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Designing Hybrid Collaborative Networks for Human-Supervised Robotic Storage

4-hour hackathon | **47 students** | **14 teams** | **5 phases · 5 gates** | **4 Innovation Days**

Motivations & Research Question(s)

- **Industry 4.0 training:** automation, efficiency and process optimisation.
- **Industry 5.0 competences:** human-centred decisions, sustainability and resilience.
- **Emerging enablers:** generative AI and human-AI collaboration, learned in context.
- Effective educational designs that operationalise these principles remain scarce.

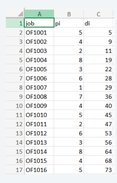
Research questions

- How can a hybrid collaborative network combining human supervision, structured data, computer vision and collaborative robotics be designed and validated in an agile, stage-based way?
- How can such a cyber-physical scenario be translated into a manageable challenge-based learning experience?
- What is the role of generative AI as a support tool without displacing human validation and accountability?

Robot in action
SCAN ME

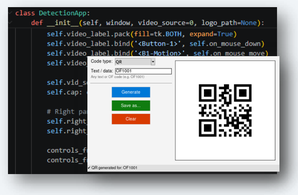
Methodology

PHASE 1



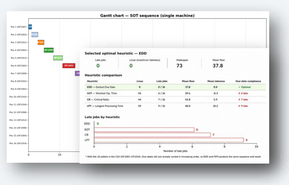
Structured data
CSV dataset: job ID, processing time (pi) and due date (di).
Gate 1 · CSV data generation

PHASE 2



Digital identity
Python app generating one QR code per manufacturing order.
Gate 2 · QR creation

PHASE 3



Sequencing & storage
Gantt chart and assignment to 16 storage positions.
Gate 3 · Sequencing

PHASE 4



Computer vision
QR reading that matches each pallet with its storage position.
Gate 4 · QR detection + position

PHASE 5



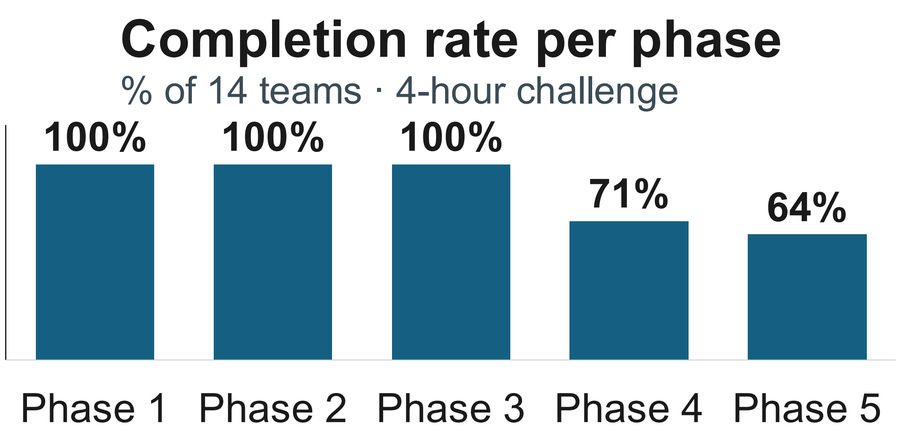
Collaborative robot
Dobot pick-and-place executed under human supervision.
Gate 5 · Full integration

AI SUPPORTS
Code generation · debugging · module integration · error correction

STUDENTS PERFORM
Interpretation · adaptation to the case · testing · human

VALIDATION GATES ENSURE
Correct outputs · consistent integration · reliable workflow

Preliminary Results



- **Full validation of the first three stages:** all 14 teams delivered the CSV dataset, the QR generator and the sequencing with storage assignment.
- **Integration emerged as the main bottleneck:** completion fell to 71% (10 teams) in Phase 4 and 64% (9 teams) in Phase 5, driven by the time needed to connect modules rather than by module failure.
- **AI-supported development:** students with limited programming experience produced functional Python applications while validating every AI-generated output.
- **Replicable format:** 4 Innovation Days already run across 4 programmes: MSc Advanced Production & Logistics Engineering (ETSII), MSc Industrial Organisation & Logistics Engineering (EPSA), BSc Electrical Engineering (EPSA) and BSc Engineering & Business Management (EDEM).

Key conclusions and perspectives

- **Hybrid network delivered:** a coordinated workflow where humans validate and supervise, digital modules structure information, vision identifies physical units and a Dobot cobot executes the storage operation.
- **Agile, stage-based design works:** functional validation gates keep complexity manageable and make integration errors visible where they emerge.
- **Educational value:** challenge-based learning builds practical competences for designing and managing hybrid collaborative networks; generative AI lowers the entry barrier but its value depends on prompting, interpreting and validating outputs.
- **Perspectives:** scale to multi-robot and multi-actor networks, measure competence development before and after the challenge, and transfer the format to industrial training.

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