

Integrating SME-Oriented Training Tools into Higher Education: Applying the ExCurs Approach in a University Learning Factory

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Abstract

This paper presents a teaching approach derived from the ExCurs – Excellence based Curriculum for the Improvement of LEAN & Green Management Skills in SME project, which links vocational education with labour-market needs. The project developed a self-assessment tool and modular e-learning platform enabling SMEs to identify strengths and weaknesses in Lean and Green Management and receive tailored training recommendations. In a university course, students simulated consultancy projects by applying this tool to fictional SMEs, interpreting assessment results, and designing customized training plans. The exercise fostered applied learning in organisational diagnosis, needs-based training design, and sustainability-oriented process improvement. Survey results indicate that students valued the realism of the format and reported increased confidence in translating assessment outcomes into training recommendations. The paper demonstrates how VET-oriented digital tools can be effectively integrated into higher education to enhance practice-based competence development.

Keywords: ExCurs project; Lean and Green Management; SME training; Learning factory; Experiential learning; Higher education

1. INTRODUCTION

Small- and medium-sized enterprises (SMEs) face growing pressure to simultaneously increase operational efficiency and embed sustainability into their practices. Lean management techniques, traditionally focused on reducing waste and improving workflows, are increasingly being combined with green management practices to deliver competitive and ecological performance simultaneously (e.g. integrated Lean & Green frameworks). However, many SMEs lack systematic mechanisms for assessing where they stand in terms of organizational structures, technical competences, and green skills, and how to prioritise training accordingly. [1–4]

To address this gap, the project ExCurs developed a digital self-assessment tool that allows SMEs to benchmark their strengths and weaknesses in Lean & Green Management areas. Based on the assessment, the system recommends appropriate modules via an online platform. SMEs may study modules in self-paced mode, take quizzes/tests, and request hands-on training from consortium partners. This approach links organizational needs with tailored educational content and personal development pathways. [3,5,6]

In parallel, we adapted this process as a teaching format in a higher-education course. Students were organized in teams, each assigned a “fictional SME” (a use case scenario derived from real SME profiles). They ran the assessment, interpreted results, suggested modules, and formulated training plans. Through this exercise, they learned not only the theory of Lean & Green Management assessment but also the practical steps of consulting-style recommendation and training design. [2,4]

This paper describes how we structured the use cases, how we mapped student groups to SME profiles, the teaching concept behind the exercise, and how students evaluated their own learning experience. In doing so, we contribute to the literature on vocational training, skills development in SMEs, and experiential learning in higher education.

2. ANALYSIS OF THE STATE OF THE SCIENCE

This section reviews the current state of research on Lean and Green Management practices in small- and medium-sized enterprises (SMEs) and outlines the educational challenges associated with developing these competencies. It is divided into three parts.

2.1. Application of LEAN & Green Management skills in SMEs

Lean and Green Management is a growing field of scholarship in which operational efficiency (lean thinking) is combined with environmental sustainability goals. Integrated lean-green practices are increasingly seen as necessary for SMEs to maintain competitiveness while meeting regulatory and social expectations. Research shows that SMEs which do not allocate staff or resources to “green jobs” or environmental competencies are less likely to adopt resource-efficiency practices. Furthermore, integrated lean-green frameworks have been proposed to drive supply chain and process performance improvements. [7,8]

Despite growing interest, SMEs often struggle with internal capacity: limited financial resources, lack of dedicated green-skills personnel, and managerial time constraints. [7]

2.2. SME needs in these areas

The literature emphasises that SMEs require tailored, low-barrier training opportunities that are aligned with their actual organizational and technical deficits. One OECD LEED report on skills development in SMEs (West Midlands case) suggests that training must be accessible, flexible, and responsive to a company’s lifecycle stage, rather than delivered as generic off-the-shelf programmes. [7]

Similarly, skills development initiatives must recognize the diversity among SMEs: some struggle with organisational maturity (structures, leadership buy-in), others have technical process issues, while others are gearing toward digital transformation and Industry 4.0 readiness combined with sustainability. This heterogeneity calls for an assessment-based matching of needs to learning modules, rather than uniform curricula.

2.3. Training of students in these areas

There is increasing interest in embedding real-world project-based learning into higher education curricula to give students exposure to organisational challenges. For instance, agile methods in higher-education have been shown to work well when students engage with real or simulated business-partner-style projects. Likewise, learning factories and simulated company environments have been used to teach lean and process-improvement techniques in a controlled academic context (e.g. the “learning factory” concept). [9,10]

However, fewer studies exist that combine student-led assessments of SME-style organisational needs with tailored module-based training focusing jointly on lean and green management, particularly within vocational-education–training-oriented projects. Our approach seeks to fill that gap by showing how the ExCurs tool and platform can serve both the SME-training mission and the academic teaching mission.

3. USE CASE DEFINITION

To translate the ExCurs methodology into a higher-education learning environment, a series of simulated use cases were developed. Each use case represented a typical SME scenario derived from the findings in Chapter 2, reflecting different levels of organisational maturity, technical competence, and digital readiness. Students were divided into groups and assigned one of these fictional companies. Within this framework, they conducted the ExCurs self-assessment, analysed the resulting strengths and weaknesses, and designed corresponding training recommendations using the platform’s modular catalogue. The following subsections describe the structure of these groups, the rationale behind their differentiation, and the resulting module recommendations.

3.1. Division into Groups – different situations for each Group

Based on insights from the literature in Section 2 and preliminary interviews with SMEs (or stakeholder representatives), we defined three archetypal SME profiles. Student teams were assigned one of the profiles as their “fictional company” for the exercise. The profiles were:

3.1.1. Group 1 – SMEs with insufficient expertise in organisational structures

This profile represents a company with weak organisational practices: informal structures, lack of documented workflows, poor process standardisation, limited leadership buy-in for continuous improvement, and minimal green-thinking integration. Their priority is to build foundational organisational maturity before advanced technical or environmental modules.

3.1.2. Group 2 – SMEs with good organisational structures but little technical expertise

Here, the company has solid organisational maturity (process documentation, leadership support for continuous improvement), but lacks technical or “green-oriented” process skills: energy/resource-use measurement, environmental impact evaluation, or sustainable process redesign.

3.1.3. Group 3 – SMEs on the path to Industry 4.0

This group represents SMEs that already have reasonably advanced organisational and technical maturity, perhaps with some digitalisation investments, but seek to integrate sustainability goals and lean/green process optimisations in preparation for Industry 4.0 transitions. Their training needs are likely to be more advanced and specialised.

3.2. Recommendations from the groups

Before selecting suitable training modules, each group was required to create a detailed company profile based on the description of its assigned fictional SME. This profile included key information on organisational structure, production processes, workforce characteristics, and strategic objectives. Using this profile, students then completed the ExCurs self-assessment.

While answering each question of the assessment tool, the teams had to continuously estimate how the employees of their fictional company would likely respond, based on the available contextual information. This process encouraged critical reflection on organisational dynamics and the interpretation of qualitative indicators. Through these iterative estimations, students developed a realistic understanding of internal company perspectives and constraints, enhancing their ability to link assessment results with practical improvement needs.

Based on the resulting assessment outcomes, each group formulated specific recommendations for training modules from the ExCurs platform, as described below.

Group 1 – SMEs with insufficient expertise in organisational structures

This group focused primarily on building foundational management and process-awareness capabilities. Their recommendations emphasized:

- **Module 8 – Process Identification and Mapping**, to visualise current workflows and identify inefficiencies;
- **Module 9 – Continual Improvement Benchmarking**, to introduce systematic performance evaluation and best-practice comparison;
- **Module 12 – Brainstorming**, to foster participative problem-solving and employee engagement;
- **Module 10 – Digital Human Resource Management**, to strengthen internal communication, skill tracking, and team coordination; and
- **Module 11 – EU-UN-ILO Policies Combined**, to develop awareness of international sustainability and labour-standards frameworks guiding organisational improvement.

Group 2 – SMEs with good organisational structures but little technical expertise

These teams identified a need for enhanced data-driven and digital-process capabilities. Their training pathway typically included:

- **Module 3 – Data Enabled Resource Optimisation**, focusing on energy and material-efficiency through data analytics;
- **Module 6 – Key Performance Indicators**, to establish quantifiable performance metrics for process monitoring;
- **Module 7 – Predictive Maintenance**, to increase technical reliability and reduce downtime;
- **Module 4 – Digital Assistant Systems**, supporting operators with context-aware information and decision-making; and
- **Module 2 – Customer Requirement Matrix**, to ensure that process improvements align with customer value creation.

Group 3 – SMEs on the path to Industry 4.0

These groups proposed advanced digitalisation and integration strategies, combining lean and green objectives with smart-factory concepts. Their recommended modules included:

- **Module 1 – Smart Factory**, to explore digital interconnectivity and automation opportunities;
- **Module 5 – Digital Twin Facility**, enabling simulation and optimisation of production systems;
- **Module 6 – Key Performance Indicators**, for real-time monitoring and decision support;
- **Module 7 – Predictive Maintenance**, integrating IoT-based data collection for proactive management; and
- **Module 9 – Continual Improvement Benchmarking**, to sustain innovation and long-term competitiveness.

Overall, the distribution of recommendations reflected a logical progression: groups representing less mature SMEs prioritised structural and cultural foundations, while more advanced profiles focused on data-driven optimisation and digital integration. This alignment between assessment outcomes and training selection confirms the practical coherence of the ExCurs framework in both SME and educational contexts.

4. THE TEACHING CONCEPT

The applied teaching concept is based on the four-step method following Riffelmacher (2019). This pedagogical approach systematically links theoretical instruction with practical application in an authentic learning environment. The four steps are: (1) teaching of theoretical content in a lecture, (2) demonstration of concepts and methods in the learning factory by the lecturer, (3) guided application of the learning content by participants using a defined example, and (4) independent application of the acquired knowledge by the participants in a realistic scenario. [11]

For first implementation tests, the ExCurs methodology and digital training modules were integrated into a graduate course within the framework of a university learning factory. Following Riffelmacher's approach, the theoretical foundations of Lean and Green Management, as well as the structure of the ExCurs assessment tool, were initially taught in lectures and supported by examples from current research. Demonstrations within the learning factory then illustrated how assessment results can be translated into concrete process improvements and digital interventions.

In the third step, students applied the ExCurs self-assessment to their assigned fictional SMEs, interpreted the results, and designed tailored training recommendations. Finally, in the independent application phase, student teams presented and discussed their training strategies, simulating real consulting scenarios with feedback from instructors and peers.

By adapting Riffelmacher's four-step method to the learning factory context, the course achieved a close integration of digital self-assessment, process simulation, and reflective learning. This structure supported experiential learning in the sense of Kolb (1984) [12], fostering the ability to transfer theoretical knowledge into practical, industry-relevant competence. Learning factories, as emphasised by Vijayan et al. (2019), provide a physical and didactic environment that bridges theory and industrial practice, making them an ideal platform for applying the ExCurs concept in higher education. [13]

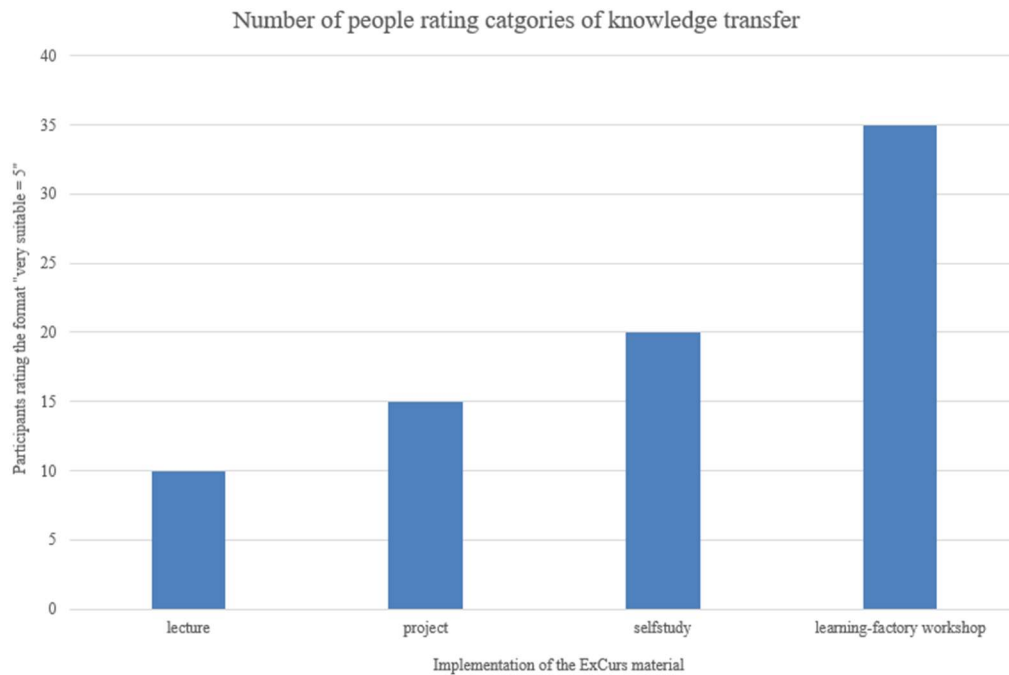


Figure 1 – Number of people rating the categories of knowledge transfer.

In addition to the structured use-case workshop described above, participating students also explored the ExCurs training modules in alternative formats, including fully self-paced online study and guided individual exercises. These experiences allowed students to familiarize themselves with the content at their own pace and to test the usability of the digital platform.

To evaluate the learning experience, a short post-workshop survey was administered to all participating students. In total, N = 40 graduate students enrolled in the course completed the questionnaire, resulting in a response rate of 100%. All participants were enrolled in an engineering-management master's program at the same institution, which reflects the typical target audience for learning-factory-based courses. The survey consisted of eight items rated on a five-point Likert scale (1 = "unsuitable", 5 = "very suitable"). Items assessed perceived usefulness of the workshop, clarity of the ExCurs materials, perceived learning gains, and the suitability of alternative learning formats. Example items include: "The workshop helped me understand how organizational assessments in SMEs are conducted" and "The ExCurs modules supported me in deriving appropriate training recommendations." Reliability metrics such as Cronbach's alpha could not be calculated because each construct was measured with a single item; however, internal plausibility checks indicated consistent response patterns across related items.

The survey was conducted anonymously to encourage candid feedback. Descriptive statistics form the basis of the results presented in Figure 1.

Figure 1 provides an overview of how many participants rated each usage format of the ExCurs materials as "very suitable" (score 5 on the 1–5 scale). The x-axis distinguishes the four tested formats: lecture, project work, self-study, and the learning-factory workshop. The y-axis indicates the number of students assigning the top rating. Each bar, therefore, represents the count of participants who selected the score 5 for the respective format. As shown in the diagram, the learning-factory workshop received the highest number of top ratings, indicating that this interactive, experimental setup was perceived as the most

effective way to work with the ExCurs content. Students highlighted that the collaborative setting of the workshop fostered engagement, enhanced understanding of organizational assessment processes, and improved their ability to translate assessment results into tailored training recommendations. These results indicate that the workshop format most effectively supports experiential learning and the practical application of theoretical concepts to SME scenarios.

5. CONCLUSION AND LIMITATIONS

This paper has demonstrated how the ExCurs project's self-assessment tool and modular training platform, originally developed to support SMEs in improving Lean and Green Management practices, can be effectively adapted for higher-education teaching. By integrating the materials into a use-case-based workshop within a university learning factory, students were able to simulate real-world consultancy processes, assess organizational strengths and weaknesses, and design tailored training recommendations.

Survey results indicate that students valued the interactive, collaborative format and perceived significant learning gains in understanding organisational assessment, needs-based module selection, and the connection between assessment outcomes and training design. While alternative formats such as self-paced online study were also explored, the workshop approach proved most effective in fostering engagement and practical competence.

These findings suggest that ExCurs materials are not only suitable for SME training but also provide a robust framework for experiential learning in higher education, bridging theoretical knowledge with practical application. The project thus offers a scalable model for embedding vocational education tools into academic curricula, preparing students to support SMEs in strategic development and sustainability-oriented process improvement. However, these findings must be interpreted in light of methodological limitations such as the small and homogeneous sample and the reliance on self-reported learning gains.

Despite the positive results, several limitations must be acknowledged. First, the sample size was small ($N = 40$) and drawn from a single graduate course at one institution, which limits the generalizability of the findings. Future studies should include multiple cohorts or institutions to increase external validity. Second, the evaluation relied solely on student self-reports without complementary measures such as pre-/post-testing, rubric-based performance assessments, or comparison groups. As a result, the evidence reflects perceived rather than objectively measured learning gains. Third, the survey instrument included only single-item constructs, limiting the ability to perform reliability analyses. These methodological constraints should be addressed in subsequent iterations of the course design and evaluation.

Acknowledgements

This research was supported by the EU Erasmus+ "ExCurS" project [grant number 2022-1-ES01-KA220-VET-000086786].

6. REFERENCES

- [1] R. Siegel, J. Antony, J.A. Garza-Reyes, A. Cherrafi, B. Lameijer, Integrated green lean approach and sustainability for SMEs: From literature review to a conceptual framework, *Journal of Cleaner Production* 240 (2019) 118205.
- [2] L. Driouach, K. Zarbane, Z. Beidouri, Literature Review of Lean Manufacturing in Small and Medium-sized Enterprises, *IJTech* 10 (2019) 930.
- [3] R. Siegel, J. Antony, K. Govindan, J.A. Garza-Reyes, B. Lameijer, A. Samadhiya, A framework for the systematic implementation of Green-Lean and sustainability in SMEs, *Production Planning & Control* 35 (2024) 71–89.
- [4] W. Kosasih, I.N. Pujawan, P.D. Karningsih, Integrated Lean-Green Practices and Supply Chain Sustainability for Manufacturing SMEs: A Systematic Literature Review and Research Agenda, *Sustainability* 15 (2023) 12192.
- [5] ExCurs, ExCurs, [October 29, 2025], <https://www.excurs.eu/>.

- [6] G.A. Queiroz, P.N. Alves Junior, I. Costa Melo, Digitalization as an Enabler to SMEs Implementing Lean-Green? A Systematic Review through the Topic Modelling Approach, *Sustainability* 14 (2022) 14089.
- [7] OECD Local Economic and Employment Development (LEED) Working Papers, 2011.
- [8] F. Bassi, M. Guidolin, Resource efficiency and Circular Economy in European SMEs: Investigating the role of green jobs and skills, 2021.
- [9] E.A. Sadaj, M. Hulla, C. Ramsauer, Design Approach for a Learning Factory to train Services, *Procedia Manufacturing* 45 (2020) 60–65.
- [10] M. Neumann, L. Baumann, Agile Methods in Higher Education: Adapting and Using eduScrum with Real World Projects, 2021.
- [11] P. Riffelmacher, Konzeption einer Lernfabrik für die variantenreiche Montage, Zugl.: Stuttgart, Univ., Diss., 2013 (Nicht für den Austausch), Fraunhofer Verlag, Stuttgart, 2013.
- [12] D.A. Kolb, Experimental learning: Experience as the source of learning and development, Prentice-Hall, Englewood Cliffs, N.J., 1984.
- [13] K.K. Vijayan, O.J. Mork, L.A. Giske, Integration of a Case Study into Learning Factory for Future Research, *Procedia Manufacturing* 31 (2019) 258–263.