MODELLO D (inglese)	
General Information	
Academic subject	Software Engineering for AI-Enabled Systems
Degree course	Computer Science (second-level degree in Computer Science)
Curriculum	Artificial Intelligence
ECTS credits	6
Compulsory attendance	No
Language	English

Subject teacher	Name Surname	Mail address	SSD
	Filippo Lanubile	filippo.lanubile@uniba.it	INF/01

ECTS credits details			
Basic teaching activities	Lectures	Tutorials and lab	

Class schedule	
Period	1st semester
Year	2nd
Type of class	Lecture- workshops

Time management	
Hours	62
Hours of lectures	32 (4 credits)
Tutorials and lab	30 (2 credits)

Academic calendar	
Class begins	26/09/2023
Class ends	13/01/2024

Syllabus	
Prerequisites/requirements	
Expected learning outcomes (according to Dublin Descriptors) (it is recommended that they are congruent with the learning outcomes contained in A4a, A4b, A4c tables of the SUA-CdS)	*Knowledge and understanding* The course adopts a software-engineering perspective on building AI-enabled systems, focusing on understanding how AI components are parts of larger systems and how to turn a machine learning (ML) idea into a scalable and reliable product. It assumes a working relationship between software engineers and data scientists, and focuses on issues of design, implementation, operation, and quality assurance. *Applying knowledge and understanding* The students will be able to turn a data-driven AI/ML model into a scalable and reliable product. *Making informed judgements and choices* The students will be informed of the main challenges in engineering an AI-enabled system beyond accuracy. *Communicating knowledge and understanding* The students will learn how to communicate in teamwork through individual and collaborative exercises. *Capacities to continue learning* The students will be able to autonomously learn theoretical

	concepts and empirical evidence by reading research papers and grey literature.
Contents	Lectures - Introduction and key concepts - Requirements Engineering for ML - Code and data versioning - Experiment tracking - Quality assurance for ML - ML system design - APIs for ML - Containerization - CI/CD for ML - Monitoring Tutorials and Lab - Model Cards and Dataset Cards - Cookiecutter Data Science - Okteto or any cloud platform - Git with GitHub Flow, DVC, DagsHub - MLflow - Pynblint, Pylint, flake8 - Pytest, Great Expectations - FastAPI, Pytest - Docker, Docker Compose - GitHub Actions - Better Uptime, Locust, Prometheus, Grafana - Alibi Detect
Course program	
Bibliography	Main book - Christian Kastner, *Machine Learning in Production* — https://ckaestne.medium.com/machine-learning-in-production-book-overview-63be62393581 Other suggested books - Emmanuel Ameisen. *Building Machine Learning Powered Applications*, O'Reilly Media, January 2020, ISBN: 9781492045113 - Mark Treveil and the Dataiku Team. *Introducing MLOps*. O'Reilly Media, November 2020, ISBN: 9781492083290 - Valliappa Lakshmanan, Sara Robinson, Michael Munn. *Machine Learning Design Patterns*. O'Reilly Media, October 2020, ISBN: 9781098115784 Suggested research papers and grey literature: - F. Lanubile, S. Martinez-Fernandez and L. Quaranta, "Training future ML engineers: a project-based course on MLOps" in IEEE Software, (in print), doi: 10.1109/MS.2023.3310768 https://doi.ieeecomputersociety.org/10.1109/MS.2023.3310768 - F. Lanubile, S. Martínez-Fernández and L. Quaranta, "Teaching MLOps in Higher Education through Project-Based Learning," ICSE 2023, Software Engineering

	Education and Training Track, pp. 95-100, doi: 10.1109/ICSE-SEET58685.2023.00015 - https://arxiv.org/abs/2302.01048v1 - Sato, Wider, Windheuser. "Continuous Delivery for Machine Learning". https://martinfowler.com/articles/cd4ml.html - D. Sculley et al., "Hidden technical debt in machine learning systems" NIPS'15 - A. Vogelsang and M. Borg, "Requirements Engineering for Machine Learning: Perspectives from Data Scientists," REW 2019, https://arxiv.org/abs/1908.04674 - Margaret Mitchell, Simone Wu, Andrew Zaldivar, Parker Barnes, Lucy Vasserman, Ben Hutchinson, Elena Spitzer, Inioluwa Deborah Raji, and Timnit Gebru. 2019. Model Cards for Model Reporting. In Proceedings of the Conference on Fairness, Accountability, and Transparency (FAT* '19). https://doi.org/10.1145/3287560.3287596 https://arxiv.org/abs/1810.03993 - Luigi Quaranta, Fabio Calefato, and Filippo Lanubile. 2022. Eliciting Best Practices for Collaboration with Computational Notebooks. Proc. ACM Hum.-Comput. Interact. 6, CSCW1, Article 87 (April 2022), 41 pages. https://doi.org/10.1145/3512934 - M.T. Ribeiro, T. Wu, C. Guestrin, and S. Singh. "Beyond Accuracy: Behavioral Testing of NLP Models with CheckList." In Proceedings ACL, p. 4902–4912. (2020). https://homes.cs.washington.edu/~wtshuang/static/papers/2020-acl-checklist.pdf - J. Zhang, M. Harman, L. Ma and Y. Liu, "Machine Learning Testing: Survey, Landscapes and Horizons" in IEEE Transactions on Software Engineering, vol. , no. 01, pp. 1-1, 5555. doi: 10.1109/TSE.2019.2962027. https://arxiv.org/pdf/1906.10742.pdf - Jeremy Jordan. A simple solution for monitoring ML systems. https://www.jeremyjordan.me/ml-monitoring/ Collections of online resources: - MLOps Primer. https://elvissaravia.substack.com/p/mlops-primer-2021 - Made With ML: https://madewithml.com/
Notes	Bibliography will be integrated with the slides available on Teams platform.
Teaching methods	Lectures and tutorials supported by slides and demos.
Assessment methods (indicate at least the type written, oral, other)	Lab assessment: - model self-assigned and task consisting in building a reproducible ML pipeline and transforming the ML model from prototype to a production-level web API using containerization in a cloud-based environment. Oral assessment: - oral test, including questions about the course program
Evaluation criteria (Explain for each expected learning outcome what a student has to know, or is able to do,	The students should know the concepts presented and discussed during classes and be familiar with the tools introduced in the tutorials and lab sessions.

and how many levels of achievement there are.	
Further information	