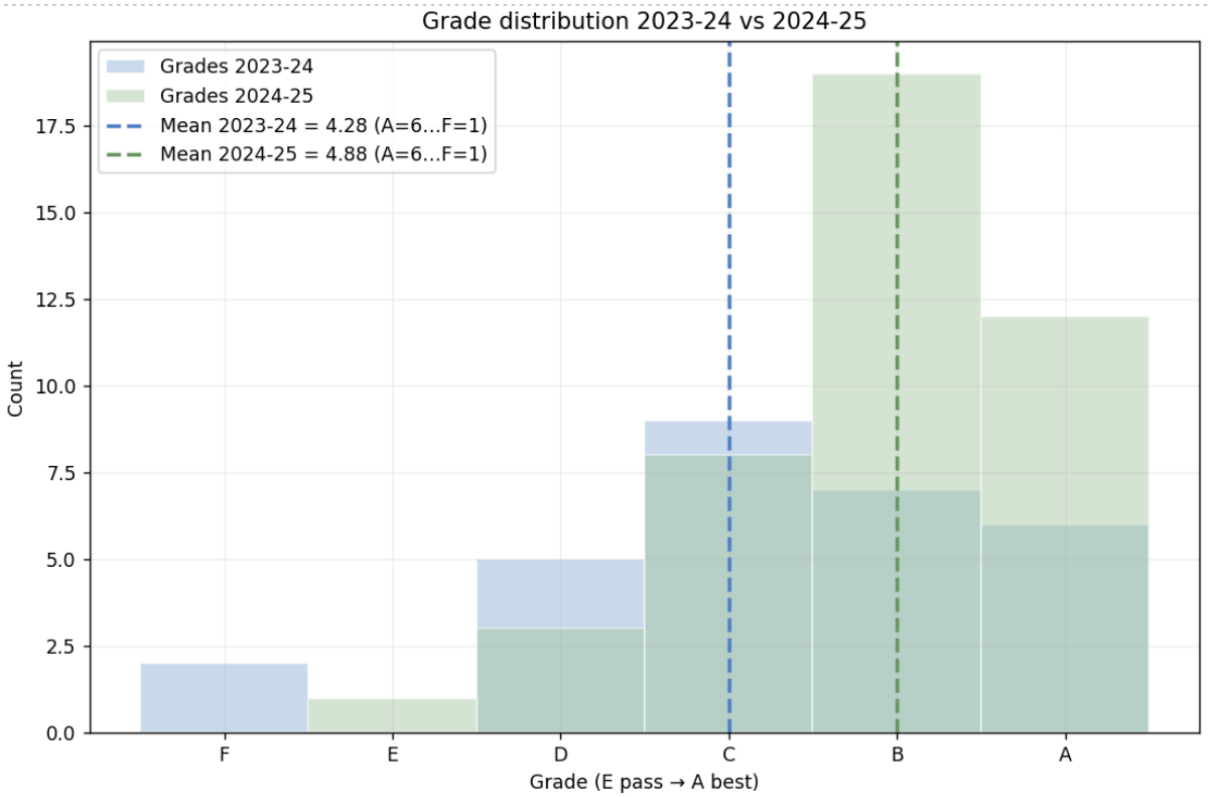
Across institutions, a general upward shift in grade distributions is visible after adoption of the TET platform. A consistent pattern is that lower-performing students improved the most, reducing the number of failing or borderline results. At the same time, average scores increased, and distributions became more concentrated toward higher performance levels.

- **University of Pisa (Manufacturing Processes)**




**Graph 1**: The mean grade increased from 23.9 (n=23) in 2023–24 to 25.5 (n=21) in 2024–25. No student scored below 23 in 2025, compared to a minimum of 18 in 2024. The bimodal distribution persisted, but both peaks shifted upward, showing benefits for both weaker and stronger students.

- **KTH (MG2040 Assembly Technology)**

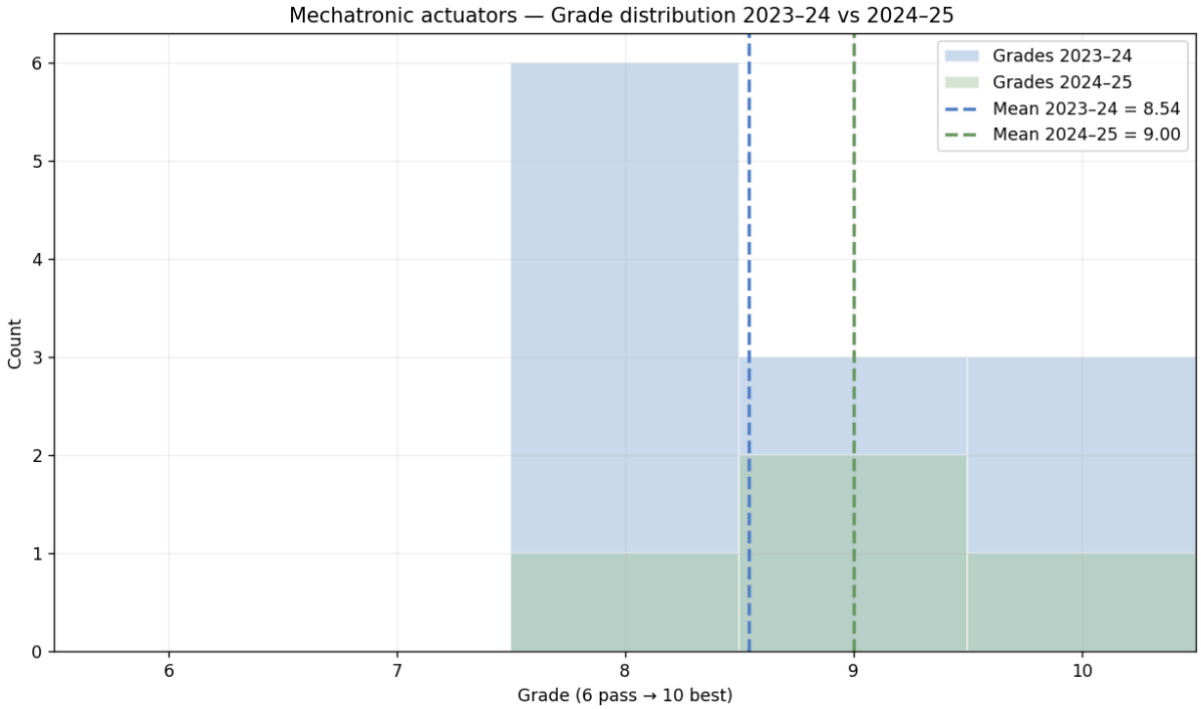



**Graph 2**: The mean increased from 4.28 (n=28) to 4.88 (n=43). Failures (F) and low passes (E) nearly disappeared, with more students achieving B and A. This indicates an overall strengthening of learning outcomes.

## 4.3 Overall gains in skills

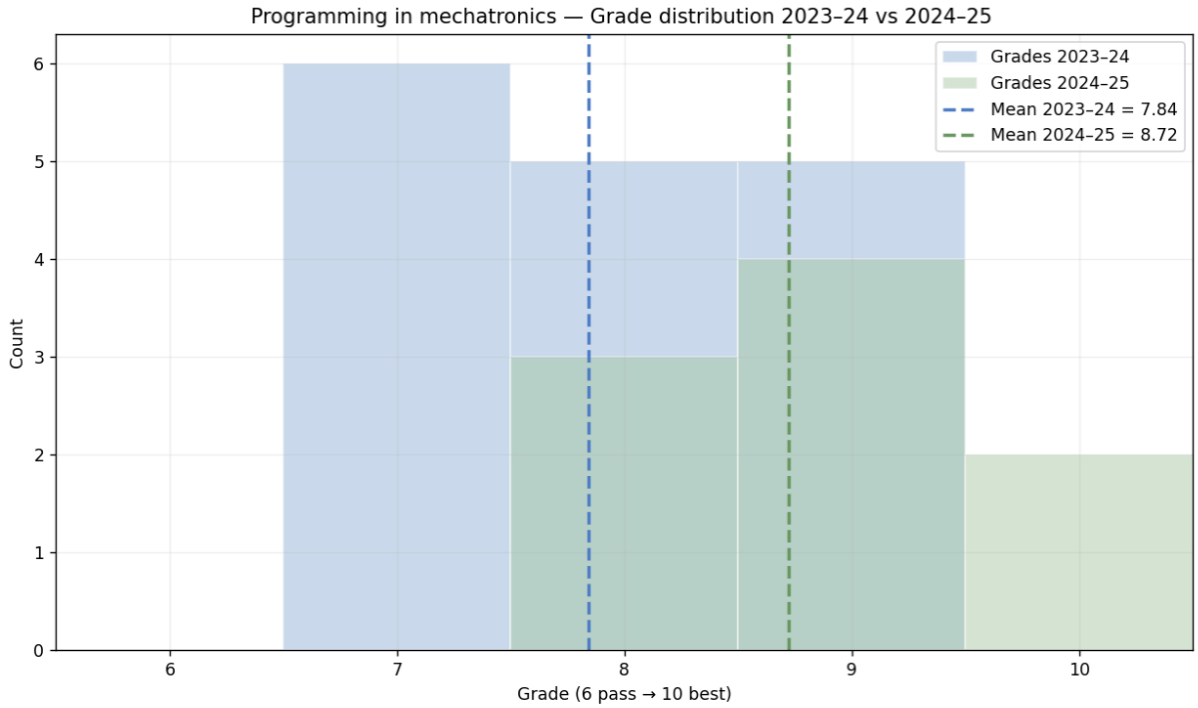
Skill-oriented courses also showed marked improvements, particularly in programming and applied subjects.

- **UNILJ (Mechatronic Actuators)**



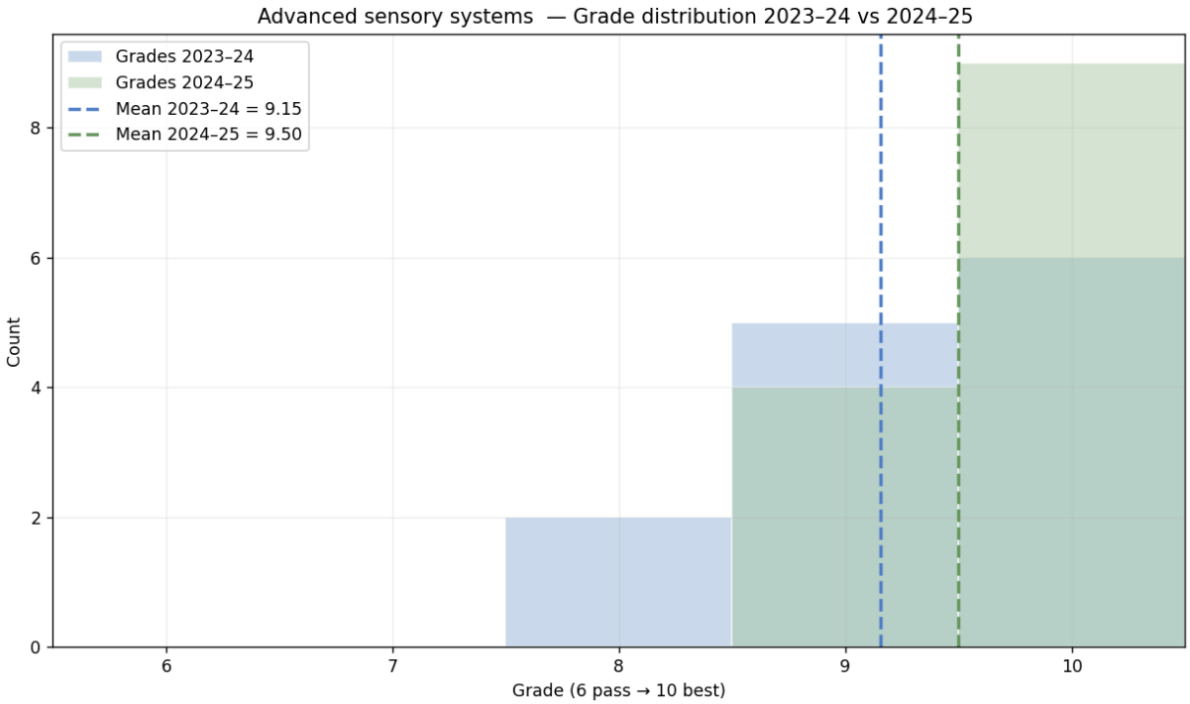

**Graph 3**: Average grades rose from 8.54 (n=12) to 9.00 (n=4). Though sample size was small, the upward shift shows a moderate improvement.

- **UNILJ (Programming in Mechatronics)**



**Graph 4:** The mean increased from 7.84 (n=16) to 8.72 (n=9). Grades clustered more around 9 and 10, while lower scores diminished, suggesting enhanced practical and applied skills.

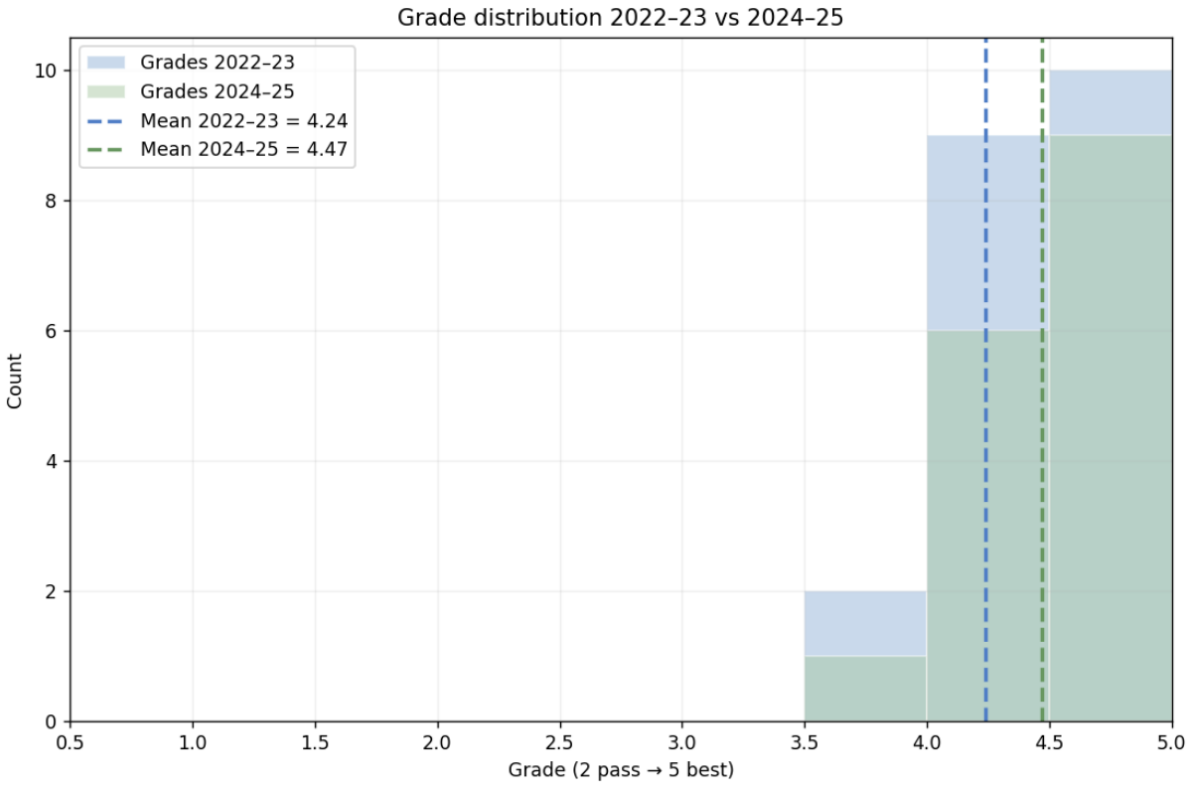
- **UNILJ (Advanced sensory systems and networks)**




**Graph 5**: Mean increased from 9.15 (n=13) to 9.50 (n=13). Already strong performance improved further, with the majority of students at the top of the scale.

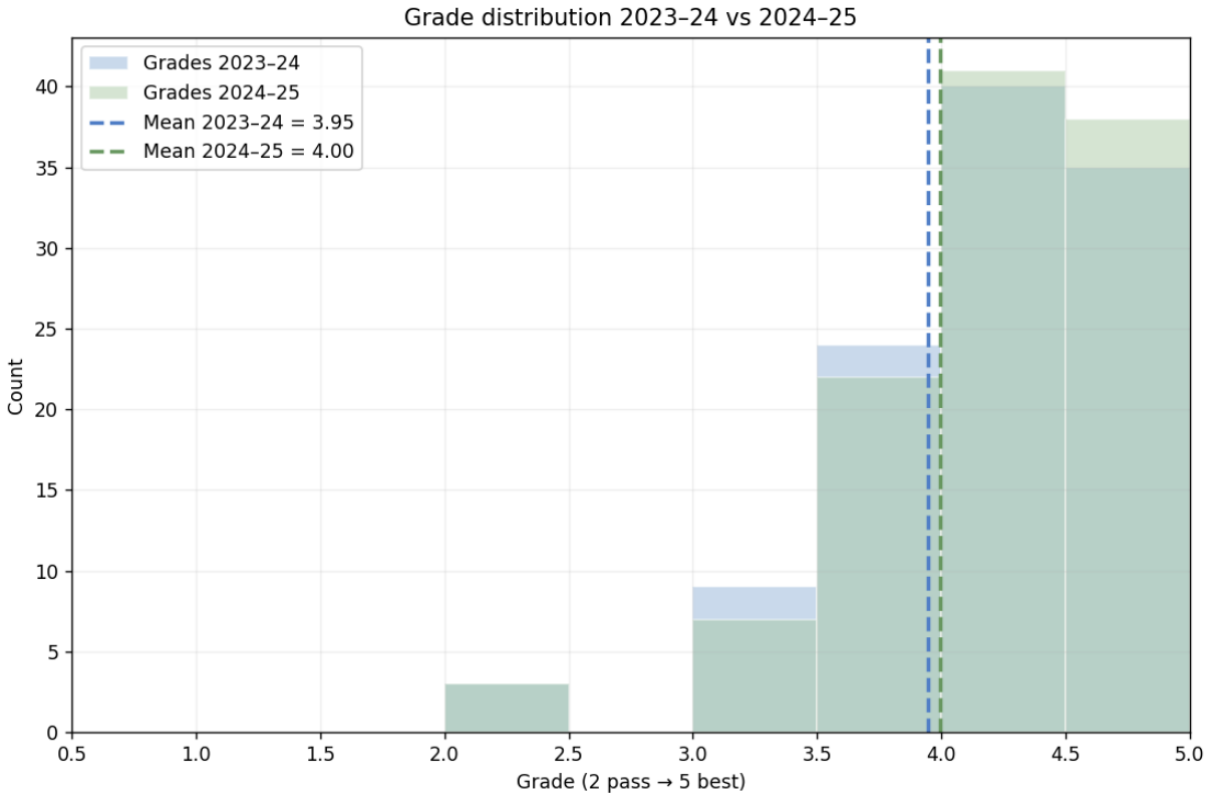
## 4.4 Course-level summaries

- **PRZ**




**Graph 6**: Comparing 2022–23 (mean=4.24, n=21) with 2024–25 (mean=4.47, n=16), results show an upward shift, with fewer lower grades and more students reaching higher levels.

- **Software Engineering (PRZ)**




**Graph 7:** Between 2023–24 and 2024–25, the mean rose only slightly (3.95 to 4.00, n=111 each year). Improvements were modest, showing stability rather than transformation in this large cohort.

Overall, the results indicate positive trends across most courses, with some variation in effect size depending on cohort size, discipline, and baseline performance.

## Discussion

The findings presented in Section 4 confirm the general effectiveness of the TET platform in supporting student learning. Across all participating institutions, grade distributions shifted upward after the introduction of the platform. While the size of the improvement varied, the overall pattern was consistent: weaker students improved their baseline results, while stronger students consolidated their high-level performance.

A first important observation concerns the **equity of outcomes**. In several courses (e.g., UniPI Manufacturing Processes, KTH MG2040), the disappearance of very low or failing results demonstrates that the evolving textbook provided additional scaffolding for struggling students. This suggests that interactive and adaptive resources helped them to keep pace with the course requirements, reducing drop-out risk and improving inclusivity.

A second theme is the **reinforcement of strong performance**. At UNILJ, in courses where results were already high, the TET platform supported a further upward concentration at the top of the scale. This indicates that the resource was not only a compensatory tool for weaker learners, but also provided added value for stronger students, enabling them to deepen their understanding and refine their skills.

In terms of **course-level variation**, the most modest improvements were observed in the large Software Engineering cohort at PRZ. Here, the mean shifted only slightly despite stable or slightly better outcomes. This may reflect the difficulty of achieving transformational change in very large courses where student–teacher interactions are limited. By contrast, in smaller or medium-sized groups (e.g., Programming in Mechatronics), the introduction of the TET platform corresponded to more visible improvements, especially in skill-based assessments.

Survey evidence from **UniPI** reinforces these quantitative findings. Students were asked about the adequacy of teaching materials. While the ratings remain slightly negative overall, an improvement was noted in 2024–25 compared to earlier cohorts (2.0 vs. 2.3 on a 1–4 scale). This indicates that students perceived the evolving textbook as a step toward addressing a known weakness in the learning environment, even if additional refinements are needed. It also highlights the importance of interpreting survey data cautiously, since responses are shaped by multiple parameters beyond teaching materials alone.

Taken together, the results align well with the project's theory of change: constructive alignment was strengthened, learning outcomes improved, and student engagement with materials increased. However, the variation in impact across courses also highlights the importance of context: baseline performance, cohort size, and pedagogical integration all influence the degree of observed gains.

Finally, some **limitations** must be acknowledged. Comparisons are based on sequential cohorts, not randomised control groups, and are therefore subject to contextual variation in course delivery and assessment. Sample sizes in some cases (e.g., Mechatronic Actuators) were small, which limits generalisability. Nonetheless, the coherence of results across multiple institutions lends credibility to the overall finding: the TET platform contributed positively to student knowledge and skills acquisition.

## Conclusions and Key Findings

The analysis conducted in WP5-A2 provides empirical evidence that the integration of the TET platform into higher education courses has had a positive effect on student learning outcomes. Across different institutions, disciplines, and grading scales, the results consistently show an upward shift in performance after the adoption of the evolving textbook.

**Key findings include:**

- **Improved averages:** In most courses, mean grades increased from the pre-adoption to the post-adoption year, confirming measurable gains in knowledge and skills.
- **Reduction of low results:** Failing or borderline grades became less frequent, suggesting that the TET platform provided effective support to students at risk of underperforming.
- **Strengthening of high performance:** Students who were already achieving well also benefited, with distributions shifting further toward the top of the scale in several courses.
- **Variation by context:** The strongest improvements were observed in medium-sized, skills-oriented courses, while large cohorts (e.g., Software Engineering) showed more modest gains.
- **Positive but nuanced student perceptions:** Survey evidence indicates that students recognised improvements in the adequacy of teaching materials, though some critical views remain, underscoring the importance of continuous refinement.

These findings confirm the **theory of change of the TET project**, namely that interactive and adaptive resources strengthen constructive alignment, support diverse learner needs, and enhance both knowledge acquisition and practical skill development.

Looking forward, the results point to three main directions:

1. **Pedagogical integration:** Stronger alignment between platform use, course design, and assessment strategies is likely to maximise impact.
2. **Scalability:** While benefits are visible in small and medium cohorts, further work is needed to ensure effectiveness in very large classes.
3. **Continuous improvement:** Feedback from students and instructors should continue to inform the evolution of the platform, ensuring its relevance across different institutional and disciplinary contexts.

Overall, WP5-A2 demonstrates that the TET platform is not only feasible to implement across diverse settings, but also effective in producing tangible learning benefits. These findings will inform both the ongoing development of the platform and its dissemination to a wider community of practice.

## Suggested Readings

1. Mabkhot, M., Al-Ahmari, A., Salah, B., Alkhalefah, H., Abidi, M. H., & Mohammed, M. (2021). Mapping Industry 4.0 enabling technologies into United Nations Sustainability Development Goals. *Sustainability, 13*(5), 2560. https://doi.org/10.3390/su13052560
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11. Antonelli, D., Lupi, F., Maffei, A., & Sala, R. (2024). Exploring the limitations and potential of digital twins for mobile manipulators in industry. *Procedia Computer Science, 232,* 1121–1130. https://doi.org/10.1016/j.procs.2024.01.110
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# Annexes

## Annex 1: Student Grades Dataset

This annex presents the anonymised student grade distributions that formed the basis for the analysis in Section 4. For each course, the corresponding figure from the supporting dataset should be inserted here. The data cover two academic years:

- **2023–24**: baseline year, before systematic use of the TET platform.
- **2024–25**: intervention year, after the adoption of the TET platform.

All grades are presented in accordance with the grading scales of the respective institutions.

**UniPI Manufacturing Processes**

**2024**

| Grade | Count |
|---|---|
| **18** | 1 students |
| **19** | 3 students |
| **20** | 1 students |
| **23** | 5 students |
| **24** | 3 students |
| **25** | 4 students |
| **26** | 2 students |
| **27** | 1 students |
| **28** | 1 students |
| **30** | 2 students |

**2025**

| Grade | Count |
|---|---|
| **23** | 5 students |
| **24** | 5 students |
| **25** | 2 students |
| **26** | 1 students |
| **27** | 1 students |
| **28** | 5 students |
| **29** | 2 students |

**KTH MG2040**

**2024**

| Grade | Count |
|---|---|
| **A** | 6 students |
| **B** | 7 students |
| **C** | 9 students |
| **D** | 5 students |
| **F** | 1 students |
| **Fx** | 1 students |

**2025**

| Grade | Count |
|---|---|

| | |
|---|---|
| **A** | 12 students |
| **B** | 19 students |
| **C** | 8 students |
| **D** | 3 students |
| **E** | 1 students |

**UNILJ Mechatronic Actuators**

**2024**

| Grade | Count |
|---|---|
| **7.5** | 1 students |
| **8** | 5 students |
| **8.5** | 1 students |
| **9** | 2 students |
| **9.5** | 3 students |

**2025**

| Grade | Count |
|---|---|
| **8** | 1 students |
| **9** | 2 students |
| **10** | 1 students |

**UNILJ Programming in Mechatronics**

**2024**

| Grade | Count |
|---|---|
| **7** | 2 students |
| **7.5** | 1 students |
| **8** | 6 students |
| **8.5** | 1 students |
| **9** | 5 students |
| **10** | 1 students |

**2025**

| Grade | Count |
|---|---|
| **7.5** | 1 students |
| **8.5** | 2 students |
| **9** | 3 students |
| **9.5** | 2 students |
| **10** | 1 students |

**UNILJ Advanced Sensory Systems and Networks**

**2024**

| Grade | Count |
|---|---|
| **8.5** | 1 students |

| | |
|---|---|
| **9** | 2 students |
| **9.5** | 3 students |
| **10** | 7 students |

**2025**

| Grade | Count |
|---|---|
| **8.5** | 1 students |
| **9** | 2 students |
| **9.5** | 4 students |
| **10** | 6 students |

**PRZ Simulation Modelling**

**2023**

| Grade | Count |
|---|---|
| **3.5** | 2 students |
| **4** | 6 students |
| **4.5** | 6 students |
| **5** | 2 students |

**2025**

| Grade | Count |
|---|---|
| **3.5** | 1 students |
| **4** | 6 students |
| **4.5** | 2 students |
| **5** | 7 students |

**PRZ Software Engineering**

**2024**

| Grade | Count |
|---|---|
| **2** | 3 students |
| **3** | 9 students |
| **3.5** | 4 students |

**2025**

| Grade | Count |
|---|---|
| **2** | 3 students |
| **3** | 7 students |
| **3.5** | 6 students |

**Lead Partner**

**Partners**