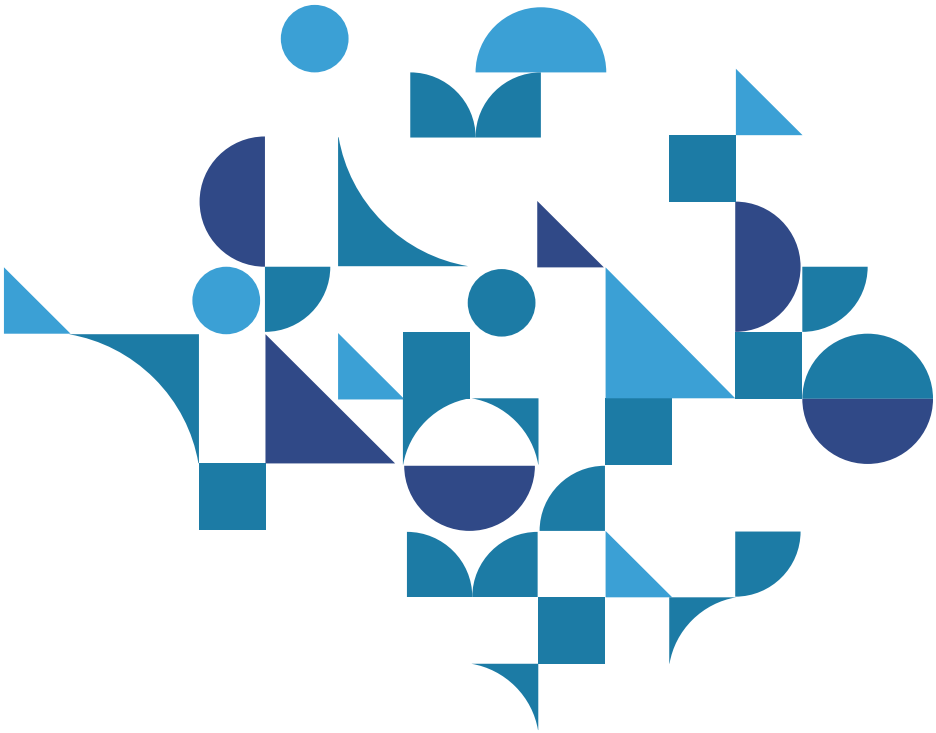
Industrial Engineering and Management of European Higher Education



IE3 Course Action Plan

DRAFT REPORT WP3 POLIBA

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This document is part of the Result 3.1 "IE3 Course Action Plan" of the Erasmus+ Project "Industrial Engineering and Management of European Higher Education / IE3", and it represents the first contribution to this deliverable from the POLIBA and BOSCH partner. The current version of the report may be subject to changes according to future project activities and findings.

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1. EXISTING COURSE MODULE

Course module: Operations Management - part B (*Gestione della Produzione Industriale*)

Master Program: Industrial engineering and management (*Ingegneria Gestionale*)

Effort: 6 ECTS (150h).

Students: ~ 120 students.

It is a compulsory course in the master program.

1.1 Objectives

The course aims at endowing second level management engineers with the following knowledge:

- Knowledge of the traditional and innovative paradigms of Operations Management.
- Management of the theoretical and practical tools for medium- and short-term production planning and control.

1.2 Current Syllabus

a. Production systems and strategic planning (1.0 ECTS)
   I. Stages and time horizons of operations management.
   II. Performance measurement of production systems.
   III. Strategic Planning.

b. Aggregate planning (2.0 ECTS)
   I. Aggregate planning. Planning bills.
   II. Master Production Schedule.
   III. Batch production systems: lot sizing

c. Inventory management (2.0 ECTS)
   I. Inventory control models. Inventory indices.
   II. Inventory management techniques (MRP).
   III. Lean systems.

d. Operations Scheduling (1.0 ECTS)
   I. Loading, sequencing and scheduling.
   II. Scheduling Criteria for single machine.
   III. Flow-shop, job-shop and open-shop.

1.3 Teaching methods and assessment

The primary approach is to split sessions between theory and practice. Concepts are presented in magisterial lessons (6 weeks, 5 hours theory and 5 hours exercises per week). Numerical cases are developed.

The scoring process is based on both written and oral exams. Written exam relates to both theoretical knowledge and numerical cases. The oral exam completes the evaluation verifying the student's ability to synthesize and integrate topics, express adequately complex concepts, and use the appropriate terminology.

When the COVID-19 emergency imposed distant learning, the approach moved to synchronous remote lessons leaving all the recordings available for students on the institutional repository (MS Teams).

1.4 Need for revision

The main reason for revision is the ambition to provide master students with actual knowledge in the field of Industrial Engineering and Management consistent with industry needs . It requires a significant shift from the traditional Planning and Control approach to the Lean Production approach based on the data-driven performance evaluation and the continuous improvement philosophy.

Moreover, the focus will be on digitalisation topics in solid connection with the usage of digital tools in industrial applications. By analysing industrial case studies and performing in teams a set of serious games, the course should provide students with evaluation tools that will quantify the efficiency of different system configurations and management options. The student will find the optimal solution for each case concerning technical parameters, constraints, and peculiar decision-making variables.

Moving from the traditional "push-based" learning approach to the flipped and experimental learning approach requires a set of new methodologies and teaching tools and a strong connection between academia and industry.

2. REVISION RELATED TO THE BoK

According to the main finding of the Body of Knowledge (BoK), the course module revision deals with course content, teaching methodology, and the strong University-Companies integration.

In particular, the following outcomes of the BoK led to both the revision and the design of new content and teaching methods for the selected course model.

In the following, the main findings of the BoK pertaining the course module revision:

"By analyzing the knowledge demand expressed by companies in the quantitative survey (questionnaire), the following technical knowledge, skill, and competencies (KSCs) have been identified in descending order of importance:

Knowledge, Skill, and Competences

- *Project Management*
- *Operations Management*
- *Quality Management*
- *Strategic Management*
- *Safety of Work".*

Moreover, *"Among listed KSCs, 'Operations Management', 'Quality Management', and 'Safety of Work' are characterized by the highest demand value for companies in the manufacturing sector".*

"As far as digital operational tools are concerned, the high companies' demand values are observed for (listed in order of descending importance):

- *Management Software Tools (e.g. ERP, CRP)*
- *Computer-based Statistic Competences*
- *Big Data Analysis."*

Finally, results of the survey carried out in the IE3 project *"forced the revision to focus on the "soft skills" characterized by a high companies' demand (listed in order of descending importance):*

- *Problem Solving and Decision Making;*
- *Team Working;*
- *Communication Skills".*

2.1 Contents

The content revision of the Course "Operations Management" primarily looks to integrate the concepts of "lean production" and "continuous performance improvement" in the Industry 4.0 environment; both concepts are the new pillars of the performance-oriented and data-driven management of the digital factory.

2.2 Teaching Methodology

According to the main findings and suggestions from the BoK, the following teaching methodologies have been adopted for the pilot course module:

1. Face-to-Face and/or distant. Balancing synchronous-asynchronous integrated lecturing;
2. Team working simulation and educational games under University/Company' professors guide;
3. Flipped classroom for selected topics;
4. On-site visits and/or Virtual tours of manufacturing facilities;
5. Digital Learning Pills (micro-learning); will be prepared in a further step.

Lectures, supported mainly by PPT presentations, have been integrated by personalized feedback and self-assessment to improve every student's work. The aim was to divide lecture contents into essential parts using quiz for self-assessment of the acquired knowledge several times during the class by the e-learning platform Moodle.

Emphasis has been placed on teamwork, self-assessment, and problem-solving in the new activities designed and performed in strong collaboration with the industrial partner BOSCH (details are in section 4 and section 5).

3. REVISED COURSE MODULE: Operations Management in Advanced Lean Systems

(Gestione della Produzione Industriale nei Sistemi Lean)

Effort: 6 ECTS (150h)

Students: ~120 students.

Schedule: 6 weeks from April to June each year in the 2nd Semester of the academic year.

3.1 Expected learning outcomes

Learning Skills

Students will learn to face the multidimensional performance evaluation of Operations at a strategic, tactical, and operational level. They will acquire methodologies and tools to design, analyze, and continuously improve the operations performance of manufacturing and service companies under the industry 4.0 data-driven environment. Additional didactic supports will also stimulate the learning ability in designing, planning, evaluating and operating lean systems: industrial simulation tools, numerical exercises, serious games, and industrial case studies designed to increase learners' learning abilities.

Judging autonomy

By considering alternative scenarios in serious games and simulations, the students will be able to refine technical knowledge and judgment skills to identify the best operations strategies.

Communicative Skills

Participation in traditional lectures and specialized seminars tenured by industry professors as well as in serious games classroom student's discussions and presentations, and involvement in guided industrial tours will drive students toward acquiring appropriate technical terminology to develop advanced communication skills, both oral and written.

3.2 Revised Syllabus

1. **Operations, Performance, and Continuous Improvement (1.00 ECTS)**
    a. Operations, trade-offs and Performance measures. Losses in production. The Overall Equipment Effectiveness (OEE).
    b. Process Analysis and Process Design. Cycle time. Throughput. WIP. Flow Time. Utilization. Little's Law
    c. Industry 4.0: Standards and Data integration for PMS
    d. Industry 4.0 and Continuous Improvement
2. **Lean systems (1.00 ECTS)**
    a. Lean Systems and Continuous improvement
    b. Value Stream Concepts, Mapping and Design
    c. Cycle time analysis
    d. System Re-design
3. **Production planning and control (2.00 ECTS)**
    a. Stages and time horizons of operations management.
    b. Strategic Planning. Aggregate planning.
    c. Bill of materials. Master Production Schedule.
    d. Short term planning. Loading and Scheduling.
4. **Inventory management (1.00 ECTS)**
    a. Inventory, KPIs and Costs.
    b. Replenishment models. EOQ. POQ. Safety Stocks. ABC Classification.
    c. Material Requirement Planning (MRP). EPQ.
    d. ERP: Production Planning module and shop floor integration
5. **Advanced Lean Systems (1.00 ECTS)**
    a. Pull & Levelling Tools. JIT, Pacemakers, Supermarkets, Kanban Circuits.
    b. Advanced Lean Systems design

3.2 Evaluation criteria

In addition to the evaluation criteria defined in section 1.3, the following specific scores have been determined for the pilot course:

- Written exam (70%);
- Oral exam (20%);
- In-Class Activity (exercises, serious games, seminars) (10%).

In the following years, in-class activities will gain more significant weight in the final grade.

4. IMPLEMENTATION OF THE REVISED COURSE MODULE

The pilot revised course module, designed and developed to meet the goal under the constraints defined in sections 1.4 and section 3, has been delivered in April and May 2021 in 3 distinctive parts.

Part 1a and Part 1b dealing with Operations Performance, Continuous Improvement and Advanced Lean Systems have been designed and delivered with the industrial partner support (BOSCH).

Part 2 focus on "traditional" topics of Production Planning and Control and Inventory Management. Even in these cases, emphasis has been devoted to the problem-solving approach and to the digital aspects of integration of management and the shopfloor operations. The ERP provider EXPRIVIA (SAP Gold Partner) held a seminar on "Production Planning module and shop floor integration in SAP".

The following tables describe the content of each specific topic, with the corresponding teaching methodology and tools adopted, the primary reference, the required students' effort (hours) and the date of the class.

PART 1a

	ECTS	Topic	hour	date	Ed. tool	Reference
Operations, Performance, and Continuous Improvement ***On-site visits of manufacturing facilities [POSTPONED]***	1.00	Operations, trade-offs and Performance measures. Losses in production. The Overall Equipment Effectiveness (OEE).	2.5	26/04/2021	Lecture (PPs, videos)	Jacobs, Chase
		Process Analysis and Process Design. Cycle time. Throughput. WIP. Flow Time. Utilization. Little's Law	2.5	27/04/2021	Lecture (PPs, videos)	Jacobs, Chase
		Industry 4.0: Standards and Data integration for PMS	2.5	27/04/2021	Lecture (PPs, videos)	IEC and ISO Standards
		Industry 4.0 and Continuous Improvement	2.5	04/05/2021	Seminar by Industry professor. (BOSCH) (PPs, videos)	Lecture notes
Lean Systems	1.00	Lean Systems and Continuous Improvement	2.5	29/04/2021	Lecture (PPs, videos)	Jacobs, Chase
		Value Stream Concepts, Mapping and Design	2.5	03/05/2021	Lecture (PPs, videos)	Jacobs, Chase. BOSCH BPS notes
		Cycle Time Analysis	2.5	04/05/2021	Serious game on the shopfloor. Team evaluation (PPs, videos, simulation tools) [on-line]	BOSCH BPS video and notes
		System Re-design & Continuous Improvement	2.5	10/05/2021	Serious game on the shopfloor. Team evaluation	BOSCH BPS videos and notes

					(PPs, videos, simulation tools) [on-line]	

PART 2

	ECTS	Topic	hour	date	Ed. tool	Reference
Production Planning and Control	2.00	Stages and time horizons of operations management. Strategic Planning	2.5	06/05/2021	Lecture (PPs, videos)	Jacobs, Chase
		Aggregate Planning. Strategies and Trade-off	2.5	11/05/2021	Lecture (PPs, videos)	Jacobs, Chase
		Case studies. Problem-solving. Excel solver for linear program	2.5	11/05/2021	Classroom Exercise (Software tools)	Lecture notes
		Bill of Materials. Master Production Schedule	2.5	13/05/2021	Lecture (PPs, videos)	Jacobs, Chase
		Short-term Planning. Loading	2.5	24/05/2021	Lecture (PPs, videos)	Jacobs, Chase
		Short-term Planning. Scheduling	2.5	25/05/2021	Flipped classroom for selected topics (PPs, videos)	Jacobs, Chase
		Case studies. Problem-solving	2.5	25/05/2021	Classroom Exercise (PPs, videos)	Lecture notes
Inventory Management	1.00	Inventory, KPIs and Costs. Replenishment models	2.5	17/05/2021	Lecture (PPs, videos)	Jacobs, Chase
		EOQ. POQ. Safety Stocks. ABC Classification	2.5	18/05/2021	Lecture (PPs, videos)	Jacobs, Chase
		Case studies. Problem-solving	2.5	18/05/2021	Classroom Exercise (PPs, videos, software tools)	Lecture notes
		Material Requirement Planning (MRP). EPQ.	2.5	20/05/2021	Lecture (PPs, videos)	Jacobs, Chase
		ERP: Production Planning module and shop floor integration in SAP	2.5	03/06/2021	Seminar by ERP Provider. Exprivia (Gold	Lecture notes

					Partner SAP) (PPs, videos)	

PART 1b

	ECTS	Topic	hour	date	Ed. tool	Reference
Advanced Lean Systems	1.00	Pull & Levelling Tools: JIT, Pacemakers, Supermarkets, Kanban Circuits.	2.5	27/05/2021	Lecture (PPs, videos)	Jacobs, Chase, BOSCH BPS notes
		Advanced Lean Systems design	5	31/05/2021 01/06/2021	Serious game on the shop floor. Team Evaluation. [on-line]	BOSCH BPS videos and notes
		Transparency, continuous improvement, roles and responsibilities, leadership	2.5	01/06/2021 [Cancelled]	Seminar by Industry professor. BOSCH	Lecture notes
Final Class EXE		Case studies. Problem-solving [Exam simulation]	2.5	03/06/2021	Classroom Exercise (PPs, videos)	Lecture notes

In brackets [] are the activities postponed or modified due to the COVID-19 emergency.

Main references:

JACOBS, CHASE. *OPERATIONS AND SUPPLY CHAIN MANAGEMENT*, FIFTEENTH EDITION. McGraw-Hill Education, 2018

BOSCH BPS. *Lean Production*. Presentations and Case studies.

Due to COVID-19 emergency, all the activities have been carried out on-line synchronous. All the recordings are available for students on the institutional repository (MS Teams).

The existing teaching tools and materials (PPs, videos, computer animations, simulation tools) have been renewed to fit the new objectives and syllabus and fully translated into English. All the teaching material is available on the institutional e-learning repository Moodle (see figure 1 and figure 2).

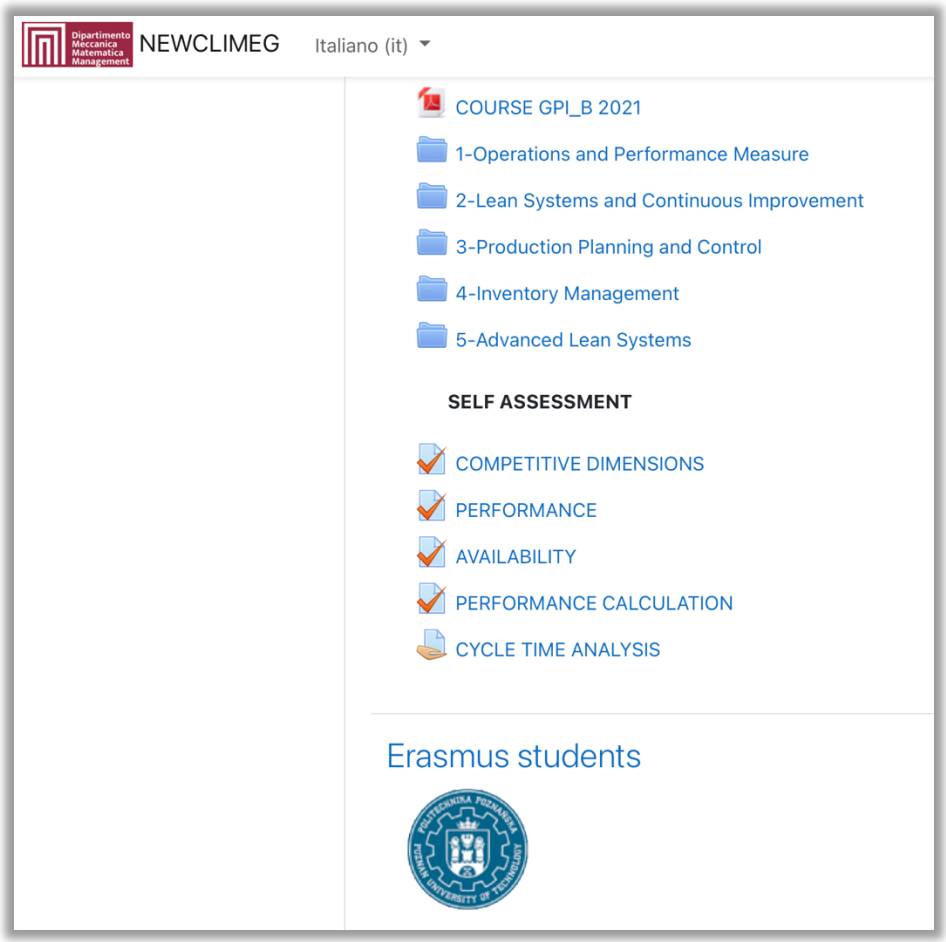


Figure 1 – Teaching material of the revised course module (Moodle)

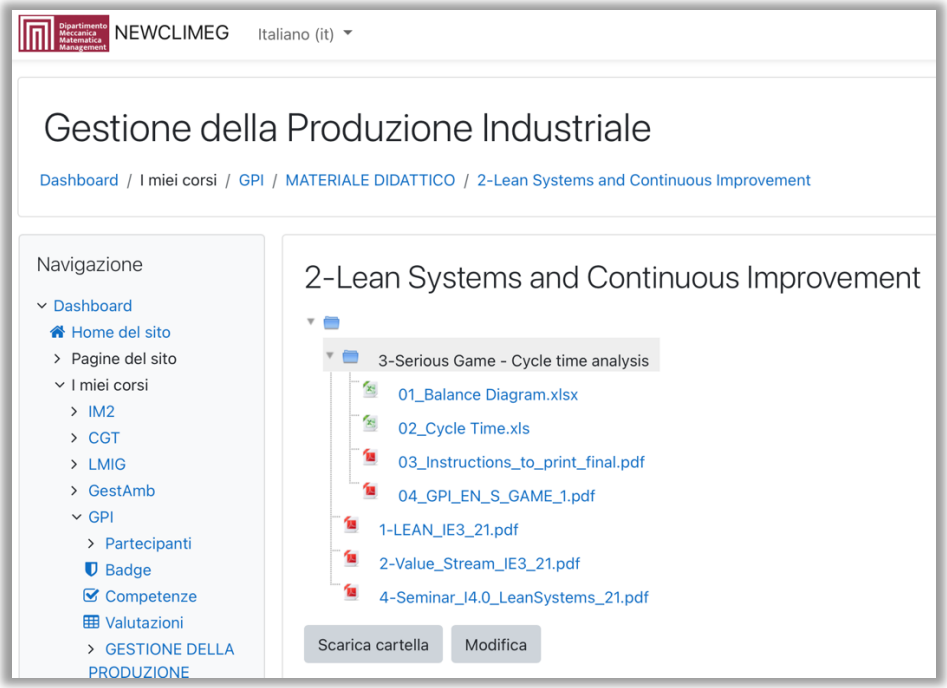


Figure 2 – Teaching material of the topic 2- Lean Systems with a focus on the Serious Game developed with BOSCH

5. INVOLVEMENT OF THE INDUSTRIAL PARTNERS

A key aspect of the project phase was the involvement of the industrial partner - in this case BOSCH. This involvement will also be important in the subsequent implementation, revision, and management phases of the course. The aim of this involvement was to add to the didactic-academic aspect perspective also a pragmatic aspect and daily use of the proposed tools. In addition to this, the participation of high-profile international and technological partners also offers the possibility of updating the course contents to follow and adapt, where possible, the same contents to the needs of the industries, thus offering a better service to the students, the final customer of the project.

5.1 Serious Games

The contribution of partner BOSCH, derived from actual industrial cases and presented in terms of practical games, aims to train students about concrete and simple contents and to increase their competencies toward the needs of industry.

The gap between the current course and the ideal one has been analyzed. The roadmap to create the defined “Digital Learning Pills” (micro-learning) goes through some crucial reflections about the current situation linked to the COVID-19 pandemic.

The first evolution of the course from a face-to-face mode to the online one was simply forced by the pandemic. It was a first, fast countermeasure, and the “cold shower” gave many precious feedbacks about students involved with the new set-up.

Slide show with a voice is somehow a “one-way” modality and the path to the “Digital Learning pills” needs two key steps to ensure active learning: interaction and gamification.

The educational games have been created to start walking in this direction by leading students:

- using the analytic observation;
- applying PDCA cycle and continuous improvement methodology;
- creating best balancing of shopfloor operations design;
- creating standard reports;
- comparing and evaluating solutions;
- and presenting results to the class.

Main contents of the serious game developed and delivered in collaboration with BOSCH were:

Serious Game 1 Part A - Cycle Time Analysis

- Paper-made airplane production: how to observe running production
- Process confirmation and Cycle time calculation (Best repeatable, average, min, MAX)
- Customer withdrawal time estimation and use of Balancing diagram

Serious Game 1 Part B - System Re-design & Continuous Improvement

- Improvable system, continuous improvement process, PDCA
- Cyclic supply, Point of use provider
- Definition of potentials & measures, lot size definition
- Design of improved balancing diagram.

Serious Game 2 - Advanced Lean Systems simulation and design

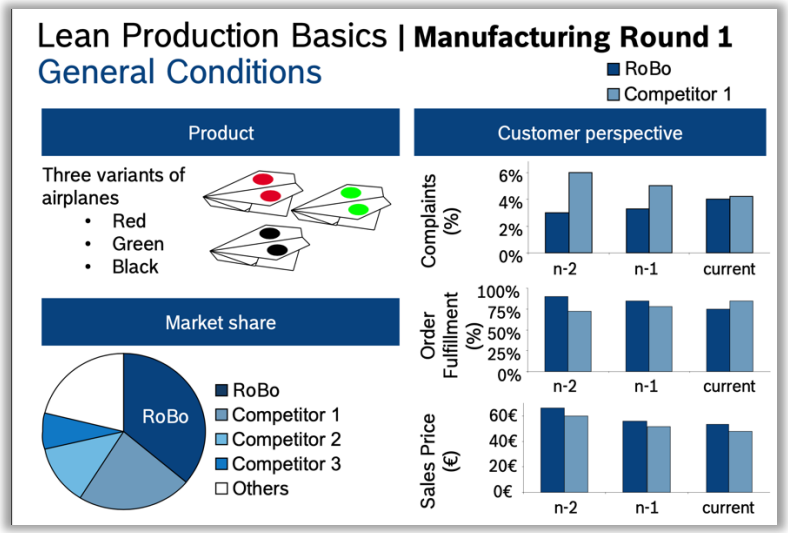
- Closed Loop System Control
- System Decoupling

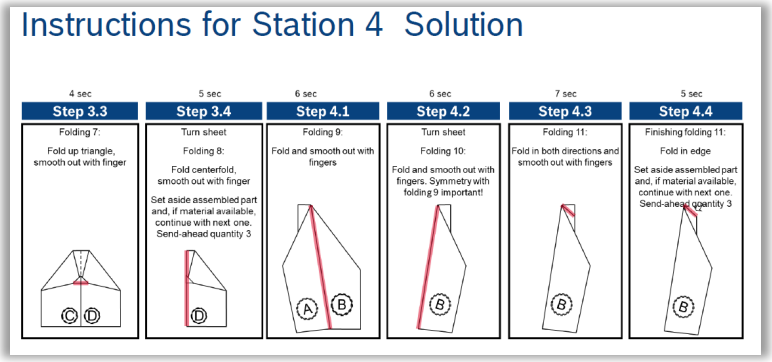
- Pull & Levelling
- Pacemaker
- Kanban calculation.

The idea of developing the game with paper airplanes gave the chance to experience it (also by remote) to the students, even if the competition was only partially allowed.

Gamification and competition are going to be strengthened in the next evolution of the course.

Section 4 shows details on both course content design and class delivery developed with the involvement of the industrial partner.





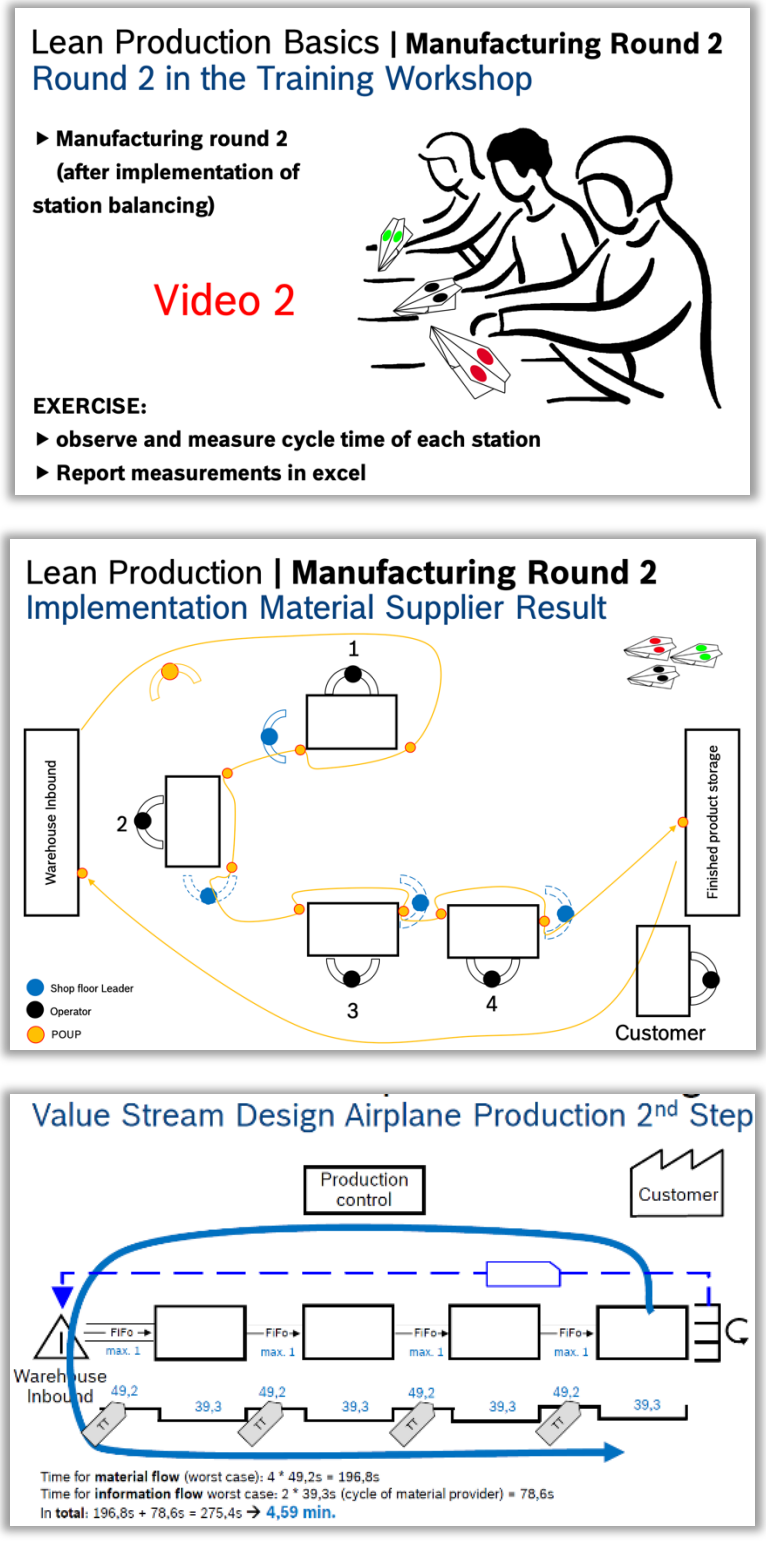
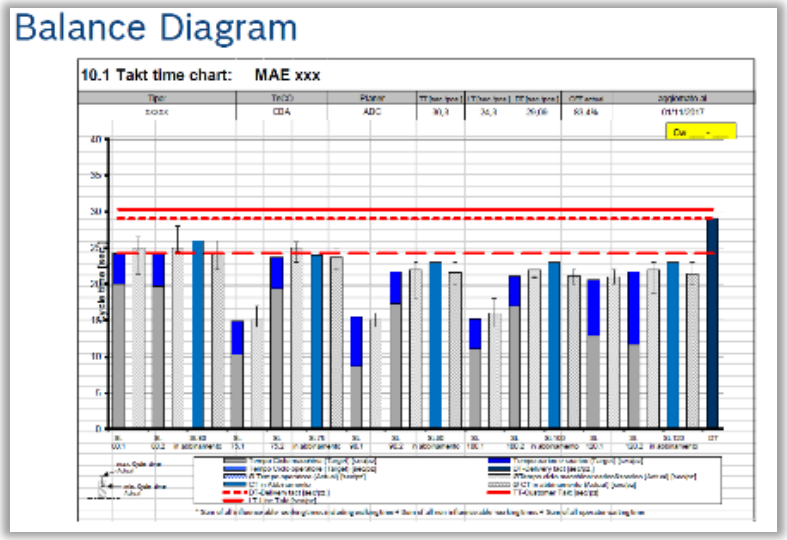


Figure 3 – Screenshot of the Serious Game 1 - Cycle Time Analysis and Continuous Improvement developed by BOSCH



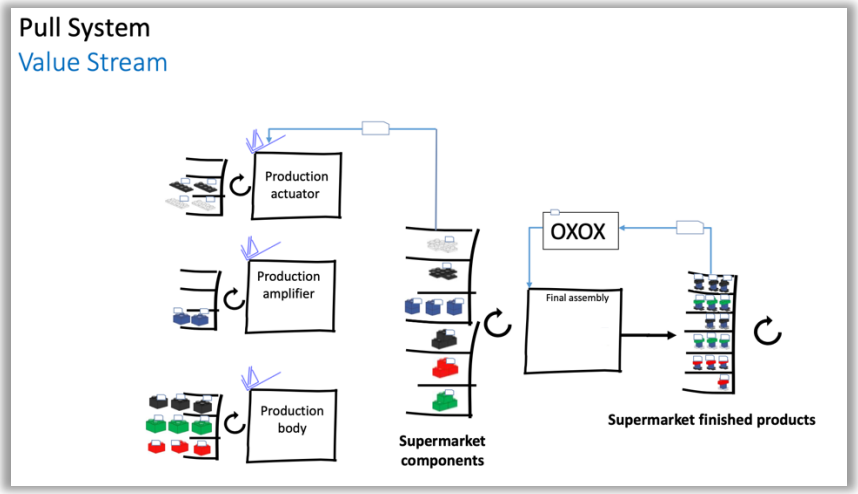


Figure 4 – Screenshot of the Serious Game "Advanced Lean Systems simulation and design" developed by BOSCH

5.2 Seminars

Main contents of the seminars developed and delivered in collaboration with the industrial partners were:

Seminar 1 - Industry 4.0 and Continuous Improvement (BOSCH)

- I4.0: background, the value of data availability
- Enabling technologies for the connected industry
- Opportunities and challenges of the connected world, Digital Twin
- BOSCH Bari approaches and use cases.

Seminar 2 - ERP: Production Planning module and shop floor integration in SAP Seminar by ERP Provider. (Exprivia SpA - Gold Partner SAP)

- SAP Architecture: Lines of Business and module integration
- Production Planning Module: Basic Data and MRP
- Shop Floor Control.

6. COURSE MODULE EVALUATION

The aim of the process is to assure that the pilot courses will meet the planned learning objectives by satisfying the needs of students as well as of the other relevant stakeholders (academic and industrial partners).

Students evaluated the Course module twice according to the newly established evaluation system:

1. At the Polytechnic University of Bari: traditionally, the evaluation is performed at the end of the class when students complete the evaluation form before attending the final exam.
2. In the current academic year: an intermediate online evaluation allowed to assess the synchronous online lessons' performance (student's satisfaction, threats, and opportunities of the distance learning).

6.1 Intermediate online evaluation - Preliminary results

The evaluation form consists of 5 parts:
A - STUDENT ATTENDANCE
B – COURSE EVALUATION
C – TEACHER EVALUATION
D – DISTANCE LEARNING EVALUATION
E – INTEREST IN THE TOPICS AND SUGGESTIONS.

On the days 10 of May to 4 of June, were collected 90 questionnaires from students.
The main results are in figures 5-9.

A - STUDENT ATTENDANCE

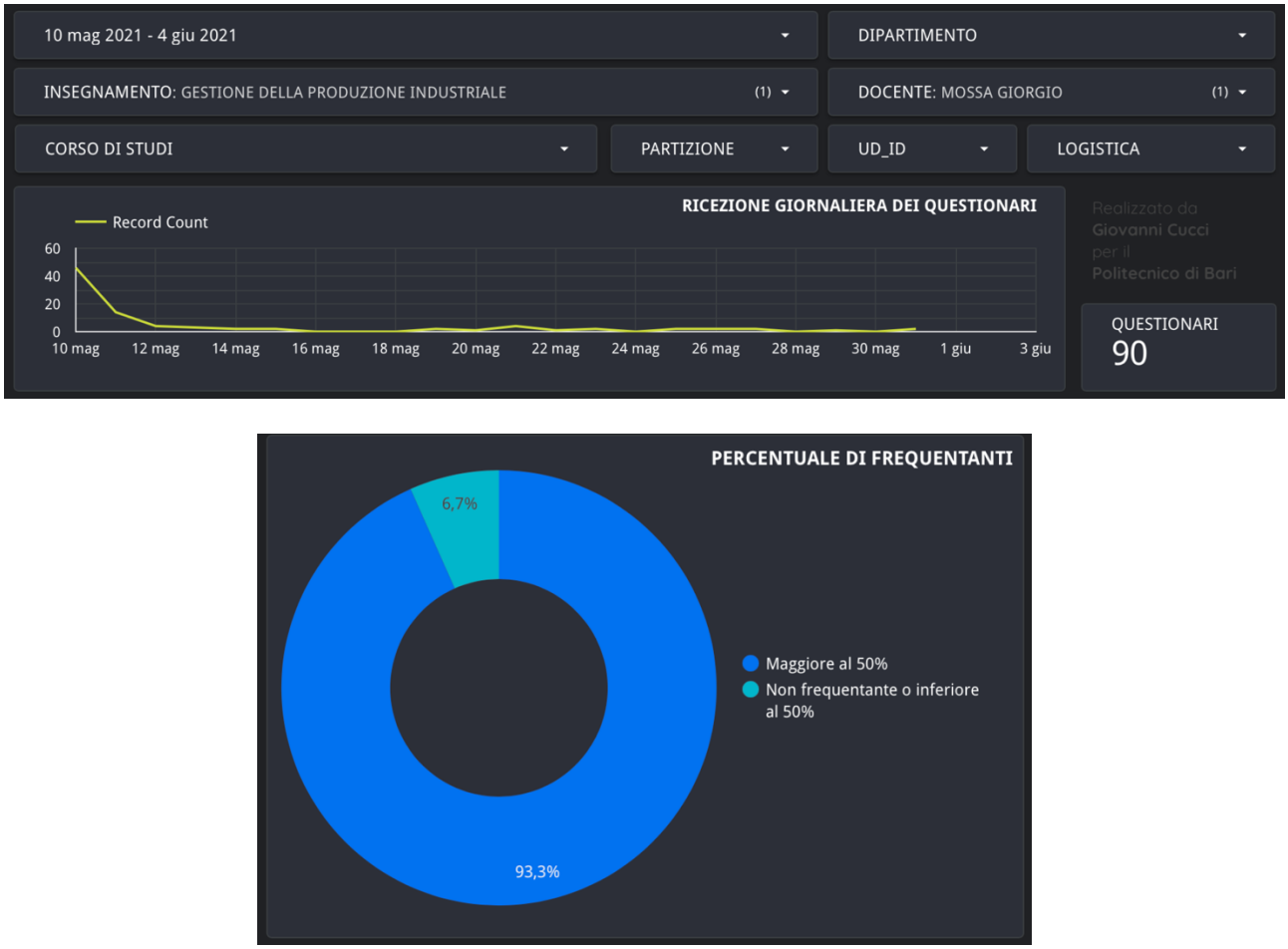


Figure 5 – Students attendance

- Regarding the current year's teaching activities, what percentage of the classes did you take?
  - Less than 50%
  - Greater than 50%

B – COURSE EVALUATION

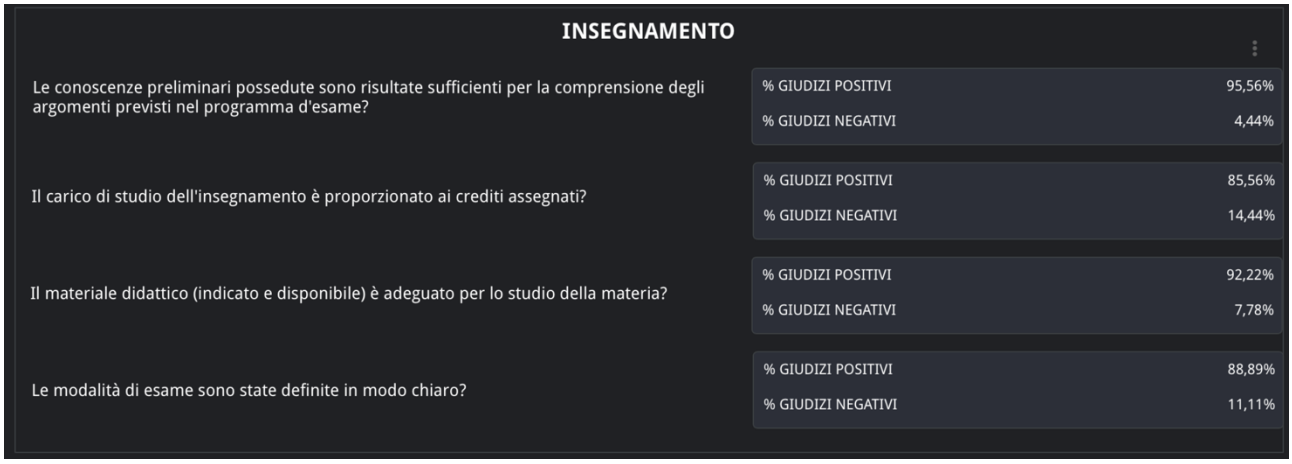


Figure 6 – “Course” Evaluation

The questions in figure 6 are respectively:

- Does your prior knowledge allow you to understand the topics covered in the course?
- Is the effort required by the course consistent with the credit awarded?)
- Is the teaching material (indicated and available) adequate for the study of the subject?
- Are the examination procedures clearly defined?

C – TEACHER EVALUATION

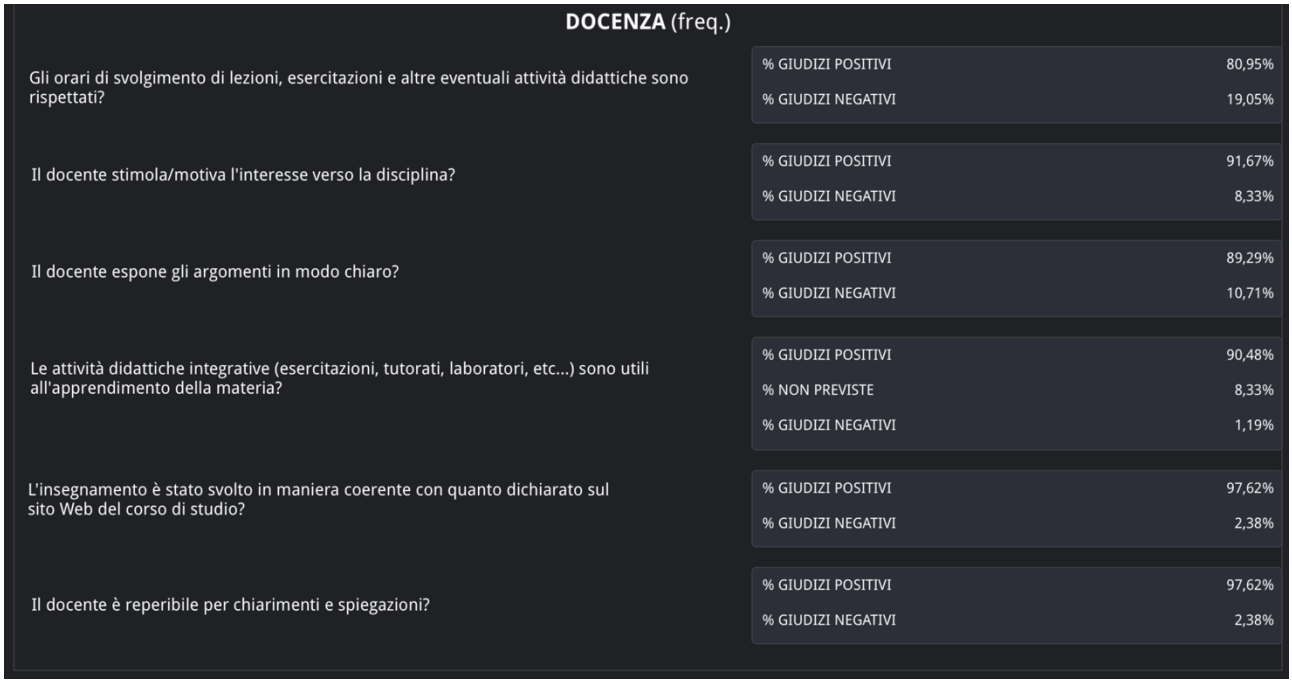


Figure 7 – “Teacher” Evaluation

The questions in figure 7 are respectively:

- Is the schedule for lectures, tutorials and any other teaching activities respected?
- Does the teacher stimulate/motivate interest in the discipline?
- Does the teacher explain the topics clearly?
- Are the supplementary teaching activities (exercises, tutorials, laboratories, etc.) helpful in learning the subject?
- Has the teaching been carried out consistently with the info on the course of study website?
- Is the teacher available for clarification and explanation?

D – DISTANCE LEARNING EVALUATION

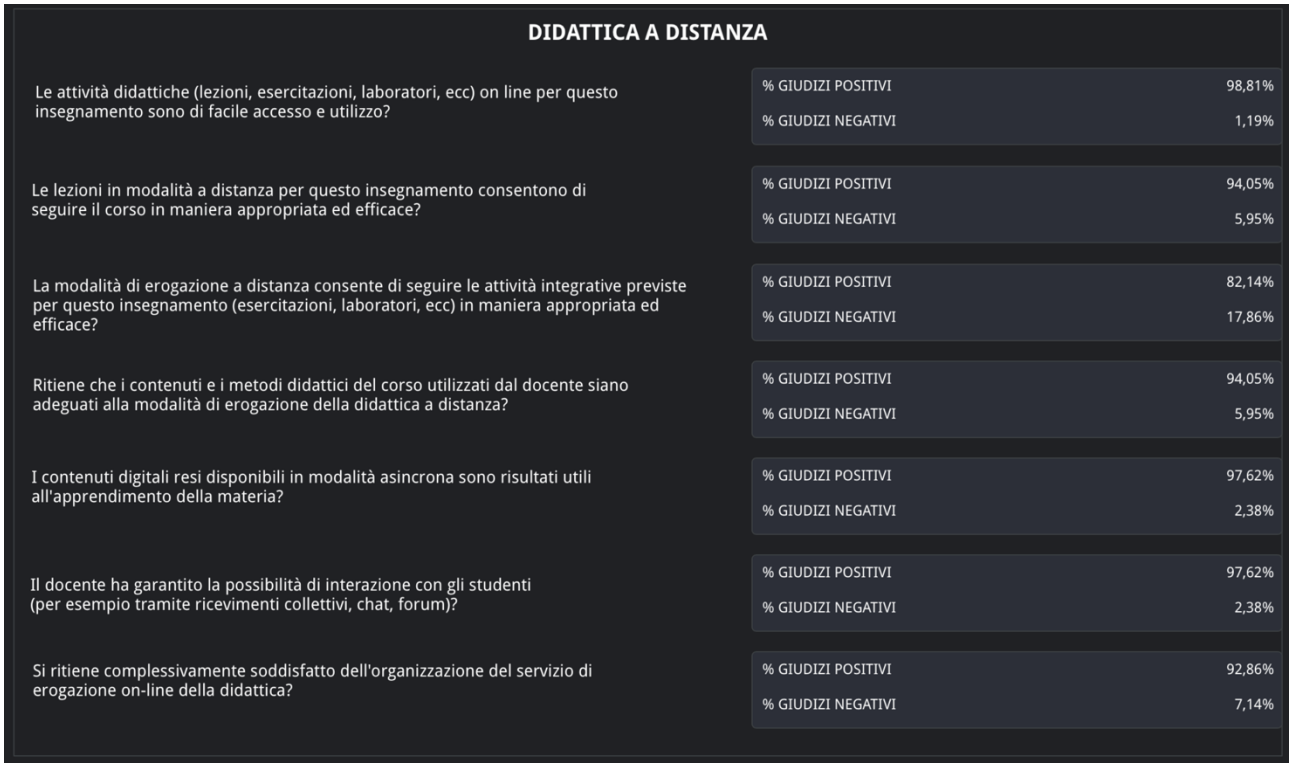


Figure 8 – “Distance Learning” Evaluation

The questions in figure 8 are respectively:

- Are the online instructional activities (lectures, tutorials, labs, etc.) easy to access and use?
- Do the distance learning lectures allow you to follow the course appropriately and effectively?
- Does the distance learning mode allow you to follow the supplementary activities planned for this course (exercises, laboratories, etc.) appropriately and effectively?
- Do you think the course contents and the teaching methods are appropriate to the distance teaching delivery method?
- Were the digital contents made available in asynchronous mode helpful in learning the subject?
- Has the teacher ensured the possibility of interaction with students (e.g. through online meetings, chat, forums)?
- Are you overall satisfied with the organization of the online teaching service?

E – INTEREST IN THE TOPICS AND SUGGESTIONS

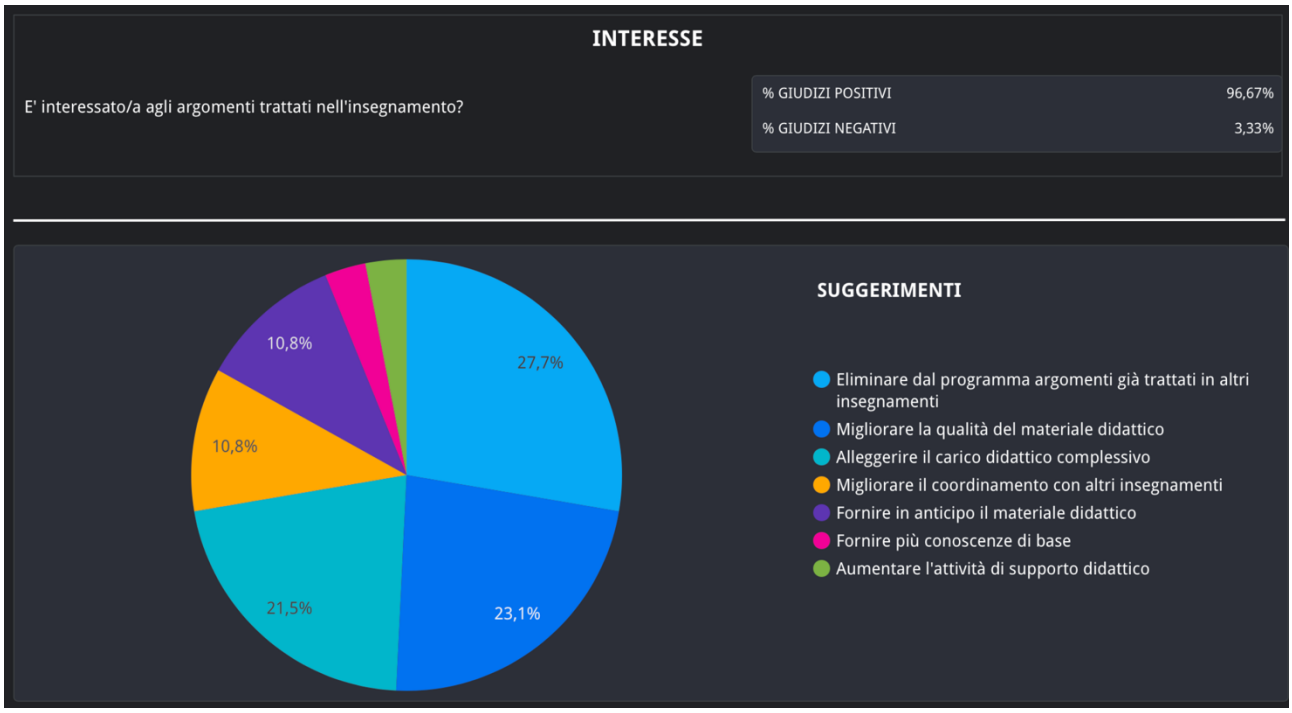


Figure 9 – Interest in the topics and suggestions

The questions in figure 9 are respectively:

- Are you interested in the topics covered in the course?

Suggestions

- Eliminate topics already covered in other courses from the program
- Improve the quality of teaching materials
- Lighten the overall teaching load
- Improve coordination with other courses
- Provide teaching materials in advance
- Provide more basic knowledge
- Increase the teaching support activity