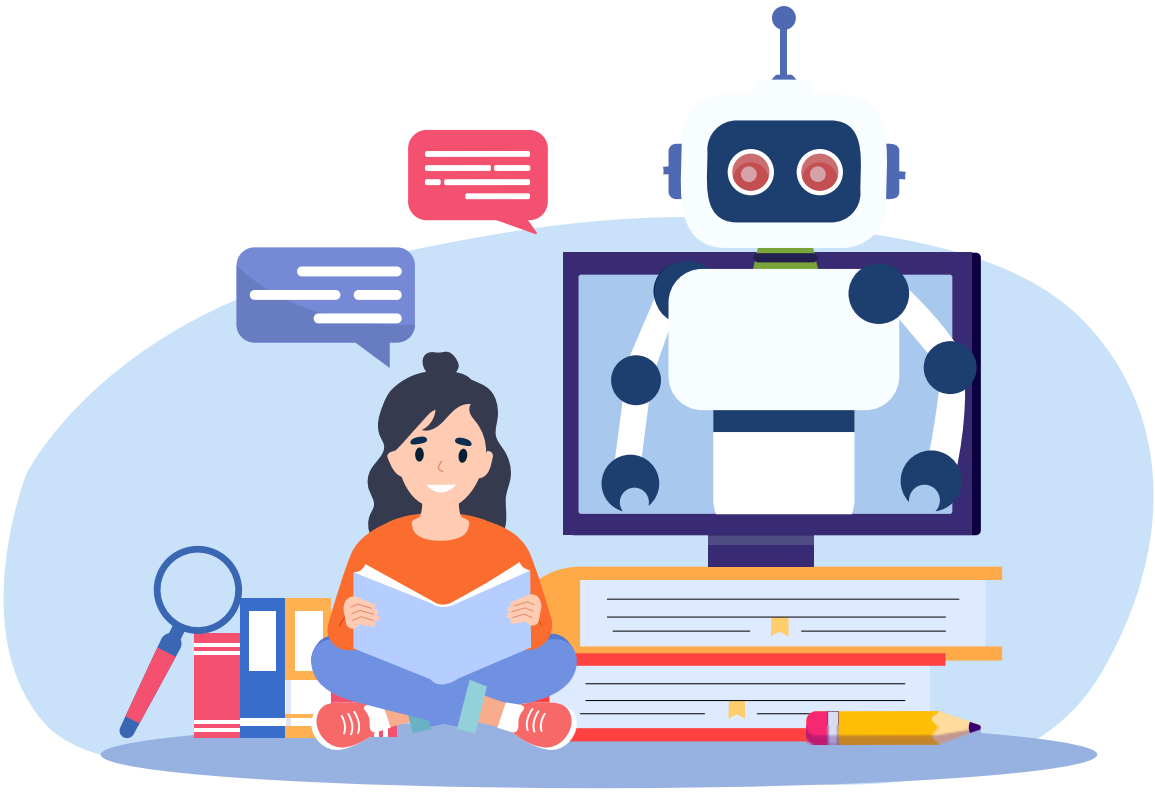
unesco

AI competency framework for students

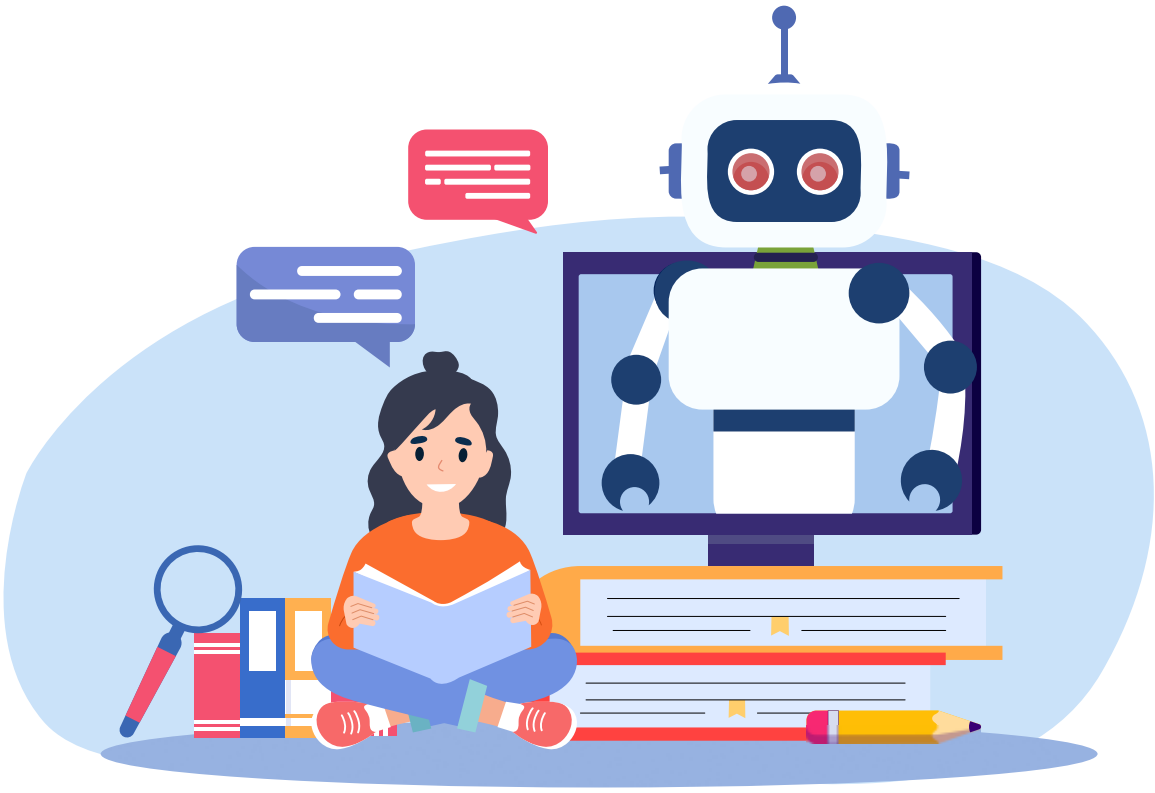


Education 2030

联合国教科文组织

人工智能能力框架

为学生



教育 2030

UNESCO – a global leader in education

Education is UNESCO's top priority because it is a basic human right and the foundation for peace and sustainable development. UNESCO is the United Nations' specialized agency for education, providing global and regional leadership to drive progress, strengthening the resilience and capacity of national systems to serve all learners. UNESCO also leads efforts to respond to contemporary global challenges through transformative learning, with special focus on gender equality and Africa across all actions.

The Global Education 2030 Agenda

UNESCO, as the United Nations' specialized agency for education, is entrusted to lead and coordinate the Education 2030 Agenda, which is part of a global movement to eradicate poverty through 17 Sustainable Development Goals by 2030. Education, essential to achieve all of these goals, has its own dedicated Goal 4, which aims to ***"ensure inclusive and equitable quality education and promote lifelong learning opportunities for all."*** The Education 2030 Framework for Action provides guidance for the implementation of this ambitious goal and commitments.

unesco
United Nations
Educational, Scientific
and Cultural Organization

Education 2030

Published in 2024 by the United Nations Educational, ScientificandC ultural Organization
7, place de Fontenoy, 75352 Paris 07 SP, France

ISBN: 978-92-3-100709-5
https://doi.org/10.54675/JKJB9835

Cover credit: Heena Rajput/Shutterstock.com*

Designed and printed by UNESCO

Printed in France

CLD1179.24

联合国教科文组织——全球教育领导者

教育是联合国教科文组织的首要任务，因为它不仅是基本人权，更是和平与可持续发展的基石。作为联合国专门负责教育的机构，教科文组织通过全球和地区层面的引领作用推动进步，增强各国教育体系服务全体学习者的韧性和能力。该组织还通过变革性学习应对当代全球挑战，所有行动都特别关注性别平等和非洲地区的发展。

unesco
United Nations
Educational, Scientific
and Cultural Organization

全球教育2030议程

作为联合国专门负责教育事务的机构，联合国教科文组织肩负着引领和协调《2030年教育议程》的重任。该议程是全球消除贫困运动的重要组成部分，旨在通过17项可持续发展目标在2030年前实现这一目标。教育作为实现所有这些目标的关键要素，被单独列为第四项目标，其核心宗旨是***"确保普及优质教育，促进全民公平享有教育机会，并为所有人创造终身学习机会。"***《2030年教育行动框架》为这一宏伟目标的实施及各项承诺提供了具体指导。

教育2030 ion

由联合国教育、科学及文化组织于2024年出版，地址：7，place de Fontenoy，
75352 Paris 07 SP，France

ISBN：978-92-3-100709-5
https://doi.org/10.54675/JKJB9835

封面：Heena Rajput/Shutterstock.com*

由联合国教科文组织设计和印刷

法国印刷

CLD1179.24

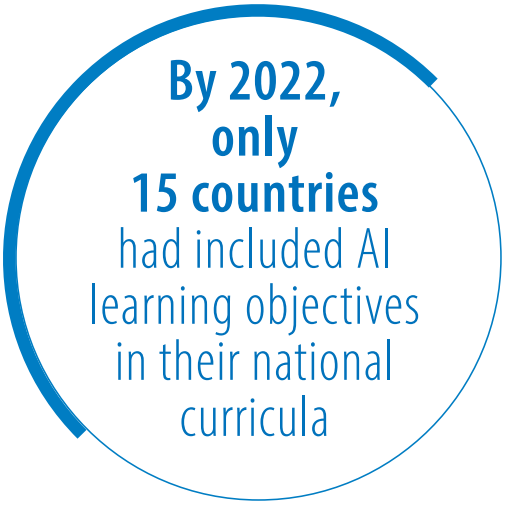
SHORT SUMMARY

Preparing students to be responsible and creative citizens in the era of AI

Artificial intelligence (AI) is increasingly integral to our lives, necessitating proactive education systems to prepare students to be responsible users and co-creators of AI. Integrating AI learning objectives into official school curricula is crucial for students globally to engage safely and meaningfully with AI.

The UNESCO AI competency framework for students aims to help educators in this integration, outlining 12 competencies across four dimensions: Human-centred mindset, Ethics of AI, AI techniques and applications, and AI system design. These competencies span three progression levels: Understand, Apply, and Create. The framework details curricular goals and domain-specific pedagogical methodologies.

Grounded in a vision of students as AI co-creators and responsible citizens, the framework emphasizes critical judgement of AI solutions, awareness of citizenship responsibilities in the era of AI, foundational AI knowledge for lifelong learning, and inclusive, sustainable AI design.



unesco

"Since wars begin in the minds of men and women it is in the minds of men and women that the defences of peace must be constructed"

SHORT SUMMARY

为学生做好准备，使其成为人工智能时代的负责任和有创造力的公民

人工智能（AI）正日益融入我们的生活，这就需要积极主动的教育体系来培养学生成为负责任的AI使用者和共同创造者。将人工智能学习目标纳入官方学校课程，对于全球学生安全且有意义地接触AI至关重要。

联合国教科文组织为学生制定的人工智能能力框架旨在帮助教育工作者实现这一融合，从四个维度概述了12项能力：以人为中心的思维方式、人工智能伦理、人工智能技术和应用、以及人工智能系统设计。这些能力涵盖三个发展阶段：理解、应用和创造。该框架详细阐述了课程目标和特定领域的教学方法。

该框架植根于将学生视为人工智能共同创造者和负责任公民的愿景，强调对人工智能解决方案的批判性判断、在人工智能时代对公民责任的认识、终身学习的基础人工智能知识以及包容性和可持续的人工智能设计。

到2022年，仅15个国家在国家课程中纳入了人工智能学习目标

联合国教科文组织

“战争起源于人类的思想，维护和平的防线也必须建立在人类的思想之上。”

AI competency framework for students

安斯克

人工智能能力框架

为学生

Foreword

© UNESCO

The past decade has seen widespread adoption of artificial intelligence (AI) in all areas of human development, with the public release of generative AI tools in November 2022 only accelerating its permeation within social life. The education sector, which is at the heart of the transformation of human societies, has been no exception.

This process of rapid technological change brings multiple opportunities but also risks and challenges for students, teachers and society at large. In the era of AI, school students need to be prepared to become active co-creators of AI, as well as future leaders who will shape novel iterations of the technology and define its relationship with society.

This is exactly the ambition of UNESCO's AI competency framework for students – the first ever global framework of its kind. It aims to support the development of core competencies for students to become responsible and creative citizens, equipped to thrive in the AI era. This will help students acquire the values, knowledge and skills necessary to examine and understand AI critically from a holistic perspective, including its ethical, social and technical dimensions.

The new framework embodies UNESCO's mandate by anchoring its vision of AI and education in principles of human rights, inclusion and equity. This approach seeks to ensure that AI supports the development of human capabilities, protects human dignity and agency, and promotes justice and sustainability.

The publication builds on UNESCO's previous work in the field, such as the *ICT competency framework for teachers, AI and education: Guidance for policy-makers*, and the more recent *Guidance for generative AI in education and research*. It reflects the contributions of a wide range of stakeholders, drawing on UNESCO Member States' insights on developing and implementing AI school curricula, the expertise of an international working group, three international consultation meetings, and multiple rounds of online consultations.

The AI competency framework for students has been developed hand in hand with a competency framework for teachers. It is my hope that these two frameworks will empower students and teachers to shape the digital futures we want.

In a world characterized by rising complexity and uncertainty, it is our collective responsibility to ensure that education remains the central space for transformation of our shared futures.

Stefania Giannini
UNESCO Assistant Director-General for Education

前言

©联合国教科文组织

过去十年间，人工智能（AI）已广泛应用于人类发展的各个领域，而2022年11月生成式AI工具的公开发布，更加速了它在社会生活中的渗透。处于人类社会转型核心的教育领域，同样也不例外。

这种技术快速变革的过程给学生、教师和整个社会带来多重机遇，同时也带来风险和挑战。在人工智能时代，学生需要做好准备，成为人工智能的积极共同创造者，成为塑造新技术迭代并界定其与社会关系的未来领导者。

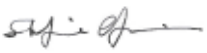
这正是联合国教科文组织人工智能素养框架为学生设定的宏伟目标——这是全球首个此类框架。该框架旨在培养学生的核心素养，使其成长为负责任且富有创造力的公民，从而在人工智能时代中游刃有余。通过这一框架，学生们将掌握必要的价值观、知识和技能，能够从整体视角批判性地审视人工智能，包括其伦理、社会和技术层面的维度。

新框架体现了教科文组织的使命，将人工智能和教育的愿景扎根于人权、包容和平等的原则。这种方法旨在确保人工智能促进人类能力的发展，保护人类的尊严和自主权，并促进正义和可持续性。

该出版物在联合国教科文组织既有研究成果基础上进一步深化，包括*面向教师的信息通信技术能力框架*《*人工智能与教育：政策制定者指南*》，以及较新的《*教育与研究领域生成式人工智能指南*》。本书凝聚了多方力量的智慧结晶，既吸收了联合国教科文组织成员国在人工智能课程开发与实施方面的真知灼见，又融合了国际工作组的专业经验，经过三次全球性专家研讨会和多轮线上意见征集的充分打磨。

学生人工智能能力框架与教师能力框架是同步开发的。我期待这两个框架能够帮助学生和教师共同塑造我们想要的数字化未来。

在一个复杂性和不确定性与日俱增的世界里，我们有责任确保教育仍然是改变我们共同未来的中心领域。



斯特凡妮娅·贾尼尼
教科文组织教育助理总干事

Acknowledgements

Under the leadership of Stefania Giannini, Assistant Director-General for Education, and the guidance of Sobhi Tawil, Director of the Future of Learning and Innovation Division at UNESCO, the drafting of the publication was led by Fengchun Miao, Chief of Unit for Technology and AI in Education.

The framework was drafted by Fengchun Miao, Chief of Unit for Technology and AI in Education at UNESCO, Kelly Shiohira, Director of the Global Science of Learning Education Network and Natalie Lao, Executive Director of the App Inventor Foundation. The development of the framework also benefited from the contribution of Lidija Kralj, Education Analyst at EduConLK.

Special appreciation is also extended to the following experts for peer-reviewing the publication: Kate Arthur, Co-founder and partner at Comz; Ke Gong, President of the World Federation of Engineering Organizations (WFEO); Kaśka Porayska-Pomsta, Professor of AI in Education at University College London; Nisha Talagala, Co-Founder and CEO of AIClub and AIClubPro; Monique Brodeur, Hugo Couture, Sophie Gosselin, Yves Munn and Benoit Petit from the *Conseil supérieur de l'éducation du Québec*; and Luc Bégin, Nicolas Bernier and Guillaume Pelletier from the *Commission de l'éthique en science et en technologie*.

Thanks also go to the following UNESCO colleagues for contributing to the peer-review process: Andrea Detmer at the Executive Office of the Culture Sector; Amal Kasry, Chief of the Basic Sciences, Research, Innovation and Engineering Section; Karalyn Monteil, Head of the Programmes and Stakeholder Outreach Unit at the Culture Sector; Renato Opertti, Senior Education Expert at the International Bureau of Education; Arianna Valentini at the International Institute for Higher Education in Latin America and the Caribbean; Soichiro Yasukawa, Chief of the Disaster Risk Reduction Unit in the Science Sector; Martiale Kana Zebaze, Senior Programme Specialist for Science, Technology and Innovation at the UNESCO Harare Office; as well as Jaco Du Toit, Chief, and Zeynep Varoglu, Programme Specialist, at the Section for Universal Access to Information and Digital Inclusion in the Communication and Information Sector.

Special thanks go to Luisa Ferrara at the Unit for Technology and AI in Education within the Future of Learning and Innovation Division, for managing expert inputs, and to Glen Hertelendy from the same Unit for coordinating the production of the publication.

Additionally, UNESCO is grateful to Jenny Webster for copy-editing and proofreading the text.

Finally, UNESCO would like to thank the Tomorrow Advancing Life (TAL) Education Group of China for generously supporting this publication project and, more broadly, for promoting the potential of artificial intelligence for the future of education.

致

在教育助理总干事Stefania Giannini的领导下，在教科文组织学习与创新未来司司长Sobhi Tawil的指导下，该出版物的起草工作由教育技术和人工智能部门主管Miao Fengchun领导。

该框架由联合国教科文组织教育技术与人工智能部门主管冯春苗、全球学习科学教育网络主任凯莉·塩平以及应用发明基金会执行董事娜塔莉·劳共同起草。框架的制定还得到了EduConLK教育分析师莉迪亚·克拉尔的贡献。

我们特别感谢以下专家对本出版物进行同行评审的贡献：康姆兹公司联合创始人兼合伙人凯特·亚瑟（Kate Arthur）；世界工程组织联合会（WFEO）主席龚克（Ke Gong）；伦敦大学学院教育人工智能教授卡斯卡·波拉伊斯卡-庞斯塔（Kaska Porayska-Pomsta）；AIClub及AIClubPro联合创始人兼首席执行官妮莎·塔拉加拉（Nisha Talagala）；*魁北克高等教育委员会*的莫妮克·布罗迪尔（Monique Brodeur）、雨果·库图尔（Hugo Couture）、苏菲·戈塞兰（Sophie Gosselin）、伊夫·芒恩（Yves Munn）和本诺伊特·佩蒂（Benoit Petit）；以及*科学与技术伦理委员会*的吕克·贝根（Luc Begin）、尼古拉·贝尔尼耶（Nicolas Bernier）和纪尧姆·佩莱蒂埃（Guillaume Pelletier）。

在此特别感谢以下联合国教科文组织同仁对同行评审工作的贡献：文化部门执行办公室的安德烈亚·德特默；基础科学、研究、创新与工程科科长阿马尔·卡斯里；文化部门项目与利益相关方外联部主任卡拉琳·蒙泰尔；国际教育局高级教育专家雷纳托·奥佩蒂；拉丁美洲和加勒比地区高等教育国际研究所的阿里安娜·瓦伦蒂尼；科学部门灾害风险减少科科长安田康一郎；联合国教科文组织哈拉雷办事处科技与创新高级项目专员玛蒂亚莱·卡纳·泽巴泽；以及信息与通信部门全民信息获取与数字包容科科长雅科·杜托伊特与项目专员泽伊内普·瓦罗格鲁。

特别感谢未来学习和创新司教育技术和人工智能单位的Luisa Ferrara管理专家意见，以及来自同一单位的Glen Hertelendy协调出版物的制作。

此外，教科文组织感谢Jenny Webster对文本进行编辑和校对。

最后，联合国教科文组织谨此感谢中国未来生命教育（TAL）教育小组对本出版物项目的慷慨支持，并更广泛地促进人工智能在教育未来的潜力。

Table of contents

Foreword **6**
Acknowledgements **7**
List of tables and boxes **10**
List of acronyms and abbreviations **11**

Chapter 1: Introduction **12**
1.1 Why an AI competency framework for students? 12
1.2 Purpose and target audience 13

Chapter 2: Key principles **14**
2.1 Fostering a critical approach to AI 14
2.2 Prioritizing human-centred interaction with AI 15
2.3 Encouraging environmentally sustainable AI 15
2.4 Promoting inclusivity in AI competency development 16
2.5 Building core AI competencies for lifelong learning 17

Chapter 3: Structure of the AI competency framework for students **18**
3.1 The framework 18
3.2 Progression levels 20
Level 1: Understand 20
Level 2: Apply 20
Level 3: Create 21
3.3 Aspects 21
Human-centred mindset 22
Ethics of AI 23
AI techniques and applications 24
AI system design 25

Chapter 4: Specifications of AI competencies for students **27**
4.1 Level 1: Understand 27
4.2 Level 2: Apply 37
4.3 Level 3: Create 45

目录

前言 **6**
致 **7**
表格和方框列表 **10**
缩略语和缩写词列表 **11**

第1章：简介 **12**
1.1 为什么为学生建立一个人工智能能力框架？ 12
1.2 目的和目标受众 13

第2章：关键原则 **14**
2.1 培养对人工智能的批判性方法 14
2.2 优先考虑与人工智能的人机交互 15
2.3 鼓励环境可持续的人工智能 15
2.4 促进人工智能能力发展的包容性 16
2.5 构建终身学习的核心人工智能能力 17

第三章：学生的人工智能能力 框架结构 **18**
3.1 框架 18
3.2 进度等级 20
第1级：了解 20
级别2：应用 20
第3级：创建 21
3.3 方面 21
以人为本的思维方式 22
人工智能伦理 23
人工智能技术及应用 24
AI系统设计 25

第四章：学生人工智能能力 的具体规定 **27**
4.1 第1级：了解 27
4.2 级别2：应用 37
4.3 第3级：创建 45

Chapter 5: Applying the framework **53**
5.1 Aligning AI competencies as the foundation for national AI strategies 53
5.2 Building interdisciplinary core and cluster AI curricula for AI competency 56
5.3 Framing future-proofing and locally feasible AI domains as carriers of the curriculum 58
5.4 Tailoring age-appropriate spiral curricular sequences 59
5.5 Building enabling learning environments for AI curricula 61
5.6 Promoting the professionalization of AI teachers and streamlining their support 62
5.7 Guiding the cohort-based design and organization of pedagogical activities 64
5.8 Constructing competency-based assessments on the progression of key AI aspects 69

Conclusion **78**
References **79**
Endnotes **80**

第五章：应用框架 **53**
5.1 将人工智能能力作为国家人工智能战略的基础 53
5.2 构建跨学科核心与集群人工智能课程体系，提升人工智能能力 56
5.3 将未来保障和本地可行的人工智能领域作为课程载体 58
5.4 量身定制适合年龄的螺旋式课程序列 59
5.5 为人工智能课程建立学习环境 61
5.6 促进人工智能教师专业化，简化他们的支持 62
5.7 指导基于队列的教学活动设计和组织 64
5.8 构建基于能力的评估，以了解关键人工智能方面的进展 69

结 **78**
参考文 **79**
尾注 **80**

List of tables

Table 1. AI competency framework for students **19**

Table 2. Competency blocks for level 1: Understand **29**

Table 3. Competency blocks for level 2: Apply **37**

Table 4. Competency blocks for level 3: Create **45**

Table 5. Examples of assessment tasks **73**

List of boxes

Box 1: Recommendation on the Ethics of Artificial Intelligence **53**

Box 2: Supporting human resource development: The Republic of Korea's *National Strategy for Artificial Intelligence* **55**

Box 3: The United Arab Emirates' interdisciplinary approach to K-12 AI curricula **57**

Box 4: The spiral curricular sequence of 'Day of AI' courses **60**

Box 5: Typical enabling learning environment set up by governments' AI curricula **61**

Box 6: An AI competency framework for AI subject teachers in China **63**

Box 7: Pedagogical methodologies in the MIT curriculum on the ethics of AI for middle school students **66**

表格清单

表1.学生的人工智能能力框架 **19**

表2.第一级：理解的能力模块 **29**

表3.第二级：应用的能力模块 **37**

表4.第三级：创建的能力模块 **45**

表5.评估任务示例 **73**

箱体清单

方框1：关于人工智能伦理的建议 **53**

方案框2：支持人力资源开发：大韩民国 *人工智能国家战略* **55**

方框3：阿拉伯联合酋长国在K-12人工智能课程方面的跨学科方法 **57**

方框4：人工智能日课程的螺旋式课程序列 **60**

方框5：政府设置的典型支持性学习环境和人工智能课程 **61**

方框6：中国人工智能学科教师的人工智能能力框架 **63**

框7：麻省理工学院中学生人工智能伦理课程的教学方法 **66**

List of acronyms and abbreviations

AGI	Artificial general intelligence
AI	Artificial intelligence
AI CFS	AI competency framework for students
CCDI	Computing, Creative Design and Innovation
CG	Curricular goal
GAN	Generative adversarial networks
K-12	Kindergarten through 12th grade
ICT	Information and communication technology
IEA	International Energy Agency
IGO	Intergovernmental organization
ITU	International Telecommunication Union
MIT	Massachusetts Institute of Technology
NGO	Non-governmental organization
STEAM	Science, technology, engineering, arts and mathematics
STEM	Science, technology, engineering and mathematics
TVET	Technical and vocational education and training
UNESCO	United Nations Educational, Scientific and Cultural Organization

缩略语和缩写词列表

阿吉	通用人工智
人工智能	人工智
AI CFS	学生人工智能能力框架
彩色反差鉴别指数	计算、创意设计和创新
CG	课程目标
GAN	生成对抗网络
K-12	幼儿园到12年级
黄疸	信息和通信技术
国际能源署	国际能源署
伊戈尔	政府间组织
国际电信同盟	国际电信联盟
麻省理工学院	马萨诸塞理工学院
非政府组织	非政府组织
水蒸气	科学、技术、工程、艺术和数学
茎	科学、技术、工程和数学
电视网	技术与职业教育和培训
联合国教科文组织	联合国教育、科学及文化组织

Chapter 1: Introduction

1.1 Why an AI competency framework for students?

The rapid iterations and proliferation of artificial intelligence (AI) across all aspects of life and all sectors are posing new challenges regarding the nature of machine intelligence, the collection and use of personal data, the role of humans and machines in decision-making, and the impact of AI on social and environmental sustainability. It is essential that education systems prepare students not only with the knowledge and skills to use AI, but also with insight into the potential impact of technology on societies and the environment at large. Given the transformative potential of AI for human societies, it is crucial to equip students with the values, knowledge and skills needed for the effective use and active co-creation of AI.

Education, as a public sector, cannot be reduced to a testing ground for the passive adoption of AI. The role of the education sector is not only to prepare students to adapt to a society that is increasingly being transformed by AI technologies; it also has a key role to play in empowering young people to help co-create sustainable futures by rebalancing our relationships, not only with others, but also with technology and the environment. By defining the core competencies that students are likely to require as we move deeper into the AI era, the ultimate aim of this AI competency framework for students (AI CFS) is to help shape responsible and creative citizens that can co-create these desirable futures.

Governments acknowledged the urgent need to develop AI literacy and more advanced AI competencies as early as 2019, when they adopted the UNESCO *Beijing Consensus on AI and Education*. Indeed, the Beijing Consensus underlined the need to equip people with AI literacy across all layers of society. However, according to a recent survey conducted across 190 countries, only some 15 countries were found to be developing or implementing AI curricula in school education (UNESCO, 2022*b*). The survey also found that there was wide variation in how countries defined AI literacy, skills and competency. The results of the survey therefore underscored the urgency of developing a harmonized approach to integrating AI-related teaching and learning content in school curricula.

Far too often, the definition of AI competencies for students is influenced by training designed and/or provided by private companies, which tends to focus on technical skills to operate profit-driven AI platforms. Such approaches seldom engage with the broader critical issues of the implications of AI for learning and citizenship, more broadly. There is currently a void in too many education systems when it comes to public-approved frameworks for introducing AI-related content and methods to educational curricula. One of the challenges that public education systems are facing in filling this void is the lack of an international reference framework on AI competencies for students. Such an international reference framework can inform the design of national/local AI competency frameworks for students that

第1章：简介

1.1 为什么为学生建立一个人工智能能力框架？

人工智能（AI）在生活各个领域和各行各业的快速迭代与普及，正引发关于机器智能本质、个人数据收集与使用、人机决策角色以及AI对社会环境可持续性影响等新挑战。教育体系不仅要培养学生掌握AI应用的知识技能，更要培养他们洞察技术对社会和环境整体潜在影响的远见。鉴于AI对人类社会具有变革性潜力，培养学生有效运用AI并积极参与协同创新所需的价值观、知识与技能显得尤为重要。

教育作为公共领域，绝不能沦为被动接受人工智能的试验场。教育部门的使命不仅是培养学生适应人工智能技术不断重塑的社会，更肩负着赋能青年的关键职责——通过重新平衡人际、科技与环境的关系，助力年轻人共同创造可持续的未来。随着人工智能时代不断深入，通过明确学生所需的核心素养，这份《学生人工智能能力框架》（AI CFS）的终极目标，是培养具有责任感和创造力的公民，让他们能携手共建理想中的未来。

各国政府早在2019年通过《*教科文组织北京人工智能与教育共识*》时，就认识到培养人工智能素养和提升相关技能的紧迫性。这份共识明确指出，必须让全社会各阶层民众掌握人工智能素养。然而根据联合国教科文组织2022年对190个国家开展的最新调查，全球仅有约15个国家正在中小学课程中开发或实施人工智能教学内容（*联合国教科文组织2022b*）。调查还发现，各国对人工智能素养、技能和能力的定义存在显著差异。这些结果充分说明，亟需制定统一标准将人工智能相关教学内容融入学校课程体系。

当前学生人工智能能力的培养标准，往往受制于私营企业设计或提供的培训体系。这类培训主要侧重于操作盈利性AI平台所需的技术技能，却鲜少触及更广泛的核心议题——人工智能对学习方式和公民意识的深远影响。当前众多教育体系在引入人工智能相关课程内容时，仍缺乏经官方认证的教学框架。公共教育系统面临的主要挑战之一，正是缺乏国际公认的AI能力标准参考框架。这种国际性参考框架的缺失，为各国制定本土化AI能力培养体系提供了重要依据。

promote a critical and ethical approach to AI tools, as well as develop the foundational knowledge required for their effective and meaningful use in education. The aim of this AI CFS is to fill this void.

AI technology is a rapidly moving target. It is therefore critical to ensure that all students have a core set of knowledge, skills and values for interacting ethically and effectively with AI in the present. This foundation can enable students to utilize future iterations of AI technology in an appropriate and human-centred manner.

The AI CFS supports educational authorities to respond to these needs by defining a core set of competencies for students that fall under four aspects: Human-centred mindset; Ethics of AI; AI techniques and applications; and AI system design. These four aspects are articulated at three levels of progression or mastery (understanding, application and creation), resulting in a total of twelve competency blocks. For each of these competency blocks, the AI CFS proposes detailed specifications on relevant pedagogical methodologies and strategies for the planning and provision of AI-related curricular content.

1.2 Purpose and target audience

The AI CFS aims to serve as a guide for public education systems to build the competencies required of all students and citizens for the effective implementation of national AI strategies and the building of inclusive, just and sustainable futures in this new technological era.

More specifically, the AI CFS: (1) provides a global reference framework on the core set of AI competencies for students to inform the design of national or institutional AI competency frameworks; (2) specifies typical attitudinal and behavioural performance relating to the key aspects of AI competencies at different levels of mastery to help design AI-related curricular content for school students; and (3) recommends an open-ended roadmap to help plan the learning sequence of AI curricula across grade levels.

As a global reference framework, the AI CFS is to be tailored to the diverse readiness levels of local education systems in terms of curricula, the enabling learning environment for teaching AI, preparedness of teachers, and the prior knowledge and capacities of specific groups of students.

The AI CFS is aimed principally at policy-makers, curriculum developers, providers of education programmes on AI for students, school leaders, teachers and educational experts.

倡导对人工智能工具采取批判性和道德化的态度，同时开发其在教育中有效且有意义使用所需的基础知识。本人工智能课程框架（AI CFS）旨在填补这一空白。

人工智能技术是一个快速发展的领域。因此，确保所有学生都具备与当前人工智能进行合乎道德且有效互动所需的核心知识、技能和价值观至关重要。这一基础将使学生能够以恰当且以人为本的方式，运用未来版本的人工智能技术。

人工智能课程框架（AI CFS）通过为学生制定四大核心能力模块，助力教育机构满足教育需求。这四大模块涵盖：以人为核心的理念、人工智能伦理、人工智能技术与应用、以及人工智能系统设计。这些能力模块按三个递进层次（理解、应用和创造）逐步展开，最终形成十二个完整的能力模块。针对每个能力模块，AI CFS都制定了详细的教学方法与策略规范，为人工智能相关课程内容的规划与实施提供指导。

1.2 目的和目标受众

人工智能CFS旨在为公共教育系统提供指导，以建立所有学生和公民所需的能力，有效实施国家人工智能战略，并在这个新的技术时代建立包容、公正和可持续的未来。

具体而言，人工智能能力框架（AI CFS）包含三大核心功能：首先，为学生提供涵盖人工智能核心能力的全局性参考框架，为制定国家或机构层面的人工智能能力标准提供依据；其次，明确不同掌握程度下与人工智能关键能力相关的核心态度和行为表现标准，助力学校设计人工智能课程内容；最后，提出开放式路线图方案，帮助规划跨年级的人工智能课程学习序列。

作为全球参考框架，人工智能CFS将根据当地教育系统在课程、教学人工智能的有利学习环境、教师的准备程度以及特定学生群体的先验知识和能力等方面的多样化就绪水平进行调整。

人工智能CFS主要面向政策制定者、课程开发者、为学生提供人工智能教育项目的提供商、学校领导人、教师和教育专家。

Chapter 2: Key principles

2.1 Fostering a critical approach to AI

Critical thinking is a fundamental skill that students need to meaningfully engage with AI as learners, users and creators. Students also have the responsibility to determine what types of AI should be developed and how they should be used to drive human societies towards inclusive, environmentally sound, shared futures. School students need to be supported to become active co-creators of AI, as well as potential leaders who will define further iterations of AI and its interactions with human society for present and future generations. To support this vision, the AI CFS is designed to foster a critical approach to AI by engaging students with fundamental questions, such as: is AI poised to help solve real-world challenges faced by humans, or does it pose insurmountable threats to humans? Are adverse impacts on climate of training and using AI disproportionate to its anticipated benefits? What social, economic, political and demographic impacts of the use of AI should be carefully reviewed?

The AI-driven transformation across development sectors has profound implications for human agency, human interactions, social equity, economic inclusiveness, and environmental sustainability. Thus, in the first place, school students are expected to be conscious and knowledgeable of the advantages and limitations of existing affordances of AI. The pre-condition for responsible use consists in students' abilities to detect the trustworthiness and proportionality of AI tools. The AI CFS aims to prepare students with the values, knowledge and skills necessary to critically examine the proportionality of AI from an ethical perspective. This includes examining and understanding its impact on human agency, social inclusion and equity, institutional and individual security, cultural and linguistic diversity, the construction and expression of plural opinions, as well as on the environment and on ecosystems. Students are expected to move beyond the misconception that AI is a solution to everything. Rather, they are to become conscious decision-makers on when AI systems and applications should, or should not, be used; what problems they may or may not solve; and when and how AI should be designed and used as one part of a wider solution. The AI CFS aims to nurture students' aspirations to apply and design AI tools to serve meaningful specific purposes or to address real-world challenges and promote sustainable development.

Societies are moving into the era of AI at different paces, but students everywhere are, or will be, citizens in contexts characterized by widespread AI integration. They will not only have to comply with legal regulations and ethical principles, but, as citizens, they will also have to contribute to the adaptation of AI standards and regulations. The framework therefore highlights the importance of supporting students to become responsible and ethical users of, as well as contributors to, AI. It engages students to reflect on key controversies surrounding AI, internalize ethical principles, and become familiar with related regulations.

第2章：关键原则

2.1 培养对人工智能的批判性方法

批判性思维是学生作为学习者、用户和创造者与人工智能深度互动时必须掌握的核心技能。学生们还肩负着重要责任：既要决定应开发何种类型的人工智能，也要探索如何运用这些技术推动人类社会迈向包容、环保且共享的未来。我们需要支持学生成为人工智能的积极参与者和潜在引领者——他们将定义人工智能的未来发展形态及其与人类社会的互动方式，造福当代及子孙后代。为此，人工智能CFS项目通过引导学生探讨以下根本性问题来培养批判性思维：人工智能能否真正解决人类面临的现实挑战？还是会对人类构成不可逾越的威胁？人工智能在培训和应用过程中对气候造成的负面影响是否与其预期效益不成比例？使用人工智能时，哪些社会、经济、政治及人口结构层面的影响需要我们审慎考量？

人工智能在各发展领域的变革对人类能动性、人际互动、社会公平、经济包容性和环境可持续性具有深远影响。因此，首先需要让学生们充分认识到现有AI技术的优势与局限。负责任使用AI的前提条件在于学生能否辨别AI工具的可信度和适用范围。人工智能能力框架（AI CFS）旨在培养具备必要价值观、知识和技能的学生，能够从伦理角度批判性审视人工智能的相称性。这包括考察和理解其对人类能动性、社会包容与公平、机构和个人安全、文化语言多样性、多元观点的构建与表达，以及对环境和生态系统的影响。

学生们需要突破“人工智能能解决所有问题”的固有认知。相反，他们应当成为具备判断力的决策者：明确何时该使用AI系统与应用、何时不该使用；认清AI可能解决或无法解决的问题；并懂得如何将AI作为整体解决方案的一部分进行设计与应用。人工智能课程框架（AI CFS）致力于培养学生的远见卓识——通过设计和应用AI工具来实现具体目标，应对现实挑战，推动可持续发展。

各社会正以不同速度迈入人工智能时代，但全球学子们已然或即将成为身处AI深度融入社会的公民。他们不仅要遵守法律法规与伦理准则，更需以公民身份参与制定人工智能标准与规范。为此，该框架着重强调培养学生作为负责任且具备道德意识的AI使用者及贡献者的重要性。通过引导学生深入思考AI引发的核心争议、内化伦理准则并熟悉相关法规，构建起完整的知识体系。

The AI CFS sets out a forward-looking vision of the type of citizenship required by societies increasingly shaped by AI. It proposes that students be challenged and enabled to make meaningful use of AI for self-actualization; to evaluate its social, economic and environmental impacts; and to contribute, at a level appropriate for their age or grade, to the development of AI regulations, helping to shape our relationship with technology in society at large.

2.2 Prioritizing human-centred interaction with AI

In the era of AI, interaction between humans and AI systems and applications will become an essential constituent element of public service, production and commerce, social practice, learning, and daily life. Establishing the competencies needed to understand and ensure human-centred interaction with AI in these domains is a priority for the AI CFS.

UNESCO's human-centric approach advocates that the design and use of AI should serve the development of human capabilities, protect human dignity and agency, and promote justice and sustainability throughout the entire AI life cycle and all possible human–AI interaction loops. Such an approach must be guided by human rights principles and respect for the linguistic and cultural diversity that defines the knowledge commons. A human-centred approach also requires that AI be used in ways that ensure transparency and explainability, as well as human control and accountability.

As AI becomes increasingly sophisticated and more widely used, a key danger is its potential to undermine human agency and compromise the development of human intellectual skills. While AI can be used to challenge and extend human thought, it should not be allowed to usurp or replace critical thinking. The protection and enhancement of human agency should, therefore, always be a core principle in the design of AI curricula and education programmes. The AI CFS aims to support students to understand the types of data that AI may collect from them, the methods with which the data may be used to train AI models, and the impact that the data cycle may have on their privacy and wider lives. It seeks to stimulate students' intrinsic motivation to grow and learn as individuals and to reinforce their autonomy in contexts in which sophisticated AI systems are increasingly being integrated. Critical AI competencies, as proposed in this framework, can also guide students to understand the unique value of social interaction and of the creative works produced by humans that should not be replaced by AI outputs. By developing competencies for human-centred engagement with AI, the framework aims to prevent students from becoming addicted to or dependent on AI, and to foster behaviours that maintain human accountability for high-stakes decisions.

2.3 Encouraging environmentally sustainable AI

As co-creators and potential leaders of the next generations of AI technology, students need to have a critical understanding of the adverse environmental impact of profit-driven approaches to the design, training and deployment of AI models. Education systems bear the responsibility of ensuring that students understand carbon emissions,

《人工智能公民框架》（AI CFS）勾勒出一个面向未来的愿景，描绘了在人工智能日益主导社会的背景下所需培养的新型公民形象。该框架提出要培养学生运用人工智能实现自我价值的能力，引导他们评估其社会、经济及环境影响，并根据年龄或年级特点参与制定人工智能相关法规，共同塑造人类与技术在社会中的互动关系。

2.2 优先考虑与人工智能的人机交互

在人工智能时代，人类与人工智能系统及应用之间的互动将成为公共服务、生产、商业、社会实践、学习和日常生活的基本要素。建立在这些领域中理解和确保以人为中心的人工智能互动所需的能力，是人工智能CFS的优先事项。

联合国教科文组织秉持以人为本的理念，主张人工智能的设计与应用应当服务于人类能力的发展，保护人类尊严与自主权，并在人工智能全生命周期及所有可能的人工智能互动环节中促进公正与可持续性。这一理念必须以人权原则为指导，尊重构成知识共享体系的语言文化多样性。以人为本的思路还要求，人工智能的应用必须确保透明度与可解释性，并建立人类控制与问责机制。

随着人工智能变得越来越复杂和广泛使用，一个关键的危险是它可能破坏人类的能动性

人工智能的发展可能损害人类智力技能的培养。虽然AI能挑战并拓展人类思维，但绝不能让其取代或替代批判性思考能力。因此，在设计人工智能课程和教育项目时，保护和增强人类自主权始终应是核心原则。人工智能认知框架（AI CFS）旨在帮助学生理解：AI可能收集的个人数据类型、用于训练AI模型的数据处理方式，以及数据生命周期对隐私保护和生活影响。该框架致力于激发学生作为个体的内在学习动力，在日益融入复杂AI系统的环境中强化其自主决策能力。

该框架提出的AI核心能力，还能引导学生理解人际互动的独特价值，以及人类创作的创意成果不应被AI替代。通过培养以人为核心的人机互动能力，该框架旨在防止学生对AI产生依赖或成瘾，并促进在重大决策中保持人类责任的行为模式。

2.3 鼓励环境可持续的人工智能

作为下一代人工智能技术的共同创造者和潜在领导者，学生们需要对以利润为导向的人工智能模型设计、训练和部署方式对环境造成的负面影响有一个批判性的理解。教育系统肩负着确保学生了解碳排放的责任，

analyse the root causes of climate change, and act judiciously to protect the climate and the environment.

In the race to produce increasingly powerful AI models, environmental sustainability is often considered to be of secondary importance. In some instances, it has even been intentionally obscured by claims that AI holds the promise of solving climate change. As global leaders and policy-makers work to consider regulations around the consumption of energy and the protection of the environment, it is imperative that students understand how the training of AI models is contributing to the destruction of the natural environment. Learning about AI should empower them to urgently explore more climate-friendly approaches to the design, training and use of AI models. The AI CFS attends to this by guiding students to design and implement project-based learning activities on the environmental impacts of AI use and training, prompting students to investigate potential solutions to mitigate these impacts.

2.4 Promoting inclusivity in AI competency development

Access to AI and AI competencies represent the two sides of citizens' basic rights in today's world. All students should have inclusive access to the environments required for learning about AI at the basic level, and they should be supported to learn how to embed the principle of inclusivity into the design of AI and be prepared to contribute to an inclusive AI society.

When defining AI competencies, school students should be provided with opportunities to understand and apply the principle of inclusivity across the AI life cycle. This covers the selection of representative data, the choice of bias-agnostic algorithms and anti-discrimination training methods, the design of accessible functionalities, testing for the inclusiveness of AI outputs, and impact assessment of the use of AI on social inclusion. With regard to AI system design, students can deepen their understanding and application skills to assess the needs of users with different abilities as well as those from diverse linguistic and cultural backgrounds.

In selecting the models and categories of technologies as vectors of AI-related teaching and learning, care is needed to avoid favouring certain demographics over others. When recommending specific AI tools for educational purposes, rigorous public validation mechanisms must be applied to avoid algorithms with bias(es) related to gender, ability, socio-economic status, language, ethnicity and/or culture. AI tools that are designed to support individuals with disabilities and promote linguistic and cultural diversity should be given priority. Where such validation mechanisms are unavailable, the recommendation of specific AI tools for use at scale should be avoided.

Turning to delivery of the curriculum, specific measures can be outlined to provide basic enabling conditions for the implementation of the AI CFS-based curriculum. While AI frameworks or educational programmes should be designed to be applicable to all students, including those who live in low-tech settings, engagement with AI without access to the internet and AI tools will limit the scope and mastery level of AI competencies. Governments should commit to promoting inclusive access to basic internet connectivity, updated digital devices, open-source or affordable AI

分析气候变化的根源，并采取明智的行动保护气候和环境。

在人工智能模型性能持续升级的竞赛中，环保可持续性常被视作次要考量。某些情况下，这种忽视甚至通过“AI有望解决气候变化”的宣传语被刻意淡化。当全球领导人和政策制定者着手制定能源消耗与环境保护法规时，学生必须认清AI模型训练如何加剧自然环境破坏。学习人工智能应当赋予他们探索气候友好型AI设计、训练及应用方法的紧迫感。CFS人工智能课程通过指导学生设计实践项目，开展AI应用与训练对环境影响的研究，并鼓励他们探索缓解这些影响的解决方案。

2.4 促进人工智能能力发展的包容性

在当今世界，接触人工智能及其相关技能，是公民基本权利的两个重要维度。所有学生都应享有平等获取基础人工智能学习环境的权利，并获得支持以掌握如何将包容性原则融入人工智能设计，从而为构建包容性人工智能社会做好准备。

在定义人工智能能力时，应为学生提供机会来理解和应用人工智能的包容性原则

人工智能的全生命周期管理。这包括选取具有代表性的数据样本、选择无偏算法与反歧视训练方法、设计无障碍功能、测试AI输出的包容性，以及评估人工智能在促进社会融合中的实际影响。在AI系统设计方面，学生可深化理解并提升应用技能，从而准确评估不同能力水平用户的需求，以及来自多元语言文化背景群体的特殊需求。

在选择作为人工智能教学载体的技术模型和类别时，必须谨慎行事以避免偏袒特定群体。推荐教育用途的人工智能工具时，必须建立严格的公众验证机制，避免使用存在性别、能力、社会经济地位、语言、种族或文化相关偏见的算法。应当优先选用那些旨在支持残障人士并促进语言文化多样性的AI工具。
在无法获得此类验证机制的情况下，应避免推荐特定AI工具的规模化使用。

在课程实施方面，我们可以制定具体措施为人工智能基础课程体系的构建奠定基础。虽然人工智能框架或教育项目应面向全体学生设计（包括身处技术资源匮乏地区的学生），但若学生无法接触互联网和人工智能工具，其学习参与度将受到限制，知识覆盖面和掌握水平也会大打折扣。
人工智能能力。政府应致力于促进基本互联网连接的包容性接入、更新数字设备、开源或负担得起的人工智能

programmes and software, and essential AI devices, with the support of academia or the private sector, where appropriate. Once again, these efforts must pay particular attention to students who have disabilities and/or are from linguistic or cultural minority groups.

2.5 Building core AI competencies for lifelong learning

AI-related teaching and learning should serve to build core AI competencies that allow students to accommodate new knowledge, as well as adapt to solving problems in new contexts with novel AI technologies. First and foremost, these core competencies must include values associated with an ethical and human-centred mindset. Students need guidance to progressively deepen their understanding of particular human rights – such as rights to equality, non-discrimination, privacy and plural expression – as well as their implications for varying forms of human–AI interaction. The competencies also reflect the need to understand controversies surrounding AI and the key ethical principles that guide regulation, as well as foster practical skills to combat bias, protect privacy, promote transparency and accountability, and adopt an ethics-by-design approach to the co-creation of AI.

The core competencies are brand-agnostic and product-agnostic, ensuring that students can appropriately engage with a range of tools, as well as with future iterations of AI technologies. It enables them to develop an age-appropriate and progressively deeper understanding of AI data, algorithms, models and system design. Students must be supported to construct this understanding by connecting AI concepts with real-world challenges to develop critical problem-solving skills. Students should be further encouraged to exploit their creativity in an effort to optimize existing AI models or co-create more meaningful AI. These core competencies constitute the foundation for further learning and more specialized use of AI in further education, work and life.

在学术界或私营部门的支持下，适当使用程序和软件，以及基本的人工智能设备。这些努力必须再次特别关注残疾学生和/或来自语言或文化少数群体的学生。

2.5 构建终身学习的核心人工智能能力学

人工智能相关的教学应当致力于培养核心素养，使学生既能接纳新知识，又能运用新型人工智能技术适应新情境下的问题解决。首要的是，这些核心素养必须包含与伦理和以人为本理念相关的核心价值。学生需要引导逐步深化对特定人权的理解——例如平等权、非歧视权、隐私权和多元表达权——以及这些权利对不同形式人机交互的影响。这些核心素养还体现了理解围绕人工智能的争议以及指导监管的关键伦理原则的必要性，以及培养应对偏见、保护隐私、促进透明度和问责制的实际技能，并采用“设计伦理”方法来共同创造人工智能。

核心能力具有品牌与产品无关的特性，确保学生能够熟练运用各类工具，并适应未来人工智能技术的迭代发展。这使他们能逐步建立符合年龄特征且不断深化的人工智能数据、算法、模型及系统设计认知体系。需要通过将AI概念与现实挑战相结合的方式，帮助学生构建这种理解，从而培养关键性问题解决能力。同时应鼓励学生发挥创造力，优化现有AI模型或共同开发更具价值的人工智能应用。这些核心能力为后续学习及在教育、工作和生活中更专业地运用人工智能奠定了基础。

Chapter 3: Structure of the AI competency framework for students

3.1 The framework

The AI CFS specifies twelve competency blocks based on a matrix of two dimensions. The first dimension comprises four interlinked aspects of AI competencies, while the second dimension includes three levels of progression or mastery that students are expected to engage with iteratively.

While the AI CFS anchors the definition of AI competency on three pillars that frame wider core competencies for students – namely, knowledge, skills and values – it also aims to encourage an ethical understanding of human-led methods underlying AI systems. Based on this conceptualization, the framework defines four essential constituent elements of students' AI competency: a human-centred mindset, ethics of AI, AI techniques and applications, and AI system design. These elements focus on fundamental values, social responsibilities to uphold ethical principles, foundational knowledge and skills, and higher-order thinking skills for system design. While different elements can be developed through domain-specific learning and pedagogical methodologies, AI competencies are ultimately a set of interdisciplinary, general abilities and value orientations that extend beyond particular AI domains or tools.

The first aspect positions students' competencies within a human-centred attitude towards the benefits and risks of AI. It also aims to foster a critical understanding of the proportionality[1] of specific AI tools for our human needs and for the sustainable development of the environment and ecosystems. Ethics of AI, the second aspect, encompasses the social and ethical components of students' AI competencies, including the social skills to navigate, understand, practise and contribute to the adaptation of a growing set of principles that regulate human behaviour throughout the entire life cycle of AI.

The third aspect, AI techniques and applications, represents an integrated view of the intrinsically linked conceptual knowledge on AI and associated operational skills, using selected AI tools and authentic tasks. The last aspect is AI system design, which covers comprehensive engineering skills that determine the problem scoping, architecture building, training, testing and optimization of AI systems. This aspect aims to challenge and enable students to gain a deeper understanding of AI systems and scaffold their exploratory learning for the pursuit of further study in the field of AI.

The second dimension of the framework outlines three levels of progression: Understand, Apply and Create, which are designed to reflect levels of mastery across all four aspects outlined above. They can be used to furnish AI curricula or programmes of study with a spiral learning sequence

第三章：AI能力结构学生框架

3.1 框架

AI CFS基于二维矩阵规定了12个能力模块。第一维度包含四个相互关联的人工智能能力方面，第二维度包含三个逐步提升或掌握的层次，学生需要反复参与其中。

虽然AI CFS将AI能力的定义锚定在三个支柱上，这些支柱为学生提供了更广泛的核心能力
——即知识、技能和价值观
该框架还致力于培养对人工智能系统背后人类主导方法的伦理认知。基于这一理念，框架明确了学生人工智能素养的四大核心要素：以人为本的思维方式、人工智能伦理观、AI技术与应用、以及AI系统设计。这些要素聚焦于基础价值观、践行伦理原则的社会责任、基础知识与技能，以及系统设计所需的高阶思维能力。尽管各要素可通过领域学习和教学方法进行培养，但人工智能素养本质上是一套跨学科的通用能力与价值取向，其适用范围超越特定AI领域或工具。

第一个方面将学生的能力置于以人为本的态度中，以了解人工智能的益处和风险。该课程还致力于培养对人工智能工具与人类需求及环境生态系统可持续发展[1]的比例关系的批判性认知。作为第二核心维度的人工智能伦理，着重培养学生在AI应用中应具备的社会素养与道德判断力，包括如何驾驭、理解、践行并推动适应日益增多的规范原则——这些原则将指导人类行为贯穿于人工智能全生命周期。

第三个方面是人工智能技术与应用，它通过精选AI工具和真实任务，将人工智能领域的核心概念知识与相关操作技能有机结合。最后一个方面是AI系统设计，涵盖确定问题范围、架构构建、训练测试及优化等关键工程技能。该部分旨在激发学生对AI系统的深入理解，并为其探索性学习搭建桥梁，助力他们在人工智能领域进一步深造。

框架的第二个维度概述了三个层次的进展：
理解、应用和创造，旨在反映上述四个方面的掌握水平。它们可用于为人工智能课程或学习计划提供螺旋式学习序列。

across grade levels, to assist students in progressively building a systematic and transferable schema of competencies.

The framework matrix cuts across the four aspects for the three levels of progression or mastery (see Table 1). At the intersection of these levels and aspects are twelve constituent blocks of AI competencies whose characteristics underpin the critical thinking, ethical examination, practical use and iterative co-creation of AI. These competency blocks should be understood as interlinked units for the framing of key components. Rather than considering them as fragmented and disparate topics to be learned in isolation, they can be connected and woven together as the operational organs of AI competency.

The matrix provides a blueprint for learning outcomes at a minimum level of mastery within a certain competency block. More specifically, the matrix is designed to guide: (1) the scoping of main AI-related focus areas and expected mastery levels, tailored to local AI readiness and available instructional time; (2) the identification of AI-related learning content that can be integrated across existing curricula, subject areas, and grade levels; (3) the definition of proficiency levels and the development of assessment criteria to assess students' general AI competencies and progression; and (4) the design and exploration of age-appropriate and domain-specific agile teaching and learning methodologies. Many of these factors will be vital to consider when a country, district or school localizes this framework; the selection of focus aspects and specification of the desired mastery levels, for instance, will depend on students' existing AI competencies, the training and skills of teachers, the availability of learning hours, and local AI readiness, including affordability and infrastructure.

Table 1. AI competency framework for students

Competency aspects	Progression levels		
	Understand	**Apply**	**Create**
• **Human-centred mindset**	• Human agency	• Human accountability	• Citizenship in the era of AI
• **Ethics of AI**	• Embodied ethics	• Safe and responsible use	• Ethics by design
• **AI techniques and applications**	• AI foundations	• Application skills	• Creating AI tools
• **AI system design**	• Problem scoping	• Architecture design	• Iteration and feedback loops

跨年级，以帮助学生逐步建立一个系统和可转移的能力模式。

框架矩阵贯穿三个进步或掌握层级的四个维度（见表1）。在这些层级与维度的交汇处，分布着十二个构成人工智能能力的核心模块，其特性支撑着人工智能的批判性思维、伦理审视、实际应用及迭代共创。这些能力模块应被理解为相互关联的整体单元，用以构建关键要素框架。
与其把它们视为孤立学习的零散和不同的主题，不如说它们可以相互联系、相互交织，成为人工智能能力的操作器官。

该矩阵为在特定能力模块中达到最低掌握水平的学习成果提供了蓝图。更具体地说，该矩阵旨在指导：

(1) 主要人工智能相关重点领域和预期掌握水平的范围，根据当地人工智能准备情况和可用教学时间量身定制；
(2) (3)明确人工智能相关学习内容的整合标准，这些内容可融入现有课程体系、学科领域及不同年级的教学；(4)制定能力分级标准并建立评估体系，用于衡量学生的人工智能综合能力及学习进度；(5)研发适龄且符合学科特点的敏捷教学方法。在将该框架应用于具体国家、地区或学校时，需重点考量这些要素：例如，教学重点的选择与目标掌握水平的设定，应结合学生的现有AI素养、教师的专业培训背景、课时资源分配，以及当地人工智能发展水平（包括资金投入和基础设施建设）来综合确定。

表1.学生人工智能能力框架

能力方面	进度等级		
	了解	申请	创建
• 以人为本的思维方式	• 人道主义机构	• 人类问责制	• 人工智能时代的公民身份
• 人工智能伦理	• 身体化伦理	• 安全和负责任的使用	• 设计中的伦理
• 人工智能技术及应用	• 人工智能基金会	• 应用技能	• 创建AI工具
• AI系统设计	• 问题范围界定	• 体系结构设计	• 迭代和反馈循环

3.2 Progression levels

The three levels reflect increasing sophistication, proficiency and ethical consciousness in using and co-creating AI technology. Students are expected to progress through them reciprocally. These levels, and the specifications of each competency block, can guide both the formative and summative evaluations of students' AI competencies, as well as inform the design of contextually relevant and agile pedagogical methodologies.

Level 1: Understand

This first level is designed for all students. All individuals are, or will be, interacting with some form of AI over the course of their lives. It is also true that AI providers have been mining and manipulating data from almost all internet users. All students must therefore develop the human-centred values, knowledge and skills needed to engage in a safe, informed and meaningful manner in their daily interaction with AI in various spheres of life.

At the 'Understand' level, students are expected to foster an understanding of what AI is and construct age-appropriate interpretations of the values, ethical issues, concepts, processes and technical methods underlying AI tools and their uses. They should be able to explain or exemplify their knowledge with connections to real-life or social practices and assimilate novel knowledge by integrating them into their own knowledge schemas.

This level of mastery provides the essential attitudinal, cognitive and practical foundations for the further study of AI. It does not define the exit-level competencies for specific areas or domains of AI overall.

Level 2: Apply

Given that the use of AI has permeated all sectors, as well as all aspects of life, including education and work, students at school should be prepared to become responsible, active and effective users of AI, both for the sake of their own individual interests, as well as to address shared sustainability challenges. The outcomes at the second level, 'Apply', are therefore relevant for all school students and can be used to tailor the scope, breadth and level of difficulty of thematic modules of a formal AI curriculum. Studying at this level requires students to have acquired a basic understanding of the human-centred approach and essential ethical principles for AI, as well as basic AI knowledge and application skills.

At the 'Apply' level, students are expected to enhance, transfer and adapt their learned values, knowledge and skills to new learning processes. They do so by addressing theoretical questions and/or practical tasks in more complex contexts, and by critically examining advanced technical methods behind AI tools. Upon achieving this level, students will have constructed a sound and transferable foundation of conceptual knowledge and associated AI skill-sets. They should also be able to apply the human-centred mindset and ethical perspective to the assessment, study and practical uses of AI tools.

3.2 进度等级

这三个层次反映了在使用和共同创造人工智能技术时，复杂程度、熟练程度和道德意识的提高。学生应该通过这些层次相互交流。

这些层次，以及每个能力块的规格，可以指导学生人工智能能力的形成性和总结性评价，也可以为设计与情境相关的、灵活的教学方法提供信息。

第1级：了解

这个初级阶段面向全体学生开放。每个人在成长过程中都会与人工智能产生互动，未来也将持续接触。事实上，AI服务提供商早已对几乎所有网民的数据进行采集和利用。因此，所有学生都必须培养以人类为中心的价值观、知识储备和技能，以便在日常生活中与人工智能的各类互动中，能够安全、明智且富有意义地参与其中。

在“理解”层面，学生需要掌握人工智能的基本概念，并能根据年龄特点对支撑AI工具及其应用的价值观、伦理问题、核心原理、运行机制和技术方法形成科学认知。他们应当能够结合现实生活或社会实践来阐释或举例说明所学知识，并通过整合新知识到自身认知框架中实现知识内化。

这一层次的掌握为人工智能的进一步学习提供了必要的态度、认知和实践基础，但并没有定义人工智能整体上特定领域或领域的退出水平能力。

级别2：应用

鉴于人工智能已渗透到各行各业及教育、工作等生活的方方面面，学生们应当主动成为负责任、积极主动且高效的AI使用者——这既是为了个人发展，也是为了应对共同的可持续发展挑战。因此，第二层级“应用”阶段的教学成果对全体学生都具有指导意义，可作为调整正式AI课程主题模块范围、广度及难度的依据。要达到这一层级的学习目标，学生需掌握以人类为中心的人工智能方法论基础，理解核心伦理原则，并具备基本的人工智能知识与应用技能。

在“应用型”阶段，学生需要将所学价值观、知识和技能进行深化、迁移与创新应用，将其融入新的学习场景。具体而言，他们需在更复杂的环境中解决理论问题或实践任务，并深入剖析人工智能工具背后的技术原理。完成该阶段后，学生将构建起扎实且可迁移的概念知识体系与AI技能组合，同时具备运用以人为本的思维模式和伦理视角，对人工智能工具进行评估、研究及实际应用的能力。

Students at this level may progress to the third, more specialized level, Create. However, it is possible that some students will not have a strong interest in AI, or will lack sufficient time or opportunities to finetune their AI competencies within the formal learning environment at school. For many, 'Apply' at Level 2 will be the point of exit for their AI-related competency development, at least at school.

Level 3: Create

The exponential pace of innovation within the AI sector means that technology providers are defining the terms of the transformation of our societies. Developing critical AI competencies is critical to ensuring that the design, deployment and use of AI responds to the needs of users and benefits the public. School students should be prepared to create trustable AI tools and to take a leading role in the definition and design of the next generation of AI technologies. At the 'Create' level, students are expected to become conscientious AI co-creators, developing human-centred solutions to positively impact the design and use of AI. Study at this level requires the integrated application of the acquired values, knowledge and skills on AI to design, implement and test AI solutions that can help address real-world challenges.

Students will critically leverage their knowledge and skills on data, algorithms and ethical design; actively craft AI applications; and deliberate on the adaptation of AI regulations.

At the 'Create' level, students are expected to reinforce their interest in AI innovation and develop new AI tools based on open-source and/or customizable datasets, programming tools or AI models. Throughout the iterative process of customizing and testing AI technologies, students are expected to reinforce the sense of being an AI co-creator and belonging within a broader community, helping to lead the human-centred design and use of AI. At this level, students are also expected to enhance their capacity to critically assess the social implications of AI and to personalize the responsibilities of being a citizen in AI-driven societies.

Learning at the 'Create' level also aims to foster students' creative problem-solving skills and a proactive attitude to advocating for ethical AI practices. Meeting the requirements of this level in full will require sufficient allocation of learning time and space within the curriculum (e.g. an entire semester or multiple semesters). The learning programme must also provide the necessary AI resources and facilitate age-appropriate innovative pedagogical methodologies. For students who do not have a strong interest in pursuing deeper study in the field, the learning outcomes at this level, in particular under the 'AI system design' aspect, should be offered as elective programmes rather than as compulsory requirements for all students.

3.3 Aspects

The four aspects specify the essential constituent elements of AI competencies that students need to build and continuously update in order to become responsible users and active co-creators of AI, and potential leaders in defining and developing next generations of AI.

这个级别的学生可以继续学习第三个更专业的级别，Create。
不过，有些学生可能对人工智能不感兴趣，或者缺乏足够的时间和机会在学校正规学习环境中完善自己的AI能力。对很多人来说，二级考试的“应用”部分将是他们在学校里AI相关能力发展的终点站。

第3级：创建

人工智能领域的创新速度呈指数级增长，这意味着技术供应商正在定义我们社会转型的条件。培养关键的人工智能能力对于确保人工智能的设计、部署和使用至关重要。
人工智能既满足用户需求又造福社会。在校学生应当做好准备，开发值得信赖的人工智能工具，并在下一代人工智能技术的定义与设计中发挥引领作用。在“创造”层面，学生需要成为负责任的人工智能共创者，开发以人为本的解决方案，积极影响人工智能的设计与应用。这一阶段的学习要求将已掌握的人工智能价值观、知识与技能融会贯通，设计、实施并测试能够应对现实挑战的人工智能解决方案。

学生将批判性地利用他们在数据、算法和道德设计方面的知识和技能；积极地设计人工智能应用程序；并考虑人工智能法规的适应性。

在“创建”层面，学生应该能够强化他们对人工智能创新的兴趣，并基于开源和/或可定制数据集开发新的人工智能工具，编程

在定制和测试人工智能技术的迭代过程中，学生需要强化作为AI共同创造者的身份认同感，并融入更广泛的人文社群。通过这一过程，他们将引领以人类为中心的人工智能设计与应用方向。在此阶段，学生还需提升批判性评估人工智能社会影响的能力，并在AI驱动的社会中明确自身公民责任的个性化实践。

在“创造”层级开展教学，旨在培养学生的创新性问题解决能力，以及倡导符合伦理的人工智能实践的积极态度。要全面满足该层级的教学要求，需要在课程中合理安排充足的学习时间和空间（例如：
整个学期或多个学期)。
课程体系还应配备必要的AI资源，并推动适龄创新教学模式的发展。对于对人工智能领域深造兴趣不大的学生，该阶段的学习成果——特别是“AI系统设计”模块——应当作为选修课程设置，而非强制要求所有学生必须完成。

3.3 方面

这四个方面明确了学生需要构建和不断更新的人工智能能力的基本组成要素，以成为负责任的用户和积极的共同创造者，并在定义和发展下一代人工智能方面成为潜在的领导者。

Human-centred mindset

Competency aspects	Progression levels		
	Understand	**Apply**	**Create**
• **Human-centred mindset**	• Human agency	• Human accountability	• Citizenship in the era of AI

The 'Human-centred mindset' aspect focuses on students' values, beliefs and critical thinking skills, applied to the examination of whether AI is fit for purpose, whether its use is justified, how humans should interact with it, and what responsibilities individuals and institutions should take on to contribute to the building of safe, inclusive and just AI societies. A human-centred mindset lays the foundation for further engagement with all aspects of AI. The full expression of this aspect also encompasses human identities in relation with AI, assuming social and civic responsibilities, and the pursuit or deepening of personal interests in the AI era. The values and skills that this aspect is intended to nurture can be characterized by the following three competency blocks:

Human agency: Students are expected to be able to recognize that AI is human-led and that the decisions of AI creators influence the way in which AI systems impact human rights, human–AI interaction, as well as their own lives and societies. They are expected to understand the implications of protecting human agency throughout the design, provision and use of AI. Students will understand what it means for AI to be human-controlled, and what the consequences might be when this is not the case.

Human accountability: Students are expected to recognize that human accountabilities are the legal obligations of AI creators and AI service providers, and to understand what human accountabilities they should assume during the design and use of AI. They should also develop an awareness that human accountability is a legal and social responsibility when using AI to assist in decision-making, and that human choice should not be ceded to AI when making high-stakes decisions.

Citizenship in the AI era: Students are expected to critically understand the impact of AI on human societies and to promote responsible and inclusive design and use of AI for sustainable development. They should have an awareness of their civic and social responsibility as citizens in the era of AI. Students are also expected to develop a desire to continue learning about, and using, AI throughout their lives to support self-actualization.

以人为本的思维方式

能力方面	进度等级		
	了解	申请	创建
• 以人为本的思维方式	• 人道主义机构	• 人类问责制	• 人工智能时代的公民身份

“以人为本的思维模式”这一维度着重培养学生的价值观、信念体系及批判性思维能力，旨在探讨人工智能是否具备适用性、其应用是否合理、人类应如何与其互动，以及个人与机构应承担何种责任以共同构建安全、包容且公正的人工智能社会。这种以人为本的思维方式为深入参与人工智能各领域奠定了基础。该维度的完整内涵还包含人类在人工智能时代与之关联的身份认同、承担社会责任及公民义务，以及在人工智能时代追求或深化个人兴趣的实践。这一维度旨在培养的价值观与技能可归纳为以下三大核心能力模块：

人类行为：学生应该能够认识到人工智能是由人类主导的，人工智能创造者的决定影响着人工智能系统对人权、人与人工智能的互动以及他们自己的生活和社会的影响。
他们将理解在人工智能的设计、提供和使用过程中保护人类能动性的意义。学生将理解人类控制人工智能意味着什么，以及当这种情况不发生时可能产生的后果。

人类责任：学生需要认识到，人类责任是人工智能开发者和AI服务提供商的法定义务，并理解在设计和使用AI过程中应当承担哪些人类责任。同时应培养这样的认知：当使用AI辅助决策时，人类责任既是法律义务也是社会责任；在涉及重大决策时，人类的选择权不应被完全让渡给AI。

人工智能时代的公民意识：学生需要深刻理解人工智能对人类社会的影响，并推动其以负责任且包容的方式设计和应用，从而促进可持续发展。他们应当意识到，在这个AI时代作为公民应承担的公民责任和社会义务。同时，学生还需培养终身学习和运用人工智能的热情，以此助力自我实现。

Ethics of AI

Competency aspects	Progression levels		
	Understand	**Apply**	**Create**
• Ethics of AI	• Embodied ethics	• Safe and responsible use	• Ethics by design

The 'Ethics of AI' aspect represents the ethical value judgements, embodied reflections, and social and emotional skills students require to navigate, understand, practise and contribute to the adaptation of a growing set of principles and regulatory rules relative to the entire life cycle of AI systems. Students are expected to understand and apply knowledge on the governance of ethics at the intersection of global implications and local contexts. As the rapid iterations of AI are triggering more profound controversies, the scope of the ethics of AI is expanding, and new regulations, laws and rules are being adopted. The three competency blocks for this aspect outline key steps for students to gradually internalize ethical principles as well as habituate compliance with AI regulations.

Embodied ethics: Students are expected to develop a basic understanding of the issues underlying key ethical debates around AI, including the impact of AI on human rights, social justice, inclusion, equity and climate change within their local context and personal lives. They will have understood, internalized, and adopted the following principles in their reflective practices and uses of AI tools in their learning and beyond:

- **Do no harm:** Students demonstrate an understanding that AI systems should not be used for purposes that might be harmful for humans (such as facial recognition for surveillance or assigning social status, or predictive algorithms for grading examinations). This includes the ability to assess whether a certain AI solution infringes upon human values and rights, particularly data privacy, and to decide on whether a particular AI method complies with global or local regulations.
- **Proportionality:** Students develop the capacity – as appropriate for their age and ability level – to examine whether or not the use of a specific AI system is advantageous in achieving a justified aim, and whether or not a given AI method is appropriate to the context.
- **Non-discrimination:** Students are aware of and are able to detect gender, ethnic, cultural and other biases embedded in AI tools or their outputs. Further, students are aware of AI divides within and between countries, and understand the need to make efforts to address these and ensure greater accessibility and inclusivity.
- **Sustainability:** Students are able to explain and illustrate the implications of AI systems for environmental sustainability.

人工智能伦理

能力方面	进度等级		
	了解	申请	创建
• 人工智能伦理	• 身体化伦理	• 安全和负责任的使用	• 设计中的伦理

“人工智能伦理”模块旨在培养学生在应对、理解、实践及推动适应人工智能系统全生命周期相关原则与监管规则时所需的道德价值判断、内化反思能力以及社会情感能力。学生需掌握全球影响与本土情境交汇处的伦理治理知识并能灵活运用。随着人工智能快速迭代引发的争议日益深化，其伦理范畴持续扩展，相关法规体系也在不断更新完善。该模块的三大核心能力板块，为学生逐步内化伦理准则及养成遵守人工智能法规的习惯提供了关键路径。

身临其境的伦理学：学生需在本地环境和个人生活中，对人工智能引发的核心伦理争议建立基本认知，包括其对人权、社会公正、包容性、公平性及气候变化的影响。通过反思实践和学习应用，学生应内化并践行以下原则——这些准则不仅适用于人工智能工具的教学场景，更延伸至日常生活的方方面面：

- **不要伤害：**学生们展示了对人工智能系统的理解，即不应该使用可能对人类有害的目的(如用于监控的人脸识别或分配社会地位，或用于考试评分的预测算法）。这包括评估某种人工智能解决方案是否侵犯人类价值观和权利，特别是数据隐私，并判断特定人工智能方法是否符合全球或地方法规。
- **成比例性：**学生发展能力——根据其年龄和能力水平——检查使用特定AI系统是否有利于实现合理的目标，以及给定的AI方法是否适合于上下文。
- **不歧视：**学生了解并能够察觉嵌入在AI工具或其输出中的性别、种族、文化及其他偏见。此外，学生还了解国家内部和国家之间的AI鸿沟，并理解需要努力解决这些问题，以确保更大的可及性和包容性。
- **可持续性：**学生能够解释和说明人工智能系统对环境可持续性的影响。

- **Human determination in human–AI collaboration:** Students are able to demonstrate why humans should bear ethical and legal responsibilities for the use of AI; they are able to exemplify how humans can remain accountable in AI-assisted decision-making loops, rather than cede determination to machines.
- **Transparency and explainability:** Students are aware that users are entitled to request explanatory information from designers and providers on how AI tools work, how their outputs are produced based on algorithms and models, and the degree to which the deployment and application of certain AI tools are appropriate for users of a certain age or ability level.
- **Safe and responsible use:** Students are expected to be able to use AI in a responsible manner in compliance with ethical principles and locally applicable regulations. They are aware of the risks of disclosing data privacy and they take measures to ensure that their data are collected, used, shared, archived and deleted only with their deliberate and informed consent. They are also aware of the specific risks of certain AI systems, and are able to protect their own safety, as well as that of their peers, when using AI.
- **Ethics by design:** Students are expected to adopt an ethics-by-design approach to the design, assessment and use of AI tools, as well as to the review and adaptation of AI regulations. Students are aware that assessing the intent behind AI design involves examining all steps of the AI life cycle, starting with the stage of conceptualization. Students should be able to assess the compliance of an AI tool with ethical regulations, as well as review AI regulations and inform adaptation.

AI techniques and applications

Competency aspects	Progression levels		
	Understand	**Apply**	**Create**
• AI techniques and applications	• AI foundations	• Application skills	• Creating AI tools

The 'AI techniques and applications' aspect represents the intrinsically linked conceptual knowledge on AI and associated operational skills, in connection with concrete AI tools or authentic tasks. This aspect serves as the most important and transferable technical foundation for a concrete understanding and application of a human-centred mindset and its associated ethical principles. The basic knowledge structure and practical skills on data and AI programming is the foundation for the capacity to design and build AI systems, especially for students who have strong interests and abilities in the field. The 'AI techniques and applications' aspect implies

- **人类与人工智能协作中的人类决心：**学生能够证明为什么人类应该承担使用人工智能的道德和法律责任；他们能够举例说明人类如何在人工智能辅助的决策循环中保持问责，而不是将决心让给机器。
- **透明度和可解释性：**学生们知道，用户有权要求设计师和提供者解释人工智能工具是如何工作的，他们的输出是如何基于算法和模型产生的，以及某些人工智能工具的部署和应用在多大程度上适合特定年龄或能力水平的用户。
- **安全和负责任的使用：**学生应该能够以负责任的方式使用人工智能，遵守道德原则和当地适用的法规。他们知道关于披露数据隐私的风险，他们采取措施确保他们的数据收集、使用、共享、归档和删除只有在他们的深思熟虑和知情同意下。他们还意识到某些人工智能系统的特定风险，并能够在使用人工智能时保护自己和同伴的安全。
- **“伦理设计”理念：**学生在设计、评估和使用人工智能工具时，以及在审查和调整人工智能法规时，应秉持“伦理设计”原则。学生需明确，评估人工智能设计初衷的关键在于审视其全生命周期的每个阶段，从概念化阶段开始。学生应能判断人工智能工具是否符合伦理规范，同时具备审查现行人工智能法规并推动其改进的实践能力。

人工智能技术及应用

能力方面	进度等级		
	了解	申请	创建
• 人工智能技术及应用	• 人工智能基金会	• 应用技能	• 创建人工智能工具

“人工智能技术与应用”这一维度，涵盖了与具体AI工具或真实任务紧密关联的人工智能概念知识及操作技能。该维度作为最重要的技术基础，为实际理解和应用提供了可迁移的支撑体系。

以人类为中心的思维方式及其相关伦理原则。数据与人工智能编程的基础知识结构和实践技能是设计和构建AI系统能力的基石，尤其对于对该领域有浓厚兴趣且具备相应能力的学生而言。“AI技术与应用”这一维度则意味着

that students are expected to look into exemplar AI tools to gain insight on how AI is developed, based on data and algorithms. Students will synchronically acquire skills in AI programming and reinforce the transferability of their knowledge and skills by applying them to the crafting of AI tools. In the stream of the three progression levels, students are also expected to integrate ethical, cultural and social parameters, and solidify the interdisciplinary foundational knowledge and skills in science, technology, engineering, mathematics, arts, languages and social studies.

AI foundations: Students are expected to be able to build basic knowledge and skills on AI, particularly with respect to data and algorithms, understanding the importance of the interdisciplinary foundational knowledge required to gradually deepen understanding of data and algorithms. Students should also be able to connect conceptual knowledge on AI with their activities in society and daily life, concretizing a human-centred mindset and ethical principles by understanding how AI works and how AI interacts with humans.

Application skills: Students are expected to be able to construct an age-appropriate understanding of data, AI algorithms and programming, as well as acquire transferable application skills. Students are expected to be able to critically evaluate and leverage free and/or open-source AI tools, programming libraries and datasets.

Creating AI tools: Students are expected to be able to deepen and apply knowledge and skills on data and algorithms to customize existing AI toolkits to create task-based AI tools. Students are expected to integrate their human-centred mindset and ethical considerations into the assessment of existing AI resources. They are also expected to develop the social and emotional skills needed to engage in creating with AI, including through adaptivity, complex communication and teamwork skills.

AI system design

Competency aspects	Progression levels		
	Understand	Apply	Create
• AI system design	• Problem scoping	• Architecture design	• Iteration and feedback loops

The aspect of 'AI system design' focuses on the systemic design thinking and comprehensive engineering skills required for problem scoping, design, architecture building, training, testing and optimization of AI systems. This aspect aims to challenge the explainability of AI systems and to enable exploratory learning for students who will pursue further programmes of study in the field. Students are also expected to deepen and practise 'ethics by design'. Although the systemic design thinking methodology, associated human-centred values and ethical principles, and required knowledge and skills on AI may be embedded in all other aspects of students' AI competencies, this aspect mainly targets students who have a

学生需要深入研究典型的人工智能工具，通过数据与算法的分析，深入了解AI技术的开发原理。在同步学习过程中，学生将掌握人工智能编程技能，并通过实际应用这些知识来提升知识迁移能力。在三个进阶阶段的衔接中，学生还需融入伦理、文化和社会维度的考量，同时夯实科学、技术、工程、数学、艺术、语言及社会科学等跨学科领域的基础知识与实践技能。

人工智能基础：学生应能构建人工智能的基础知识和技能，尤其在数据与算法方面，理解跨学科基础理论的重要性，从而逐步深化对数据与算法的理解。学生还应能将人工智能的概念知识与自身在社会和日常生活中的活动联系起来。

通过了解人工智能的工作方式以及人工智能与人类的互动方式，将以人为本的思维模式和道德原则具体化。

应用技能：学生应能够构建与年龄相符的数据、AI算法和编程的理解，并获得可转移的应用技能。学生应能够批判性地评估和利用免费和/或开源的AI工具、编程库和数据集。

开发AI工具：学生需要深化并运用数据与算法领域的知识技能，对现有AI工具包进行定制化改造，开发任务导向型AI工具。在评估现有AI资源时，需融入以人为本的思维方式和伦理考量。同时，学生还需培养参与AI创作所需的社会情感能力，包括适应性调整、复杂沟通以及团队协作等核心素养。

AI系统设计

能力方面	进度等级		
	了解	申请	创建
• AI系统设计	• 问题范围界定	• 体系结构设计	• 迭代和反馈循环

“AI系统设计”方向着重培养系统性设计思维与综合工程能力，涵盖人工智能系统的任务界定、架构设计、训练测试及优化等全流程环节。该方向旨在突破AI系统的可解释性限制，为有志于继续深造的学生提供探索性学习平台，助力其在专业领域开拓创新。

在实践领域，学生还需深入学习并践行“设计伦理”。虽然系统性设计思维方法论、以人为本的价值观与伦理准则，以及人工智能领域的必备知识技能，可能已融入学生AI能力培养的其他维度，但本模块主要针对已具备...

particular interest in, and commitment to, deepening their knowledge and skills in this field.

Problem scoping: Students are expected to be able to understand the importance of 'AI problem scoping' as the starting point for AI innovation. They are expected to be able to examine whether AI should be used in particular situations, from a legal, ethical and logical perspective; and to define the boundaries, goals and constraints of a problem before attempting to train an AI model to solve it. Students are also expected to acquire the knowledge and project-planning skills needed in order to conceptualize and construct an AI system, including the ability to assess the appropriateness of different AI techniques, define the need for data, and devise test and feedback metrics.

Architecture design: Students are expected to be able to cultivate basic methodological knowledge and technical skills to configure a scalable, maintainable and reusable architecture for an AI system covering layers of data, algorithms, models and application interfaces. Students are expected to develop the interdisciplinary skills necessary to leverage datasets, programming tools and computational resources to construct a prototype AI system. This includes the expectation that they apply deepened human-centred values and ethical principles in their configuration, construction and optimization.

Iteration and feedback: Students are expected to enhance and apply their interdisciplinary knowledge and practical methods to evaluate the appropriateness and methodological robustness of an AI model and its impact on individual users, societies and the environment. They should be able to acquire age-appropriate technical skills to improve the quality of datasets, reconfigure algorithms and enhance architectures in response to results of tests and feedback. They should be able to apply a human-centred mindset and ethical principles in simulating decision-making on when an AI system should be shut down and how its negative impact can be mitigated. They are also be expected to cultivate their identities as co-creators within the wider AI community.

对深化他们在这一领域的知识和技能特别感兴趣，并致力于此。

问题界定能力：学生需掌握“人工智能问题界定”作为创新起点的重要性。他们需要从法律、伦理和逻辑角度分析特定情境下是否应使用人工智能，并在训练AI模型前明确问题边界、目标及限制条件。此外，学生还需掌握构建AI系统所需的知识储备与项目规划能力，包括评估不同AI技术适用性、确定数据需求以及制定测试反馈指标等核心技能。

架构设计：本课程要求学生掌握构建可扩展、可维护、可复用的AI系统架构的基础方法论知识和技术技能，涵盖数据层、算法层、模型层和应用接口层。要求学生能够开发需要跨学科能力，以利用数据集、编程工具和计算资源构建原型AI系统。这包括期望他们在配置、构建和优化过程中应用深化的人本价值观和道德原则。

实践与反馈：学生需运用跨学科知识和实践方法，评估人工智能模型的适用性及方法论稳健性，并分析其对个人用户、社会及环境的影响。他们应掌握符合年龄特征的技术技能，通过测试反馈优化数据集质量、调整算法参数、改进架构设计。在模拟决策过程中，需秉持人文关怀理念与伦理准则，明确人工智能系统何时应终止运行，并制定缓解其负面影响的策略。同时，学生应培养作为AI领域共同创造者的身份认同。

Chapter 4: Specifications of AI competencies for students

The following specifications of the AI CFS clarify what each competency block entails in terms of curricular goals, desirable pedagogical methods and required learning environments, with consideration given to inclusivity as well as variation in levels of AI readiness.

The specifications outlined below are based on the assumption that students' AI competencies are the result of the integrated interventions of national AI curricula; extracurricular programmes; informal learning through various media, including the internet; and engagement with families and local communities. To guide the development of an AI curriculum, the AI CFS specifies the expected learning and behavioural outcomes of a formal AI curriculum while considering the impact of informal learning in social contexts. AI-related learning – introduced into curricula as a specific subject, or as modules within related disciplines, such as computer science or information and communication technology (ICT) – should be allocated adequate instructional time within a semester, or preferably, across multiple semesters.

The specified curricular goals outline domain-specific values, knowledge and skills that can be applied to students at a range of ages and ability levels, who are exposed to AI-related learning for the first time. It is up to national or institutional curriculum agencies to define concrete learning objectives for specific student cohorts, based on their AI readiness and that of their teachers, available instructional time and local learning environments. The specifications include recommendations for configuring these environments in line with the curricular goals, with regard to inclusivity, the potential of open-source options, and the sharing of AI resources with academic institutes and the private sector.

Finally, the specifications also propose pedagogical methodologies for specific domains of AI at a certain progression level. These may inspire teachers and students to explore agile methods of delivery that are relevant for specific contexts and needs.

4.1 Level 1: Understand

The overall goal of this level is to support all students to acquire an understanding of what AI is and to construct age-appropriate interpretations of the values, ethical issues, concepts, processes and technical methods underlying AI tools and their uses. Students should also be supported to make connections between their knowledge of AI and real-life experiences, and between domain-specific knowledge of AI and knowledge of related learning areas.

The curricular goals outlined in **Table 2** help to map the set of foundational values, ethical principles, knowledge and understanding that can ensure the proper and effective use of AI by students – an ability sometimes referred to as 'AI literacy'. The suggested pedagogical methods are designed to

第四章：人工智能能力规范为学生

以下AI CFS规范明确了每个能力块在课程目标、理想教学方法和所需学习环境方面的含义，并考虑了包容性以及AI就绪水平的差异。

以下规格说明基于以下假设：学生的AI能力是国家AI课程体系、课外项目、通过互联网等各类媒介进行的非正式学习，以及与家庭和社区互动共同作用的结果。为指导AI课程开发，AI课程标准（CFS）在考虑社会情境中非正式学习影响的同时，明确了正规AI课程应达到的预期学习成果与行为目标。无论是作为独立学科还是计算机科学、信息通信技术（ICT）等相关学科中的模块引入课程体系，AI相关学习都应在每学期合理分配教学时间，最好能跨多个课时进行。
学期

课程目标明确规定了不同年龄段和不同能力水平的学生在首次接触人工智能相关学习时，可应用的领域特定价值观、知识和技能。具体学习目标由国家或机构课程管理机构根据学生特点制定。

该计划根据各机构及其教师的人工智能准备程度、可用教学时间及本地学习环境进行分类。具体要求包括：根据课程目标配置教学环境，涉及包容性设计、开源解决方案的应用潜力，以及与学术机构和私营部门共享人工智能资源等建议。

最后，该规范还针对特定人工智能领域的不同进度阶段提出了教学方法。这些方法可以启发教师和学生探索与特定情境和需求相关的敏捷教学方法。

4.1 第1级：了解

本课程层级的总体目标是帮助全体学生理解人工智能的本质，并构建符合年龄特征的认知框架，深入理解支撑AI工具及其应用的价值观、伦理问题、核心概念、运作流程和技术方法。同时，应引导学生建立AI知识与现实经验之间的关联，促进AI专业领域知识与相关学科知识的有机融合。

表2中概述的课程目标有助于绘制出基础价值观、道德原则、知识和理解的集合，以确保学生正确有效地使用人工智能——这种能力有时被称为“人工智能素养”。建议的教学方法旨在

facilitate age- and domain-appropriate teaching and learning practices that can potentially stimulate students' interests and support their learning trajectory on the basis of concrete tools, personal experiences, and real-world use scenarios. The specifications also recommend basic learning settings, which include practising with unplugged and low-tech options.

促进适合年龄和领域的教学和学习实践，这些实践可能激发学生的兴趣，并支持他们的学习轨迹
具体的工具，个人的经历，以及实际使用场景。规范还推荐基本的学习设置，其中包括练习不插电和低技术选项。

Table 2. Competency blocks for level 1: Understand

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
Human-centred mindset	**4.1.1 Human agency** • Students are expected to be able to recognize that AI is human-led and that the decisions of the AI creators influence how AI systems impact human rights, human–AI interaction, and their own lives and societies. They are expected to understand the implications of protecting human agency throughout the design, provision and use of AI. Students will understand what it means for AI to be human-controlled, and what the consequences could be when that is not the case.	• **CG4.1.1.1 Foster an understanding that AI is human-led:** Based on selected AI tools, explain to students that AI is human-led; facilitate students to develop a stepwise and integral comprehension of human agency which may cover principles on data ownership and data privacy, protection of human rights in collecting and processing data, explainability of AI methods, human control in deployment, and human determination in using AI for decision-making. Guide students to understand that AI cannot replace human thinking or intellectual development. • **CG4.1.1.2 Facilitate an understanding on the necessity of exercising sufficient human control over AI:** Expose students to real-world scenarios and guide students to experience the consequences of human oversight in controlling AI (e.g. weak regulations failing to prevent the design and production of harmful AI tools, the institutional use of AI to substitute for humans when making high-stakes decisions, and the absence of human validation of the accuracy of AI outputs). Help students to grasp the necessity of exercising human control over AI	• **Visualizing the abstract concept of human agency throughout the AI life cycle:** Ask students to draw concept maps of human agency in key steps of the life cycle of selected AI tools, including data ownership, respecting data privacy when collecting and processing data, explainability of AI algorithms and AI models, human-controlled evaluation of AI outputs, and human determination in AI-assisted decision-making. The concept maps should also reflect on the potential consequences of a loss of human agency at each step, for the individual and for society. • **Simulating an AI Act courtroom debate to evaluate creators' intents underlying prohibited AI systems:** Based on an age-appropriate interpretation of the definition of AI systems prohibited under the European Union's AI Act, organize students to act as jury members to evaluate selected examples of AI systems that are due to be prohibited under the AI Act, deliberating on what their creators' intents and motivations may have been. Help students understand how these systems can do harm to humans, especially by undermining human agency: for example, an	• Unplugged learning settings like paper-based articles, printed reading materials and worksheets. • Locally available AI tools including mobile phones with AI applications. • Predownloaded or recorded videos and other resources related to specific case studies, or scenarios that present a dilemma. • Search engines, online videos and supplemental online learning courses.

表2.第一级：理解的能力模块

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
人 位于中心的观念模式	**4.1.1 人道主义机构** • 学生需要理解人工智能本质上是人类主导的，其创造者的选择将直接影响系统对人权、人机交互以及自身生活与社会的影响。他们应当掌握在人工智能的设计、开发和应用过程中保障人类自主权的关键要素。通过学习，学生将深刻理解人类控制人工智能的本质特征，并预见当这种控制权缺失时可能引发的连锁反应。	• **CG 4.1.1.1 培养对人工智能人类主导认知：**通过精选AI工具实例，向学生阐释人工智能始终由人类主导。引导学生系统掌握人类能动性全链条理解，涵盖数据所有权与隐私保护原则、数据收集处理中的人权保障、AI方法可解释性、部署阶段的人类管控，以及决策过程中人类的判断权等核心要素。帮助学生理解：人工智能无法替代人类思维或智力发展。 • **CG 4.1.1.2 帮助学生理解对人工智能实施充分人类管控的必要性：**通过真实案例教学，引导学生体验人类监管缺失对AI发展的负面影响（例如监管漏洞导致有害AI工具设计生产、机构用AI替代人力进行高风险决策、以及AI输出结果未经人工验证）。帮助学生深刻认识到在人工智能领域实施人类管控的紧迫性。	• **在人工智能全生命周期中具象化人类能动性的抽象概念：**要求学生绘制人工智能工具关键发展阶段的人类能动性概念图，涵盖数据所有权、数据收集处理中的隐私保护、AI算法模型的可解释性、人工审核AI输出结果以及AI辅助决策中的人为判定等核心环节。概念图需深入剖析每个阶段丧失人类能动性可能对个人和社会造成的潜在影响。 • **通过模拟《人工智能法案》法庭辩论评估AI系统开发者意图：**根据欧盟《人工智能法案》对禁止类AI系统的年龄适宜解释，组织学生扮演陪审团成员，对即将被法案禁止的特定AI系统案例进行评估，探讨其开发者可能存在的意图与动机。帮助学生理解这些系统如何危害人类，特别是通过削弱人类自主权的方式：例如，	• 不插电的学习环境，如纸质文章、印刷阅读材料和工作表。 • 本地可用的AI工具，包括带有AI应用程序的手机。 • 预下载或录制的视频和其他与特定案例研究相关的资源，或呈现困境的场景。 • 搜索引擎、在线视频和补充在线学习 课程

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
Human-centred mindset		systems at regulatory, institutional and individual levels to protect human safety, morality and dignity. • **CG4.1.1.3 Nurture critical thinking on the dynamic relationship between human agency and machine agency:** Expose students to real-world cases in which AI can support human agency and human decision loops, support students to understand how humans can properly interact with AI to enhance human capacities. Guide students in holding conflict-based debates on dynamic boundaries between human agency and AI agency, revealing situations in which a certain extent of machine agency might be needed (e.g. detecting medical patterns that are undetectable for human doctors in diagnosing rare diseases, auto spell check and autocorrection when humans draft reports, auto captioning or automating video-production in the development of course materials, automatic language translation, etc.). Foster a critical view that while human agency must be upheld when using AI to make high-stakes decisions, the relationship between human and machine agency in real-world situations should be examined based on the specific needs and contextual factors involved.	AI system may deploy techniques to weaken a person's awareness or purposefully impair their ability to make an informed decision. • **Scenario-based understanding of human-controlled interaction with AI:** Select examples or scenarios in which AI tools are used in workplaces or daily life, denoting what they and their human users are contributing to the target task units. Encourage students to recognize the contribution AI can make in scenarios where human capabilities and intelligence may have limitations, underlining the importance of using AI to enhance human capacities while ensuring human control. • **Debating the dynamic boundary between human agency and machine agency:** Based on the real-world cases of dilemmas surrounding humans' reliance on machine agency, encourage students to conduct a debate on the changing roles humans and AI may play in AI-supported problem-solving and decision-making processes. Guide student to visualize the abstract boundaries between human agency and machine agency in various contexts.	

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
人 位于中心的观念模式		在监管、制度和个人层面的系统，以保护人类的安全、道德和尊严。 • **CG 4.1.1.3 培养对人类能动性与机器能动性动态关系的批判性思维：**通过真实案例引导学生理解人工智能如何支持人类能动性及决策循环，帮助学生掌握正确运用AI以提升人类能力的方法。组织学生围绕人类能动性与AI能动性之间的动态边界展开辩论，揭示需要适当运用机器能动性的场景（例如：在罕见病诊断中检测人类医生无法识别的医疗模式、人工撰写报告时的自动拼写检查与修正、课程开发中的视频制作自动化字幕生成或视频制作、自动语言翻译等）。培养批判性认知——在使用AI进行高风险决策时必须维护人类能动性，但需根据具体需求和情境因素，审慎评估人机能动性在现实场景中的关系。	人工智能系统可能会采用技术手段削弱一个人的意识或故意损害其做出知情决定的能力。 • **通过具体场景理解人类与人工智能的交互关系：**选取工作场所或日常生活中应用人工智能工具的具体案例，说明AI工具及其人类使用者对目标任务单元的贡献。鼓励学生认识到在人类能力与智慧可能存在局限的场景中，人工智能可以发挥的作用，强调在确保人类掌控的前提下，合理运用AI增强人类能力的重要性。 • **探讨人类能动性与机器能动性之间的动态边界：**通过现实世界中人类依赖机器能动性所引发的困境案例，引导学生就人类和人工智能在AI辅助问题解决及决策过程中可能扮演的角色变化展开辩论。指导学生在不同情境下直观理解人类能动性与机器能动性之间的抽象界限。	

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
Ethics of AI	**4.1.2 Embodied ethics** • Students are expected to be able to develop a basic understanding of the ethical issues around AI, and the potential impact of AI on human rights, social justice, inclusion, equity and climate change within their local context and with regard to their personal lives. They will understand, and internalize the following key ethical principles, and will translate these in their reflective practices and uses of AI tools in their lives and learning: • Do no harm: Evaluating AI's regulatory compliance and potential to infringe on human rights • Proportionality: Assessing AI's benefits against risks and costs; evaluating context-appropriateness • Non-discrimination: Detecting biases and promoting inclusivity and sustainability	• **CG4.1.2.1 Illustrate dilemmas around AI and identify the main reasons behind ethical conflicts:** Based on concrete AI tools, guide students to surface dilemma decisions that individual or corporate creators need to make in the design and development of AI (e.g. maximizing the scale of data collection versus protecting data ownership, recording users' private data for the training of AI models versus protecting their privacy, promoting machine control to generate profit versus guaranteeing the primacy of human agency, and prioritizing AI safety versus accelerating the iteration of AI). Support students to associate perspectives on these dilemmas with the reasons behind ethical conflicts around AI. • **CG4.1.2.2 Facilitate scenario-based understandings of ethical principles on AI and their personal implications:** Offer students opportunities to discuss age-appropriate real-world cases around the six core AI ethical principles: (1) 'do no harm', (2) proportionality, (3) non-discrimination, (4) sustainability, (5) human determination, and (6) transparency and explainability. Guide students to build a knowledge framework on the ethics of AI and practice	• **Case studies on scenarios containing controversies around AI:** Present age-appropriate real-world or simulated scenarios, and guide students to surface controversies surrounding the AI tools and their uses. Discuss the main reasons behind such ethical conflicts and facilitate students to draw infographics or concept maps illustrating the core AI ethical principles. • **Individual or group reflection on the personal implications of ethical dilemmas:** Engage students in group discussion and opinion taking on ethical dilemmas that may arise from uses of AI in daily life and learning in local contexts (e.g. whether large language models should use the data of local communities in their training or not; to what extent AI has a negative environmental impact or mitigates climate change; how much of their privacy users should forego to exchange benefits of AI services). Guide students to present their opinions through age-appropriate formats such as essays, posters, drawings or storyboards. • **Searching for and validating examples of 'AI for the public good':** Organize individual or group scoping of examples of AI tools or approaches to the use of AI that	• Unplugged learning settings and materials including print stories or case studies, worksheets and posters. • Locally available AI tools including those available through mobile phone apps. • Predownloaded or recorded videos and other resources related to specific cases or scenarios that present a dilemma. • Search engines, online videos or resources related to case studies.

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
人工智能伦理	**4.1.2 道德内化** • 学生应具备在本地环境及个人生活中，对人工智能相关的伦理问题形成基本认知的能力，并理解其对人权、社会公平、包容性、平等及气候变化等议题的潜在影响。他们需要掌握并内化以下核心伦理准则，并将这些原则融入日常反思实践，以及在生活和学习中使用人工智能工具时的决策过程： • 不伤害原则：评估人工智能的合规性和侵犯人权的可能性 • 比例性：评估人工智能的益处与风险和成本；评估上下文的适当性 • 不歧视：发现偏见，促进包容性和可持续性	• **CG 4.1.2.1 展示人工智能领域的伦理困境并分析其根源：**通过具体人工智能工具案例，引导学生梳理出在AI设计开发过程中需要个人或企业决策者做出的困境抉择（例如：扩大数据收集规模与保护数据所有权、记录用户隐私用于模型训练与保护个人隐私、追求机器控制以获取利润与保障人类主体性优先权、优先保障AI安全与加速迭代开发之间的矛盾）。帮助学生将这些困境的视角与人工智能伦理冲突的根源联系起来。 • **CG 4.1.2.2 基于场景地理解人工智能伦理原则及其个人影响：**为学生提供机会，围绕六大核心人工智能伦理原则展开年龄适宜的真实案例讨论：(1)“不(1)危害性，(2)比例原则，(3)非歧视原则，(4)可持续性原则，(5)人类自主权原则，以及(6)透明度与可解释性原则。引导学生构建关于人工智能伦理与实践的知识框架	• **关于涉及AI争议的场景案例研究：**选取当前现实世界或模拟场景，引导学生挖掘涉及AI工具及其应用的争议。探讨此类伦理冲突的主要原因，并指导学生绘制信息图或概念图，展现核心的AI伦理原则。 • **个人或群体反思道德困境的个人影响：**让学生参与小组讨论，就日常生活中和本地学习中可能因使用人工智能而产生的道德困境发表意见（例如，大型语言模型是否应该使用当地社区是否参与培训；人工智能对环境造成的负面影响程度及其减缓气候变化的效果如何；用户应为换取AI服务的便利而放弃多少隐私权）。指导学生通过适合其年龄的表达形式（如论文、海报、绘画或故事板）来阐述观点。 • **搜索和验证示例“人工智能造福公众”：**组织个人或团体界定人工智能工具或方法的示例范围，或人工智能应用的范围。	• 不插电的学习环境和材料，包括印刷故事或案例研究、工作表和海报。 • 本地可用的AI工具，包括通过手机应用程序提供的工具。 • 预先下载或录制的视频和其他资源，与特定案例或存在困境的场景相关。 • 搜索引擎、在线视频或案例研究相关资源。

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
Ethics of AI	(understanding AI's environmental and societal impacts) • Human determination: Emphasizing human agency and accountability in AI use • Transparency: advocating for the rights of users to understand AI operations and decisions	them in evaluating the AI tools being used in their lives and schools. • **CG4.1.2.3 Guide the embodied reflection and internalization of ethical principles on AI:** Guide students to understand the implications of ethical principles on AI for their human rights, data privacy, safety, human agency, as well as for equity, inclusion, social justice and environmental sustainability. Guide students to develop embodied comprehension of ethical principles; and offer opportunities to reflect on personal attitudes that can help address ethical challenges (e.g. advocating for inclusive interfaces for AI tools, promoting inclusion in AI and reporting discriminatory biases found in AI tools).	support the public good, including promoting equity and inclusion for people with disabilities, preserving linguistic and cultural diversity, and increasing social justice and environmental sustainability. Guide students to collect evidence on and discuss examples that genuinely serve the public good; validate and categorize these examples.	
AI techniques and applications	**4.1.3 AI foundations** • Students are expected to develop basic knowledge, understanding and skills on AI, particularly with respect to data and algorithms, and understand the importance of the interdisciplinary foundational knowledge required for gradually deepening	• **CG4.1.3.1 Exemplify the definition and scope of AI:** Based on examples of AI tools (e.g. for facial recognition, social media recommendations, pattern analyses underlying scientific data, medical diagnoses, self-driving cars and predicting the risk of loan defaults), facilitate students to understand what AI is and is not; guide students to find and share exemplar tools under the main categories of AI technologies and explain	• **Example-based definition and scope of AI:** Investigate and experiment with examples of AI tools (e.g. in the medical field using supervised learning and image classification for cancer diagnosis, or in business contexts using natural language processing and generative AI for automated minute-taking and composing literature reviews). Based on selected examples, help students to understand what AI is and is not, and the main categories of AI technologies adopted in daily life, as well	• Unplugged learning settings and resources, including textbooks, essays, worksheets and printed materials. • Online or downloaded videos and other media introducing AI innovations or tools. • Locally available AI tools including basic AI-assisted

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
人工智能伦理	（了解人工智能的环境和社会影响） • 人类决定：强调在使用人工智能方面的人类能动性和问责制 • 透明度：倡导用户了解人工智能操作和决策的权利	他们在评估生活中和学校里使用的人工智能工具时。 • **CG 4.1.2.3 指导体现并内化人工智能的道德原则：**指导学生理解人工智能的道德原则对其人权、数据隐私、安全、人类行为以及公平、包容、社会的影响 促进司法公正与环境可持续发展。引导学生建立对伦理原则的切身理解；并提供反思个人态度的机会，以帮助应对伦理挑战（例如：倡导人工智能工具的包容性界面、推动人工智能领域的包容性以及报告人工智能工具中存在的歧视性偏见）。	支持公共利益，包括促进残疾人平等和包容性、维护语言和文化多样性、增进社会公正和环境可持续性。指导学生收集并讨论真正服务于公共利益的案例证据；验证并分类这些案例。	
人工智能技术及应用	**4.1.3 人工智能基金会** • 学生应掌握人工智能的基础知识、理解和技能，特别是数据和算法方面的知识，并理解逐步深化所需跨学科基础知识的重要性。	• **CG 4.1.3.1 阐释人工智能的定义与范畴：**通过人脸识别、社交媒体推荐、科学数据模式分析、医疗诊断、自动驾驶汽车及贷款违约风险预测等典型AI应用实例，帮助学生理解人工智能的本质属性；引导学生在主要技术类别下发现并分享代表性工具，并阐释	• **基于示例的AI定义和范围：**研究和实验AI工具的示例（例如。 在医疗领域运用监督学习和图像分类技术进行癌症诊断，或在商业场景中使用自然语言处理和生成式AI实现自动化会议记录与文献综述撰写。通过精选案例帮助学生理解人工智能的本质与局限，并掌握日常生活中主流应用的AI技术类型。	• 不插电的学习环境和资源，包括教科书、论文、工作表和印刷材料。 • 介绍人工智能创新或工具的在线或下载视频和其他媒体。 • 本地可用的AI工具，包括基本的AI辅助

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
AI techniques and applications	understanding of data and algorithms. Students should also be able to connect conceptual knowledge on AI with their activities in society and daily life, concretizing a human-centred mindset and ethical principles through an understanding of how AI works and how AI interacts with humans.	their main functions and techniques in an age-appropriate manner. • **CG4.1.3.2 Develop conceptual knowledge on how AI is trained based on data and algorithms:** Foster students' example-based abstraction of conceptual knowledge on how machine-learning models are trained using data and algorithms; help students to develop an age-appropriate understanding of the three types of AI algorithms, namely, supervised learning, unsupervised learning and reinforcement learning. This should include how data behind the three types of AI algorithms are acquired and labelled. Debunk the claims that AI will automate the programming of algorithms and that humans do not need to learn about algorithms. • **CG4.1.3.3 Foster open-minded thinking on AI and an interdisciplinary foundation for AI:** Enable students to gain appropriate knowledge on AI methods and research topics such as the uses of artificial neural networks and the difference between strong AI and weak AI. Offer extended learning opportunities on data and algorithms to students who have strong interests and abilities in AI. Guide students to understand the interplay between knowledge	as in economic and social activities. Guide students to explore the key steps of the AI life cycle; where appropriate, draw a diagram of the cycle for particular AI systems and label the key AI techniques used. • **Spiral learning from examples to abstract concepts and from concepts to specific techniques:** Use selected examples to guide students to abstract how a machine learning model is trained, including the steps of problem definition, data collection, data processing, training, evaluation, deployment and iteration based on tests and feedback. Support students' development of age-appropriate knowledge about (and where possible, basic operational skills on) the use of AI techniques involving datasets, algorithms, AI architectures, setting up of computing environments, design of functionalities and interfaces, and planning of deployment scenarios. • **Case analysis of innovative AI tools and innovative uses of AI:** Organize students to search for potential innovative AI tools and/or innovative uses of AI; guide students to identify the key techniques and main categories of AI used in these applications. Facilitate them to write an argumentative essay or provide an oral defense on the extent to	applications installed on smartphones. • Online AI tools, for example image and/or video creators, generative AI model and video recommendations on social media.

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
人工智能技术及应用	对数据和算法的理解。 学生还应该能够将人工智能的概念知识与他们在社会和日常生活中的活动联系起来，通过了解人工智能如何工作以及人工智能如何与人类互动，具体化以人为中心的思维模式和道德原则。	以适合年龄的方式发挥他们的主要功能和技术。 • **CG 4.1.3.2基于数据和算法开发关于如何训练人工智能的概念性知识：**培养生基于实例的抽象概念知识，即机器学习模型如何使用数据和算法进行训练； 帮助学生建立与年龄相符的对三种人工智能算法类型（即监督学习、无监督学习和强化学习）的理解，包括这三种算法背后的数据获取与标注方式。需要澄清“AI将自动化编程算法”以及“人类无需学习算法”等常见误解。 • **CG 4.1.3.3 培养开放创新的AI思维，构建跨学科AI基础：**帮助学生掌握人工智能方法论与前沿课题，例如人工神经网络的应用场景、强人工智能与弱人工智能的本质区别。为AI方向的优秀学生提供深度学习机会，拓展数据与算法领域的知识边界。引导学生理解知识体系间的内在关联。	如在经济和社会活动中。指导学生探索人工智能生命周期的关键步骤；在适当的时候，为特定的人工智能系统绘制一个周期图，并标注所使用的关键人工智能技术。 • **通过实例到抽象概念、再从概念到具体技术的螺旋式学习路径：**以精选案例为引导，帮助学生抽象化理解机器学习模型的训练过程——涵盖问题定义、数据收集、数据处理、训练、评估、部署以及基于测试反馈的迭代优化等关键步骤。同时助力学生掌握符合年龄特征的人工智能应用知识（在可能情况下培养基础操作技能），包括数据集管理、算法设计、AI架构搭建、计算环境配置、功能界面开发以及部署场景规划等核心环节。 • **创新AI工具与AI创新应用案例分析：**组织学生搜集潜在的创新型AI工具及AI创新应用场景，指导学生识别这些应用场景中使用的人工智能关键技术及主要类别，协助学生撰写议论文或进行口头答辩，探讨人工智能在教育领域的应用边界。	安装在智能手机上的应用程序。 • 在线人工智能工具，例如图像和/或视频创建者、生成式AI模型和社交媒体上的视频推荐。

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
AI techniques and applications		on AI and knowledge in STEM, languages and social studies, and invite them to solidify related interdisciplinary knowledge and the reflections on the reciprocal impact of AI on related subjects. • **CG4.1.3.4 Concretize human-centred considerations in the design and use of AI:** Organize tool-based reflections on AI to give form to students' understanding of its impact on life, work and societal relationships. Highlight humans' roles in the key steps of the AI life cycle (e.g. researchers, architecture engineers, data engineers, data workers, beta testers, regulators of ethics and safety, specialists in human–AI interfaces and auditors of system compliance). Guide students toward a deep familiarity with the main ethical issues related to the use of data for training AI systems.	which these AI technologies may help humans engineer innovations in their personal practices, economic or business models, or social services, and/or the risks that specific AI technologies may pose to ethical principles and human agency. • **Solidifying multidisciplinary foundation for AI with a specific focus on mathematics:** Based on lectures and problem-based inquiry, help students grasp that modern AI systems are rooted in mathematics, and learning about data and algorithms requires a strong command of mathematics and a multidisciplinary knowledge set. Nurture students' essential mathematical and interdisciplinary skills for AI development, including relevant material on algebra, probability and statistics, data structures and algorithms such as K-nearest neighbours, K-means clustering, linear regression and CART/decision trees. Cultivate students' higher-level knowledge on linear algebra for complex data representation and matrix mathematics, calculus for back propagation and gradient descent for understanding machine learning and neural networks. Support students to solidify and extend their other multidisciplinary foundational knowledge as well, especially in science, technology and engineering.	

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
人工智能技术及应用		在人工智能和STEM知识、语言和社会研究方面，并邀请他们巩固相关的跨学科知识，以及对人工智能对相关学科的相互影响的反思。 • **CG 4.1.3.4在设计和使用人工智能时具体化以人为中心的考虑：**通过组织基于工具的人工智能反思活动，帮助学生系统理解其对生活、工作及社会关系的影响。重点突出人类在人工智能生命周期关键环节中的角色（如研究人员、架构工程师、数据工程师、数据工作者、测试用户、伦理安全监管者、人机交互专家及系统合规审计师）。引导学生深入理解数据训练人工智能系统时涉及的核心伦理问题。	这些人工智能技术可能有助于人类在个人实践、经济或商业模式或社会服务方面进行创新，或者特定的人工智能技术可能对道德原则和人类行为构成的风险。 • **以数学为核心夯实人工智能跨学科基础：**通过理论讲授与案例探究相结合的教学模式，帮助学生理解现代人工智能系统根植于数学原理，掌握数据与算法学习需要扎实的数学功底和跨学科知识储备。培养人工智能发展所需的核心数学与跨学科技能，涵盖代数、概率论等相关领域的知识体系。 统计学、数据结构和算法，如K近邻、K均值聚类、线性回归和CART/决策树。 培养学生在线性代数、复数数据表示和矩阵数学方面的高阶知识，以及用于理解机器学习和神经网络的反向传播和梯度下降的微积分。同时帮助学生巩固并拓展其在其他多学科领域的基础知识，特别是在科学、技术与工程领域。	

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
AI system design	**4.1.4 Problem scoping** • Students are expected to be able to understand the importance of 'AI problem scoping' as the starting point for AI innovation. They are expected to be able to examine whether AI should be used in certain situations from legal, ethical and logical perspectives; students are able to define the boundaries, goals and constraints of a problem before attempting to train an AI model to solve it; students are also expected to acquire the knowledge and project-planning skills needed in order to conceptualize and construct an AI system, including by assessing the appropriateness of different AI techniques, defining the need for data, and devising test and feedback metrics.	• **CG4.1.4.1 Scaffold critical thinking skills on when AI should not be used:** Drawing from examples, guide students to develop critical analysis skills to examine reasons why AI should or should not be used to address certain real-world challenges (e.g. improving institutional productivity, the sustainable development of communities, or the precision and efficiency of human decision-making) with reference to human and environmental implications. Provide clarity on when, and under what conditions, AI cannot and/or should not be applied to problems (e.g. where non-AI solutions would offer the same performance with lower ethical risk and environmental impact, or where the use of AI would weaken human consciousness or manipulate human actions). • **CG4.1.4.2 Support the acquisition and reinforcement of skills in scoping a problem to be solved by an AI system:** Based on a simulation project, support the learning and practice of skills to identify and scope a problem that should and could possibly be solved by building a new AI model (e.g. training an AI model on a minority language to better serve its community, or building a model for	• **Simulating the review of project proposals:** Organize students to simulate the review of a project proposal and justification process. The proposals could, for example, be on building or selecting an AI system. Conduct a debate on whether AI should or should not be used in the project to solve the problem, considering factors such as the availability of sufficient training data, ethical implications, environmental impact and whether non-AI solutions could achieve similar outcomes with fewer risks. Guide students to outline a checkbox for the review. • **Simulating the problem-scoping and justification for the design of new AI system:** Facilitate students to research problems in their daily lives or communities (e.g. at school or in volunteer work) and identify a problem that could potentially be addressed by AI (e.g. automatic watering the school garden or helping a hard-of-hearing grandparent to detect alarms). Support students to scope and define the problem by anticipating the key features including AI algorithms and datasets, and produce a corresponding problem statement. • **Data preprocessing lab:** Using a basic dataset and the architecture of an existing AI model, organize experiments on training the model	• Unplugged learning settings including worksheets, paper-based case studies, and printouts of prototypes or plans for AI system design. • Digital devices with an internet connection. • Selected online AI systems.

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
AI系统设计	**4.1.4 问题范围界定** • 学生需要理解“人工智能问题界定”作为创新起点的重要性。他们应能从法律、伦理和逻辑角度审视特定情境下是否需要使用人工智能；在尝试训练AI模型解决问题前，需明确问题的边界、目标与限制条件；同时需掌握构建AI系统所需的知识与项目规划技能，包括评估不同AI技术的适用性、确定数据需求以及制定测试与反馈指标等核心能力。	• **CG 4.1.4.1 构建AI应用的批判性思维框架：**通过具体案例引导学生培养批判性分析能力，探讨在解决现实问题时（如提升机构生产力、促进社区可持续发展或优化人类决策精准度与效率）使用AI的利弊得失，并结合人文关怀与环境保护考量。明确界定AI在以下情形下不宜应用：当非AI解决方案能以更低伦理风险和环境影响达成同等效果时；当AI应用可能削弱人类判断力或导致行为操控时。 • **CG 4.1.4.2 支持获取并强化人工智能系统问题界定技能：**基于模拟项目，支持学习和实践识别及界定需要通过构建新AI模型解决的问题（例如针对少数语言群体训练AI模型以更好地服务其社区，或开发用于	• **模拟项目提案评审：**组织学生模拟项目提案及论证流程的评审工作。例如可选择人工智能系统构建或选型等项目提案。围绕“是否应在项目中应用人工智能技术解决问题”展开辩论，需综合考量训练数据充足性、伦理影响、环境影响等要素，并评估是否存在风险更低且效果相当的非AI解决方案。指导学生制定评审检查表。 • **人工智能系统设计问题界定与论证模拟训练：**指导学生从日常生活或社区场景（如校园环境、志愿服务活动）中发现研究课题，筛选出可通过人工智能技术解决的实际问题（例如实现校园花园自动灌溉系统、帮助听力障碍的祖父母及时发现门铃警报）。通过预判人工智能算法特性与数据集特征等核心要素，协助学生完成问题界定与框架构建，并最终形成规范的问题陈述文档。 • **数据预处理实验室：**使用基础数据集和现有AI模型的架构，组织对模型进行训练的实验	• 不插电的学习环境，包括工作表、基于纸张的案例研究以及人工智能系统设计原型或计划的打印件。 • 具有互联网连接的数字设备。 • 所选的在线AI系统。

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
AI system design		the automated tracking of migration across target regions). Students can sharpen their analytical skills by formulating problem statements that can help avoid wastage of time and effort on poorly defined problems. • **CG4.1.4.3 Develop skills on assessing AI systems' need for data, algorithms and computing resources:** Offer opportunities for students to develop planning skills by assessing the need for data, algorithms and programming languages, software, computing capabilities and hardware; study the feasibility of an AI project in terms of the data available given the regulatory and ethical restrictions and the total costs of the required processing and engineering of data, computing capabilities and hardware.	based on variations of the dataset (e.g. a challenge of classifying mystery images). Support students to apply various data preprocessing techniques, such as adjusting the coding (e.g. data augmentation, handling outliers and analysing dataset skew/imbalance). Support them to train the model based on the modified datasets and observe how the data preprocessing has affected the model's performance.	

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
AI系统设计		（通过自动化追踪目标区域间的迁移过程）。学生可以通过制定问题陈述来提升分析能力，这有助于避免在定义模糊的问题上浪费时间和精力。 • **CG 4.1.4.3 培养评估人工智能系统对数据、算法和计算资源需求的能力：**通过评估数据、算法、编程语言、软件、计算能力和硬件的需求，为学生提供培养规划技能的机会；研究在现有数据基础上，考虑到监管和伦理限制以及所需数据处理、工程设计、计算能力及硬件的总成本，人工智能项目的可行性。	基于数据集的变体（例如分类神秘图像的挑战）。支持学生应用多种数据预处理技术，例如调整编码方式（如数据增强、处理异常值以及分析数据集偏斜/不平衡问题）。支持他们根据修改后的数据集训练模型，并观察数据预处理如何影响模型的性能。	

4.2 Level 2: Apply

The overall goal of the 'Apply' level is for students to construct a solid and transferable conceptual knowledge structure and associated skill sets on AI and to habituate their application of the human-centred mindset and ethical principles to guide the assessment, learning and practice of AI tools. The curricular goals in **Table 3** aim to guide the charting of a core set of value orientations, practical ethical principles and methodological knowledge that can be used to tailor curricular modules and specify exit competencies for all students. The suggested pedagogical methods are intended to catalyse problem-based inquiry of conceptual knowledge and task-based appreciation of operational skills while integrating strategies to maintain students' curiosity for further study. Providing desirable learning environments at the 'Apply' level involves setting up hardware, software and applications to support practices of AI operation and co-creation, with considerations of open source options.

Table 3. Competency blocks for level 2: Apply

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
Human-centred mindset	**4.2.1 Human accountability** • Students are expected to be able to recognize that human accountabilities are the legal obligations of AI creators and AI service providers, and understand what human accountabilities they should assume during the design and use of AI. They should also foster an awareness that human accountability is a legal and social responsibility when using AI to assist decisions on that affect humanity	• **CG4.2.1.1 Develop a view that human accountability is a legal obligation of AI creators and AI service providers:** Leveraging prior knowledge on the human-led AI life cycle and real-world lawsuits, guide students to understand that human AI creators and service providers, and institutions deploying AI tools, are accountable for legal issues, violations and infringements that the AI system or service may cause. Explain how to hold AI creators, providers and institutional users to assume human accountability for safety incidents, ethical risks in designing and training AI, and misuses of the AI service to control users. Guide students to understand what human accountabilities they should	• **Writing guidelines on human accountability for AI creators and service providers:** Facilitate students to play the roles of AI creators and data owners and discuss their key legal and ethical accountabilities in terms of maintaining human control of the collection and processing of data, training AI models, designing functionalities and interfaces, deployment of AI systems, and monitoring and feedback loops. Guide them to write self-discipline guidelines for their studies on the design, training and iteration of AI systems, holding AI creators to account for protecting the rights of data owners and AI users.	• Unplugged and/or offline learning settings and resources, including print-based case studies, role-play scripts, videos, worksheets and flipcharts. • Online AI tools, for example learning management systems, social media platforms and generative AI platforms.

4.2 级别2：应用

“应用”阶段的总体目标是帮助学生构建扎实且可迁移的人工智能概念知识体系及相关技能组合，并培养运用以人类为中心的思维方式和伦理准则指导人工智能工具评估、学习及实践的习惯。**表3**中的课程目标旨在引导制定一套核心价值取向、实用伦理原则及方法论知识框架，这些要素可用于定制课程模块并为所有学生明确退出能力。

建议的教学方法旨在通过问题导向的探究式学习促进概念知识的掌握，同时通过任务驱动的方式提升操作技能，并整合策略以保持学生对深入学习的好奇心。在“应用”阶段营造理想的学习环境，需要配备硬件、软件及应用程序来支持教学实践。人工智能操作和共同创造，同时考虑开源选项。

表3.第二级：应用的能力模块

	学生能力	**课程目标** (AI课程或学习方案应该...)	**建议教学方法** （各机构和教师可考虑并调整以下学习方法。）	**学环境** （可提供并调整以下学习设置。）
人位于中心的观念模式	**4.2.1 人类问责制** • 学生需要理解，人类责任是人工智能开发者和服务商的法定义务，并明确在设计和使用AI时应承担哪些人类责任。同时要树立这样的认知：当使用AI辅助决策时，人类的责任既是法律义务也是社会责任——毕竟这些决策最终会影响全人类。	• **CG 4.2.1.1 建立观点：人类问责是人工智能创造者和人工智能服务提供商的法律义务：**利用人类主导的人工智能生命周期的先验知识和现实世界诉讼，引导学生理解人类人工智能创造者和服务提供商，以及部署人工智能工具的机构，应对法律问题、违规和侵权行为负责，人工智能系统或服务可能引发问题。说明如何让AI开发者、提供者和机构用户承担人类应尽的责任，包括安全事件、设计与培训过程中涉及的人类伦理风险，以及滥用AI服务控制用户的行为。引导学生理解他们应当承担哪些人类责任。	• **《人工智能创作者与服务提供商人类问责制指南》：**通过让学生扮演AI创作者和数据所有者的角色，探讨他们在数据收集处理、模型训练、功能设计、系统部署及监测反馈等环节中，如何通过法律规范与伦理准则确保人类对AI的掌控权。指导学生制定学术自律准则，规范AI系统的设计、训练与迭代过程，要求创作者切实履行保护数据所有者和AI使用者权益的责任。	• 不插电和/或脱机学习环境和资源，包括基于印刷品的案例研究、角色扮演脚本、视频、工作表和翻页板。 • 在线人工智能工具，例如学习管理系统、社交媒体平台和生成式人工智能平台。

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
Human-centred mindset	and uphold the principle that humans should not cede the determination to AI when making high-stakes decisions. They are also expected to enhance their judgement on, and attitudinal resilience to, the illusive claims on about the use of outputs and as well as predictions that AI can usurp humans' thinking and decision-making.	assume themselves when learning how to create AI tools or design AI systems. • **CG4.2.1.2 Generate the understanding that human accountability is a legal and social responsibility when using AI in making decisions about humanity:** Guide students to analyse the capabilities of AI tools used to assist decision-making. Critically interrogate the genuine capabilities of certain AI tools and debunk the hype around AI's supposed ability to make decisions. Assist students to evaluate the consequences of the institutional use of AI to make decisions about humans in complex situations such as profiling the aptitude of students to take up further learning opportunities or determining the employability of job candidates. Lead discussions on why human accountability in using AI is essential to safeguard human rights and human dignity. Facilitate students to understand why we should not use AI to replace humans when making high-stakes decisions, for example to assess the values, infer the emotions or predict the aptitudes of a natural person. AI algorithms should not be used to assign students'	• **Investigating the impact of AI-assisted decisions on humans and avenues of redress within AI regulations:** Ask students to find examples in which decisions about humans are determined or greatly influenced by AI (e.g. an AI-assisted assessment system used by a bank to approve or deny a student loan application, or a profiling system used by a hotel to predict a person's socio-economic background based on their location and the device they were using when they made their booking). Facilitate students to reveal the roles of humans and AI in the key steps of decision loops, and check whether human accountability for the decisions is in compliance with locally applicable or international regulations (e.g. the EU AI Act). • **Scenario-based practices of using AI with purpose:** Engage students in activities where they use AI tools to purposefully practise their writing skills and foster their inquiry-based learning, higher-order thinking and creativity. Lead students to discuss how the use of AI without human accountability (e.g. handing in an essay produced by AI) may reduce human intellectual development. Prompt them to outline concrete actions to protect themselves and their peers from the use of AI outputs	

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
人 位于中心的观念模式	并坚持人类在做出高风险决策时不应将决定权让渡给人工智能的原则。他们还应增强对那些关于AI可能取代人类思维和决策的模糊主张的判断力，以及对这些预测保持态度上的韧性。	在学习如何创建AI工具或设计AI系统时，他们应该这样认为。 • **CG 4.2.1.2 培养对人工智能决策中人类责任的认知：**指导学生分析辅助决策的人工智能工具功能，深入探讨某些AI工具的真实能力，并破除关于AI能自主决策的过度炒作。帮助学生评估在复杂情境下（如对学生学习潜力进行画像分析或判定求职者就业能力）通过AI辅助决策可能引发的后果。引导讨论为何在使用AI时强调人类责任对保障人权和人格尊严至关重要，阐明不应让AI替代人类进行高风险决策（例如评估价值观、推测情绪或预测自然人能力）。AI算法不得用于分配学生	• **研究人工智能辅助决策对人类的影响及AI法规中的救济途径：**让学生搜集典型案例，例如银行使用AI辅助评估系统审批助学贷款申请，或酒店通过用户定位及预订时使用的设备预测其社会经济背景的画像系统，这些决策过程中人类的判断或决策受到人工智能的决定性影响。引导学生揭示决策流程关键环节中人类与AI的角色分工，并核查相关决策是否符合当地或国际法规要求（如欧盟《人工智能法案》）的人权责任条款。 • **人工智能场景化应用实践方案：**引导学生参与使用AI工具进行写作技能专项训练的活动，培养探究式学习能力、高阶思维与创造力。引导学生探讨：若AI生成内容未经人工审核直接提交（如人工智能作文），可能对人类智力发展造成的负面影响。鼓励学生制定具体防护措施，保护自身及同伴免受AI生成内容的潜在危害。	

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
Human-centred mindset		scores (as happened during COVID-19) or decide on university admissions. • **CG4.2.1.3 Nurture the personal attitude that human accountability requires personal competencies to steer the purposeful use of AI:** Guide students to interrogate how the automation of literature reviews, writing and artistic creation may undermine human thinking processes and intellectual development. Guide students to discuss concrete actions that they can take to protect themselves and their peers from the use of AI outputs or predictions to usurp human thought, intellectual practices and continuous capacity enhancement.	or predictions to usurp thinking processes, and give them insight into the competencies that students need in order to steer the use of AI toward serving human capability development.	
Ethics of AI	**4.2.2 Safe and responsible use** • Students are expected to be able to carry out responsible AI practices in compliance with ethical principles and locally applicable regulations. They are expected to be conscious of the risks of disclosing data privacy and take measures to ensure that their data are collected, used, shared, archived and	• **CG4.2.2.1 Foster self-awareness and habitual compliance with ethical principles for the responsible use of AI**: Illustrate the ethical principles or regulatory articles concerning the responsible use of AI, drawing on concrete AI tools and real-world use scenarios. Support students to iteratively build and update a checkbox of ethical principles for ensuring their own lawful and responsible practices when engaging with AI systems. Guide students to practise and habituate their compliance with these principles, such	• **Designing an 'ethics kit' for the self-disciplined, responsible use of AI:** Design simulated scenarios containing potential ethical conflicts (e.g. sharing private data or protected content when chatting with AI systems, putting AI-generated content in a school assignment, creating a video using images of other people, or distributing misinformation, disinformation or hate speech). Organize the drafting of an 'ethics kit' that users need to habitually check when using AI, including articles drawn from locally applicable	• Unplugged learning settings and resources, including paper-based worksheets, posters and checklists of ethical principles. • Predownloaded privacy policies and AI regulations, and examples of legal or ethical cases concerning AI safety, data privacy and forms of consent. • Locally available AI tools including smartphone apps.

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构及教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
人 位于中心的观念模式		分数（如COVID-19期间发生的）或决定大学录取。 • **CG 4.2.1.3 培养个人态度：人类责任意识要求具备引导人工智能有目的使用的个人能力。**指导学生思考文献综述、写作和艺术创作的自动化如何可能削弱人类思维过程与智力发展。引导学生探讨具体行动，以保护自己和同伴免受AI输出或预测取代人类思维、智力实践及持续能力提升的影响。	或者预测，以取代思维过程，并让他们了解学生需要的能力，以便引导人工智能服务于人类能力的发展。	
人工智能伦理	**4.2.2 安全和负责任的使用** • 学生应能够按照道德原则和当地适用法规开展负责任的人工智能实践。他们应意识到数据隐私泄露的风险，并采取措施确保其数据在收集、使用、共享、存档和	• **CG4.2.2.1 Foster自我意识与践行人工智能伦理规范的养成之道：**通过具体AI工具和真实应用场景，阐释人工智能负责任使用的伦理准则或监管条款。引导学生逐步建立并更新伦理准则清单，确保在使用AI系统时遵循合法合规的实践准则。指导学生通过实践养成遵守这些伦理规范的习惯，例如	• **为自律、负责任地使用人工智能设计一个“伦理工具包”：**设计包含潜在伦理冲突的模拟场景（例如：与AI系统聊天时分享私人数据或受保护内容、将AI生成的内容用于学校作业、使用他人图像制作视频，或传播虚假信息、误导性信息及仇恨言论）。制定用户在使用AI时需定期查阅的“伦理指南”，其中应包含本地适用的伦理规范文章。	• 不插电的学习环境和资源，包括纸质工作表、海报和道德原则清单。 • 预先下载的隐私政策和人工智能法规，以及涉及人工智能安全、数据隐私和同意形式的法律或道德案例。 • 本地可用的AI工具，包括智能手机应用程序。

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
Ethics of AI	deleted only with their deliberate and informed consent. They are also expected to be conscious of typical AI incidents and the specific risks of certain AI systems, and be able to protect their own safety and that of their peers when using AI.	as protecting personal data and privacy, respecting copyright, clearly marking where AI-generated content appears, and avoiding inputs or interactions in AI systems that involve disinformation, misinformation, hate speech or sensitive details about identifiable individuals. • **CG4.2.2.2 Offer opportunities to reinforce self-discipline in the responsible use of AI**: Provide students with opportunities to gain an age-appropriate understanding of their personal, legal and ethical responsibilities when using AI; highlight the consequences of violating regulations; and build and reinforce self-disciplined behaviours, especially with regard to sensitive personal data, copyrighted materials, images depicting identifiable people, content that is AI-generated or digitally synthetized, and the spread of misinformation, disinformation and hate speech. • **CG4.2.2.3 Deepen practical knowledge on the safe use of AI and awareness of locally applicable regulations:** Facilitate students to categorize the general safety risks of AI, potential safety risks of specific AI tools, and typical AI incidents. Guide students to deepen	regulations and personal responsibilities in making legal and ethically proper use of AI tools. Guide students to practice the compliance with the principles when using AI without supervision. • **Simulation of typical AI incidents and risk management**: Expose students to simulated AI incidents that directly harm humans or AI hazards that threaten harm. Familiarize them with precautionary and interactive strategies for ensuring their personal data is collected, used, shared, archived and deleted only with their informed consent. Suggest tips for the safe use of AI, and promote awareness of the regulations that can protect their privacy and well-being and/or mitigate negative impacts in the case of AI incidents. • **Users' reviews of AI creators' policies on data privacy:** Encourage students to search for and download examples of AI creators' policies on data privacy. Guide them to leverage their knowledge on the rights of data owners and legal responsibilities of AI creators to check whether the policies comply with relevant regulations. When they discover a violation, ask them to draft a complaint to the regulatory agencies and/or a recommendation for the AI creator to improve the conformity of their policies and practices.	• Online AI tools especially platforms containing recommender algorithms and content generators.

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
人工智能伦理	只有在获得他们的故意和知情同意后才能删除。他们还应该意识到典型的人工智能事件和某些人工智能系统的特定风险，并能够在使用人工智能时保护自己和同伴的安全。	包括保护个人数据和隐私，尊重版权，清楚地标明人工智能生成内容的出现位置，避免在人工智能系统中输入或交互涉及虚假信息、错误信息、仇恨言论或可识别个人的敏感细节。 • **CG 4.2.2.2 提供强化自律的机会以负责任地使用人工智能：**为学生提供机会，使其能够获得与其年龄相符的理解，即在使用人工智能时承担的个人、法律和道德责任；强调违反法规的后果；并建立和强化自律行为，特别是在涉及敏感个人数据、受版权保护的材料、包含可识别个人的图像、人工智能生成或数字合成的内容，以及虚假信息、不实信息和仇恨言论传播等方面。 • **CG 4.2.2.3深化关于安全使用人工智能的实际知识，并加深对当地适用法规的认知：**帮助学生对人工智能的一般安全风险、特定人工智能工具的潜在安全风险和典型的人工智能事件进行分类。 引导学生深化	规范和责任，指导学生在自主使用AI工具时遵守相关原则。 • **典型情况模拟人工智能事故与风险管理：**通过模拟真实案例让学生亲身体验，包括直接危害人类的事故和存在潜在风险的人工智能事件。帮助学生掌握预防性措施和互动策略，确保个人数据的收集、使用、共享、归档及删除均基于其知情同意。提供安全使用AI的实用建议，增强对隐私保护法规的认知，以便在AI事故发生时既能维护自身权益，又能有效降低负面影响。 • **用户对AI创作者数据隐私政策的评价：**鼓励学生搜索并下载AI创作者数据隐私政策的示例。引导他们运用自己掌握的数据所有者权利和AI创建者的法律责任知识，检查政策是否符合相关法规，发现违规行为时，要求其起草投诉提交监管机构和/或建议AI创建者改进其政策和实践的合规性。	• 在线人工智能工具，特别是包含推荐算法和内容生成器的平台。

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
Ethics of AI		their knowledge on human rights to data protection and privacy and the legal responsibilities of AI creators to collect data with consent, and guide them to practise strategies for ensuring their personal data is collected, used, shared, archived and deleted only with their informed consent. Expose students to simulated scenarios containing typical AI incidents, so they can practise precautionary and interactive strategies for the safe use of AI and become familiar with regulations that can protect their safety or mitigate the negative impacts of AI incidents.	• **Debate the ownership of AI-generated content and outputs from human–AI interactions:** Organize a debate to trigger students' reflections around the ownership of content created using AI. Examine the availability and applicability of regulations on the recognition of copyright for AI-generated content and resources, and how relevant regulations recognize intellectual work that integrates different extents of AI-generated content.	
AI techniques and applications	**4.2.3 Application skills** • Students are expected to be able to construct an age-appropriate knowledge structure on data, AI algorithms and programming, and acquire transferable application skills. Students are expected to be able to critically evaluate and leverage free and/or open-source AI tools, programming libraries and datasets.	• **CG4.2.3.1 Offer opportunities to strengthen knowledge and skills on data modelling, engineering and analysis**: Provide students with task-based learning opportunities to acquire age-appropriate knowledge and skills on datasets, including applying age-appropriate tools or programming languages to acquire, clean and transform data into a suitable format for storing, processing, and analysing databases (e.g. SQL, NoSQL, SparkSQL or Apache Flink). • **CG4.2.3.2 Provide opportunities to acquire age-appropriate technical skills in AI programming**: Explain examples of AI systems that use different	• **Data biases lab:** Provide students with sample datasets with and without outliers, guide students to conduct hands-on experimentation on how the outliers impact the model (e.g. in regression or clustering examples). For image classification, ask students to conduct an experiment on how class imbalance (e.g. significantly more data in one class than the other) affects model performance per class. Guide students to learn age-appropriate skills in data engineering to remove identifiable biases and compare the results. • **Tailored optional modular courses on various AI algorithms to support cohort-based learning:** Tailor free and/or open-source	• Computers with internet connection. • Computer-based samples of datasets or locally accessible public datasets. • Computer-based applications for AI programming or locally accessible online open-source AI programming libraries. • Computer-based or locally accessible online AI tools.

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
人工智能伦理		通过讲解数据保护与隐私权相关的法律知识，以及AI开发者在收集用户同意数据时的法律责任，指导学员掌握确保个人数据仅在获得知情同意后方可被收集、使用、共享、存档和删除的实践策略。通过模拟典型AI事故场景，帮助学员演练预防性应对措施与互动式安全策略，从而熟练掌握保护自身权益或减轻AI事故负面影响的相关法规。	• **辩论AI生成内容和人机交互输出的归属权：**组织一场辩论，引发学生对AI创作内容的归属权的思考。研究关于AI生成内容和资源的版权认定法规的可用性和适用性，以及相关法规如何认可整合了不同程度AI生成内容的智力成果。	
人工智能技术及应用	**4.2.3 应用技能** • 学生应能构建与年龄相符的数据、AI算法和编程知识结构，并掌握可迁移的应用技能。学生应能批判性地评估和利用免费和/或开源的AI工具、编程库和数据集。	• **CG 4.2.3.1 提供机会以加强数据建模、工程和分析方面的知识和技能：**为学生提供任务型学习机会，使其获得与年龄相符的数据集知识和技能，包括应用与年龄相符的工具或编程语言获取、清理和转换数据，以便将其转换为适合存储、处理和分析数据库的格式（如SQL、NoSQL、SparkSQL 或 Apache Flink)。 • **CG 4.2.3.2提供机会，以掌握适合年龄的人工智能编程技术技能：**解释使用不同人工智能系统的示例	• **数据偏差实验室：**向学生提供含异常值与不含异常值的样本数据集，引导他们通过实验探究异常值对模型的影响（例如在回归或聚类案例中）。针对图像分类任务，可要求学生开展实验分析类别不平衡（即某类数据量远超另一类）对各分类模型性能的影响。指导学生掌握适合其认知水平的数据工程技能，以消除可识别的偏差并对比实验结果。 • **针对各种AI算法定制的可选模块化课程，以支持基于队列的学习：**定制免费和/或开源	• 具有互联网连接的计算机。 • 基于计算机的样本数据集或本地可访问的公共数据集。 • 基于计算机的应用程序，用于AI编程或本地可访问的在线开源AI编程库。 • 基于计算机或本地访问的在线AI工具。

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
AI techniques and applications		categories of AI algorithms to scaffold students' age-appropriate understanding of AI algorithms including supervised learning, unsupervised learning and reinforcement learning. This should include how they scrape and process data, how they're trained, how they function, and the concrete types of algorithms that underlie these categories. Where appropriate, provide students with task-based learning opportunities to cultivate methodological knowledge on selected AI algorithms. • **CG4.2.3.3 Encourage students to develop analytical and synthesis skills to leverage open-source datasets and AI tools**: Organize problem-based learning to facilitate students' acquisition of skills to critically evaluate and leverage open-source AI datasets (e.g. MNIST,[2] CIFAR,[3] or ImageNet)[4] and tools from free and/or open-source AI algorithm libraries (e.g. Teachable Machine,[5] PyTorch,[6] or Keras)[7] to address authentic tasks. Drawing on variations of problems, guide students to practise and enhance the transferability of their knowledge and skills on data and algorithms into complex contexts.	AI datasets and AI algorithm libraries according to the age and prior knowledge of target students. Develop optional modular courses on various AI algorithms and support cohorts of students to choose the courses that align with their interests, to acquire methodological knowledge and skills in applying AI algorithms. • **AI hackathons based on variations of authentic tasks:** Schedule a significant amount of continuous learning hours to challenge interested students to conduct task-based hackathons. Design a series of tasks with variations to enable students to practise their transferable AI programming skills. • **Debunking claims that AI will automate coding and human students don't need to learn AI programming:** Facilitate students' research into the professional knowledge and skills demanded by the creation and iteration of AI systems, especially the foundation of methodological knowledge necessary to explore more human-centred and innovative AI algorithms and methods. Challenge students to contemplate how using AI to replace humans' programming skills will lead to fewer people acquiring these foundational skills, and exacerbate the inequality between those with and without AI-related knowledge.	

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
人工智能技术及应用		人工智能算法的类别，以帮助学生理解适合其年龄的人工智能算法，包括监督学习、无监督学习和强化学习。 这应该包括他们如何抓取和处理数据、如何接受培训、如何运作，以及支撑这些类别的具体算法类型。在适当的情况下，为学生提供任务型学习机会，以培养他们对选定人工智能算法的方法论知识。 • **CG 4.2.3.3 培养分析整合能力，善用开源数据与AI工具：**通过问题导向式学习，帮助学生掌握批判性评估开源AI数据集（如MNIST、[2] CIFAR、ImageNet) [4]及自由开源算法库（如Teachable Machine、[5] PyTorch [6]、Keras) [7] 的技能，解决实际任务。通过多样化问题设计，引导学生将数据与算法知识迁移至复杂场景，提升知识应用的横向扩展能力。	根据目标学生的年龄和已有知识水平，开发AI数据集和AI算法库。开发可选的模块化课程，涵盖多种AI算法，并支持学生群体选择符合自身兴趣的课程，从而掌握方法论知识和应用AI算法的技能。 • **基于真实任务变体的人工智能编程马拉松：**制定大量连续学习时长，挑战有兴趣的学生开展任务型编程马拉松。设计一系列任务变体，让学生能够练习可迁移的人工智能编程技能。 • **驳斥人工智能将实现编程自动化、人类学员无需学习AI编程的说法：**帮助学员研究开发和迭代AI系统所需的专业知识和技能，特别是为探索更有人文关怀、更具创新性的AI算法和方法奠定方法论知识基础。挑战学生思考：用AI取代人类的编程技能会导致掌握这些基础技能的人越来越少，并加剧有AI知识与无AI知识人群之间的不平等。	

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
AI system design	**4.2.4 Architecture design** • Students are expected to be able to cultivate basic methodological knowledge and technical skills to configure a scalable, maintainable and reusable architecture for an AI system covering layers of data, algorithms, models and application interfaces. Students are expected to develop the interdisciplinary skills necessary to leverage datasets, programming tools and computational resources to construct a prototype AI system. This includes the expectation that they apply deepened human-centred values and ethical principles in their configuration, construction and optimization.	• **CG4.2.4.1 Scaffold the acquisition of methodological knowledge and technical skills on AI architecture:** Facilitate students to acquire and practise the necessary engineering thinking and operational skills to evaluate a variety of AI architectures with an aim to choose an appropriate solution based on a defined problem statement, while considering open-source options. Provide project-based learning opportunities to support their acquisition of methodological knowledge on the configuration of a prototype AI architecture encompassing an anti-bias data structure, an energy-efficient AI model to minimize the negative environmental impact, the human-centred design of performance and services, and metrics to test and improvise the maturity of the configuration. • **CG4.2.4.2 Support the preparation of advanced technical skills and project management competencies needed by AI system building:** Offer project-based learning opportunities to facilitate students to acquire and apply the interdisciplinary technical skills demanded by the building of a prototype AI system designed for a simple specific task (e.g. a chatbot imitating the responses of	• **Simulating the evaluation of frameworks and components for AI architectural configuration:** Based on the problem statement and feasibility study, facilitate students to evaluate a variety of frameworks for AI architectures (e.g. TensorFlow, PyTorch, or Scikit-learn). Simulate the evaluation and selection of solutions to the components of the architecture (e.g. data layer, algorithm layer, AI model layer and interface layer) based on the selected framework. Configure a prototype architecture encompassing the required datasets, algorithm tools, AI model and required computational resources, the design of main functionalities and interface, and the plans for deployment. Guide students to communicate the configuration through abstractions such as flowcharts, diagrams or pseudocode. • **Simulating the leveraging of resources to build an AI system:** Facilitate students to build the simulated AI system based on locally hosted computing devices or locally accessible cloud computing platforms (e.g. Hadoop or Spark), and the operating systems (e.g. GNU) and software needed to train the machine-learning models. Guide students to conduct trade-offs between cost and computing capability needs, and between the robustness	• Videos and metrics showing how to conduct ethical and technical evaluations of AI models. • Computer-based or locally accessible online examples of AI systems. • Computer-based samples of datasets or locally accessible public datasets. • Computer-based applications for AI programming or locally accessible online open-source AI programming libraries. • Locally hosted or open-source cloud computing and other resources shared by institutions through cloud platforms.

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
AI系统设计	**4.2.4 体系结构设计** • 学生应具备构建可扩展、可维护且可复用的人工智能系统架构所需的基础方法论知识与技术能力，该架构需涵盖数据层、算法层、模型层及应用接口层。学生还需培养跨学科技能，能够有效整合数据集、编程工具与计算资源以实现系统开发。 构建一个原型人工智能系统。这包括期望他们应用 在配置、构建和优化过程中深化以人为本的价值观和道德原则。	• **CG 4.2.4.1构建人工智能架构方法论知识与技术技能的获取框架：**促进学生获取 通过实践必要的工程思维与操作技能，评估各类人工智能架构方案，旨在根据明确的问题陈述选择合适解决方案，同时考虑开源选项。提供项目式学习机会，帮助学员掌握原型AI架构配置的方法论知识，涵盖反偏见数据结构、能效优化的AI模型以减少环境负面影响、以人为本的性能与服务设计，以及用于测试和评估配置成熟度的指标体系。 • **CG 4.2.4.2 支持构建人工智能系统开发所需的高级技术技能和项目管理能力：**提供项目式学习机会，帮助学生掌握并应用跨学科技术技能，这些技能是为构建针对特定简单任务（例如模仿聊天机器人回复的对话系统）的人工智能原型系统所必需的。	• **模拟框架和组件的评估人工智能架构配置：**基于问题陈述和可行性研究，帮助学生评估各种人工智能架构框架（例如。使用TensorFlow、PyTorch或Scikit-learn等框架，模拟架构各组件（如数据层、算法层、AI模型层和接口层）的评估与解决方案筛选过程。构建包含所需数据集、算法工具、AI模型及计算资源的原型架构，设计核心功能模块与接口交互，并制定部署方案。指导学生通过流程图、示意图或伪代码等抽象化方式，清晰表达系统配置方案。 • **模拟资源调配构建AI系统：**帮助学生基于本地部署的计算设备或本地可访问的云计算平台（如Hadoop或Spark)以及机器学习模型训练所需的操作系统（如GNU)和软件，构建模拟的AI系统。 指导学生在成本和计算能力需求之间进行权衡，以及在健壮性之间进行权衡	• 视频和指标显示如何对AI模型进行道德和技术评估。 • 基于计算机或本地访问的在线人工智能系统示例。 • 基于计算机的样本数据集或本地可访问的公共数据集。 • 基于计算机的应用程序，用于AI编程或本地可访问的在线开源AI编程库。 • 通过云平台由机构共享的本地托管或开源云计算和其他资源。

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
AI system design		an experienced teacher). Explore the leveraging and normalization of datasets, assembling of virtual computational resources, and selection and enhancements of AI models (e.g. hyperparameter optimization). Guide students to simulate the training of a machine-learning model, including the practical use of computational resources and calling of data to train the models based on the selected and preprocessed datasets. Design and arrange opportunities for students to acquire project management skills including balancing the scope of the AI systems with the resources available, coordinating the division and sharing of responsibilities, and critically evaluating and leveraging AI resources.	of the AI models and their environmental impact, aiming to optimize efficiency and minimize the waste of computational resources. Simulate the enhancement of the architecture including the optimization of hyperparameters and/or fine-tuning of existing AI models to solve simple problems (e.g. transfer learning on top of a pre-existing model, or apply novel neural networks or non-trivial modifications to foundational models). Practise using computational resources and calling data to train machine-learning models based on the selected and preprocessed datasets.	

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
AI系统设计		（有经验的老师）。 探索数据集的整合与标准化处理、虚拟计算资源的整合配置，以及人工智能模型的选择与优化（如超参数调优）。指导学生模拟机器学习模型训练过程，包括计算资源的实际运用和基于预选预处理数据集的模型训练。设计并安排实践机会，帮助学生掌握项目管理技能，包括平衡AI系统需求与可用资源、协调职责分工与资源共享，以及对AI资源进行批判性评估与优化利用。	关于人工智能模型及其环境影响，旨在优化效率和最小化计算资源的浪费。 模拟架构的增强，包括优化超参数和/或现有AI模型的微调，以解决简单的问题（例如在现有模型上进行迁移学习，或应用新的神经网络或对基础模型进行非平凡的修改）。 使用计算资源和调用数据来训练基于所选和预处理数据集的机器学习模型。	

4.3 Level 3: Create

The overall goal of the 'Create' level is to challenge and enable students to develop advanced competencies to configure AI solutions or craft new AI tools based on customizable datasets, programming tools or AI models, with consideration of open-source options. Students will also be supported to reinforce a sense of belonging to a broader community of AI co-creators and enhance their intellectual engagement with the social responsibilities that are required for being a citizen in AI societies. The curricular goals shown in Table 4 aim to inspire the outlining of a set of high-level competencies composed of advanced methodological knowledge on AI, engineering skills for AI system design, and adaptivity in compliance with personal and corporate social responsibilities when creating and testing AI systems. The suggested pedagogical methods and approaches are designed to help solve ill-structured problems and nurture higher-order thinking, including through project-based learning, problem-based exploration of methodological knowledge, and multi-faceted ethical assessments. The suggested learning environments present recommendations on the configuration of datasets, AI programming tools and necessary computational devices to support complex learning with consideration of sharing AI resources and critically leveraging open-source options.

Table 4. Competency blocks for level 3: Create

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
Human-centred mindset	**4.3.1 AI society citizenship** • Students are expected to be able to build critical views on the impact of AI on human societies and expand their human-centred values to promoting the design and use of AI for inclusive and sustainable development. They should be able to solidify their civic values and the sense of social responsibility as	• **CG4.3.1.1 Foster awareness of being a critical AI citizen:** Enable students' to gain evidence-based insights into the pervasive adoption of AI as a supporting infrastructure of social activities in human societies. Foster their awareness and critical views on challenges that human societies are facing, such as prioritizing the acceleration of AI innovation while sacrificing safety and inclusivity, or prioritizing safety first, or and inclusive access. Develop students' skills in critiquing AI-amplified biases against females, marginalized	• **Case studies on conflicts between an inclusive and just AI society and the threats AI poses to inclusion, justice and sustainability:** Organize case studies or project-based learning on the typical conflicts between an inclusive and just AI society and the risks AI poses to human-centred values. Organize a discussion of what is meant by sustainable, inclusive and just societies. Ask students to analyse cases where AI has been pervasively embedded into the infrastructure of societies, and interrogate how AI may amplify biases, widen economic and social	• Unplugged learning settings and resources, including worksheets, flipcharts, reports or videos on jobs and career development in AI societies, and print-based analytical case studies on the societal implications and environmental impact of AI. • Online AI systems or locally available AI tools for experiential and analytical

4.3 第3级：创建

“创作”课程模块的核心目标在于培养学生构建AI解决方案或开发新型AI工具的高级能力，这些工具需基于可定制数据集、编程工具或AI模型，并充分考虑开源选项。课程还将助力学生增强对AI共创社群的归属感，提升其对AI社会公民应尽社会责任的认知与参与度。表4所示课程目标旨在激发学生构建包含以下核心能力的体系：涵盖AI前沿方法论知识、AI系统设计工程技能的高级能力框架。在创建和测试人工智能系统时，根据个人和企业社会责任的适应性。本方案提出的教学方法旨在帮助解决结构化不良问题，培养高阶思维能力，具体包括项目式学习、方法论知识的探究性探索以及多维度伦理评估。在学习环境方面，我们建议配置数据集、人工智能编程工具及必要的计算设备，以支持复杂学习过程，同时注重共享AI资源并充分运用开源解决方案。

表4.第三级：创建的能力模块

	学生能力	**课程目标** (AI课程或学习方案应该...)	**建议教学方法** （各机构和教师可考虑并调整以下学习方法。）	**学环境** （可提供并调整以下学习设置。）
人位于中心的观念模式	**4.3.1 人工智能社会公民权** • 学生应能对人工智能对人类社会的影响形成批判性认知，并将人文价值观拓展至推动人工智能的设计与应用，以促进包容性和可持续发展。他们应当能够巩固公民价值观和社会责任感，成为具有社会责任感的践行者。	• **CG 4.3.1.1 培养AI批判性公民意识：**帮助学生深入理解人工智能作为社会活动支撑基础设施的广泛应用现象，培养基于实证的洞察力。引导他们形成批判性认知，认清人类社会面临的困境——例如在加速AI创新时牺牲安全与包容性，或是一味强调安全优先或全民共享。提升学生批判性分析AI加剧的性别偏见、边缘群体歧视等技术问题的能力。	• **关于包容性和公正性人工智能社会与人工智能对包容性、公正性和可持续性构成的威胁之间的冲突的案例研究：**组织关于包容性和公正性人工智能社会与人工智能对以人为中心的价值观构成的风险之间的典型冲突的案例研究或项目式学习。组织一场关于如何构建可持续、包容且公正社会的讨论。请学生分析人工智能已深度融入社会基础设施的案例，并探讨人工智能可能如何放大偏见、加剧经济与社会不平等。	• 不插电学习环境和资源，包括工作表、翻页板、报告或视频 人工智能社会中的就业和职业发展，以及基于印刷的分析案例研究，关于人工智能的社会影响和环境影响。 • 用于体验和分析的在线AI系统或本地可用AI工具

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
Human-centred mindset	a citizen in an AI society. Students are also expected to be able to reinforce their open-minded attitude and lifelong curiosity about learning and using AI to support self-actualization in the AI era.	ethnic groups and socio-economically disadvantaged people, and the effects of AI on social relationships, norms and structures. Help reveal the reasons behind AI's profound impact on societies and assess how legal, ethical and social rules should be adapted to respond to the challenges. • **CG4.3.1.2 Nurture personal and social responsibilities in AI societies:** Encourage students to share their views on what desirable AI societies would look like and delineate the main responsibilities and obligations that citizens need to undertake in order to build an inclusive, sustainable and just AI society, from the perspectives of both users and designers of AI. Support students to continuously refine their personal responsibilities as AI society citizens. Challenge students to examine challenges in upholding ethical principles for the design and use of AI in complex authentic situations with an aim to reinforce the resilience of their human-centred mindset. • **CG4.3.1.3 Nurture the sense of self-actualization as an AI citizen and the lifelong learning attitude to AI:** Guide students to dynamically review the impact of the adoption of AI across sectors and the	inequality, undermine human agency and worsen climate change. Challenge students to take and defend positions on how existing AI technology can be regulated and how the design of the next generations of AI could be steered to make positive contributions to the building of inclusive and just societies. • **Inquiry on the personal social responsibilities of being an AI society citizen:** Arrange for students to conduct group discussions on the rights of citizens in an AI society, and jointly outline the main obligations and responsibilities that citizens should assume, taking into consideration both global and local contexts, as well as the perspectives of inclusion, equity, social justice, human-centred purposes and impacts on the environment and ecosystems. This includes ensuring humans have control and accountability over all key steps of the AI life cycle. Allow students to conduct and share their self-reflections on personal social responsibilities in an AI society. • **Case studies on self-actualization in AI societies and their implications for lifelong learning:** Organize case studies for students on the adoption of AI in work, life and social practices, and challenge them to review the implications of the adoption of AI for their personal goals, career development	tests including applications on smartphones that provide personal assistants, chatbots, and intelligent tutoring systems.

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
人 位于中心的观念模式	人工智能社会中的公民。学生还应该能够强化自己的开放心态，保持终身学习的好奇心，并学会在人工智能时代运用人工智能来实现自我价值。	不同族裔群体和社会经济弱势人群，以及人工智能对社会关系、规范和结构的影响。帮助揭示人工智能对社会产生深远影响的原因，并评估法律、伦理和社会规则应如何调整以应对这些挑战。 • **CG 4.3.1.2 培养人工智能社会中的个人责任和社会责任：**鼓励学生分享他们对理想的人工智能社会的看法，并阐明公民为建设包容、可持续和公正的社会所需要承担的主要责任和义务 从用户和设计者的双重视角理解人工智能社会。帮助学生持续完善作为人工智能社会成员的个人责任意识。引导学生在复杂真实场景中审视人工智能设计与应用过程中坚守伦理原则的挑战，旨在强化其以人类为中心的思维方式的韧性。 • **CG 4.3.1.3培养作为人工智能公民的自我实现感和终身学习态度：**指导学生动态回顾人工智能在各领域的应用影响	不平等、削弱人类能动性并加剧气候变化。挑战学生就如何监管现有人工智能技术，以及如何引导下一代人工智能的设计以对建设包容和公正的社会作出积极贡献，提出并捍卫自己的立场。 • **关于人工智能社会公民个人社会责任的探讨：**指导学生围绕人工智能社会中的公民权利展开小组讨论，共同梳理公民应承担的核心义务与责任。在制定过程中需统筹全球与本土背景，兼顾包容性、公平性、社会正义、以人为本的价值理念以及对环境生态的影响。这包括确保人类能够掌控并监督人工智能全生命周期的关键环节。鼓励学生开展个人社会责任的自我反思，并分享在人工智能社会中的实践体会。 • **人工智能社会自我实现及其对终身学习的影响的案例研究：**组织学生案例研究，探讨人工智能在工作、生活和社会实践中的应用，并挑战他们审视人工智能的应用对自己个人目标和职业发展的影响	测试包括提供个人助理、聊天机器人和智能辅导系统的智能手机应用程序。

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
Human-centred mindset		competency sets that living and working in an AI society may require. Reflect on personal goals in a society where AI is pervasive, and evaluate the roles of AI in relation to self-actualization. Support students to build an adaptive and persistent attitude towards the lifelong study of AI to support their self-actualization and personal contribution to the sustainable development of societies.	and self-actualization. Guide students to build an adaptive and curious attitude to the lifelong study and use of AI to support their self-actualization and personal contribution to the sustainable development of societies.	
Ethics of AI	**4.3.2 Ethics by design** • Students are expected to be able to adopt an ethics-by-design approach to the design, assessment and use of AI tools as well as the review and adaptation of AI regulations. Students are expected to be aware that the assessment and ratification of the intent of the AI design should start from the conceptualization stage and cover all steps of the AI life cycle. Student should be able to apply parameters to assess the compliance of an AI tool with ethical regulations and use an ethical matrix of	• **CG4.3.2.1 Build awareness and understanding on 'ethics by design':** Provide conflict-based learning opportunities so students can apply an integral set of ethical principles throughout the life cycle of the design and creation of AI. Guide students to assess the ethical properness of AI tools when they are under conceptualization, anti-bias measures in data collection and engineering, discrimination-free methods for training machine learning, human-centred 'guardrails' for generating AI outputs, and the inclusive testing and auditing of AI tools. • **CG4.3.2.2 Develop a critical attitude to the ethics-by-design principles behind existing AI systems and algorithms:** Provide students with opportunities to take a holistic approach	• **Simulating the due diligence of a 'chief ethics officer' in an AI development team:** Design project-based learning practices, ask students to simulate the role of a chief ethics officer of an AI company, including drafting a checklist of ethical criteria for auditing key steps of AI system design, and defining the key due-diligence procedures to follow when overseeing the safety and ethics of the AI system being designed by a team or company. • **Simulating the use of 'ethics label' to audit selected AI tools or algorithms:** Organize students to undertake a mock audit of 'ethics by design' in selected AI tools or systems. Provide lectures on this and support students to research ethics labels for AI systems (an ethics label for AI systems is analogous to a nutrition label for food	• Unplugged learning settings and resources, including worksheets, flipcharts and print-based examples of due diligence checks and reports, ethics labels and matrices, privacy policies of AI creators and regulations on AI. • Locally available AI tools including smartphone apps. • Online AI systems for ethical analysis. • Websites sharing regulations on AI and lawsuits or court cases.

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
人 位于中心的观念模式		在人工智能社会中生活和工作所需的能力培养。思考身处人工智能无处不在的社会时个人目标的定位，评估人工智能在实现自我价值中的作用。帮助学生建立适应性与持之以恒的学习态度，通过终身学习人工智能知识来促进自我实现，并为社会可持续发展作出个人贡献。	和自我实现。 引导学生建立适应性、好奇心强的学习态度，终身学习和运用人工智能，支持自我实现和个人对社会可持续发展的贡献。	
人工智能伦理	4.3.2 设计中的伦理 • 学生应该能够采用“设计即伦理”的方法来设计、评估和使用人工智能工具 人工智能法规的审查和调整。 学生需要明确，人工智能设计的伦理评估与合规审查应当贯穿其整个生命周期，从概念设计阶段就开始实施。 学生应能运用相关评估指标来检验AI工具是否符合伦理规范，并熟练运用伦理评估矩阵进行系统性分析。	• **CG 4.3.2.1 培养对“设计伦理”的认知与理解：**通过冲突式学习提供实践机会，使学生能在人工智能设计与开发的全生命周期中运用核心伦理原则。指导学生评估以下维度的人工智能工具的伦理合理性：概念化阶段的伦理考量、数据收集与工程中的反偏见措施、机器学习训练的无歧视方法、生成AI输出时以人为本的“安全护栏”机制，以及人工智能工具的包容性测试与审计流程。 • **CG 4.3.2.2对现有人工智能系统和算法背后的设计伦理原则培养批判性态度：**为学生提供机会，使其采取整体方法	• **模拟人工智能开发团队中“首席伦理官”的尽职调查工作：**设计项目式学习实践，要求学生模拟人工智能公司首席伦理官的角色，包括为AI系统设计的关键步骤起草伦理标准检查清单，并制定监督团队或公司开发的AI系统安全与伦理时需遵循的主要尽职调查流程。 • **模拟使用“伦理标签”审计选定AI工具或算法：**组织学生对选定AI工具或系统开展“设计伦理”模拟审计。开设相关专题讲座，指导学生研究AI系统的伦理标签（AI系统的伦理标签类似于食品营养标签）	• 不插电的学习环境和资源，包括工作表、翻页板和基于打印的尽职调查检查和报告示例、道德标签和矩阵、人工智能创建者的隐私政策和关于人工智能的法规。 • 本地可用的人工智能工具，包括智能手机应用程序。 • 用于道德分析的在线人工智能系统。 • 分享有关人工智能的法规以及诉讼或法庭案件的网站。

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
Ethics of AI	multi-stakeholders to review AI regulations and inform adaptation.	to applying principles and regulations to the evaluation of the 'ethics by design' of specific AI systems or tools. Develop their critical thinking skills by requesting them to propose recommendations to the creators of AI systems to remedy any identified violations of ethical principles or regulations, and mitigate any harms their AI tools have caused. • **CG4.3.2.3 Cultivating social responsibilities to uphold 'ethics by design' in regulations on AI:** Drawing on selected AI regulations, guide students to evaluate how they align with the ethics-by-design approach and the extent to which corresponding measures are sufficient in monitoring and regulating typical ethical risks embedded in algorithms and AI systems. Enhance students' awareness of, and skills in carrying out, their social responsibilities by guiding them to recommend modifications of existing local regulations or draft proposals on the development of regulations to govern ethics by design in their communities.	items). Guide students to construct or adapt an ethical label to audit the intent of the designers of selected AI systems and services, including collecting information beyond their published statements (e.g. the creators of a shopping-recommendation platform state that its intent is to help customers find the most appropriate products, while the hidden purpose may be to make users dependent on or addicted to using the platform). Write reports on the findings of the audit. • **Simulating the use of an ethics matrix to review regulations on AI and suggest adaptations:** Invite students to research an ethics matrix for involving relevant stakeholders in regulations on AI. Support them to construct an adaptive ethics matrix with core ethical principles forming its columns and relevant stakeholders forming the rows (e.g. AI creators, regulators, institutional deployers and individual users). Students can apply their matrix to analyse relevant articles of a selected regulation and draft reports or reviews including recommendations for further adapting or iterating the regulations. Where local regulations are not available, write a proposal on the creation of a new AI regulation with an outline of articles for relevant stakeholders.	

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
人工智能伦理	多方利益相关者审查人工智能法规并告知适应措施。	将原则和法规应用于特定人工智能系统或工具的“设计伦理”评估。通过要求他们向人工智能系统开发者提出建议，以纠正已发现的违反道德原则或法规的行为，并减轻其AI工具造成的任何危害，从而培养他们的批判性思维能力。 • **CG 4.3.2.3 培养社会责任意识，践行“设计伦理”：**通过选取具有代表性的AI法规案例，引导学生评估相关法规是否符合设计伦理原则，并考察其监测和规范算法及AI系统中常见伦理风险的措施是否充分。通过指导学生提出修订现有地方法规或制定社区设计伦理监管法规草案的建议，增强其社会责任意识与实践能力。	指导学生构建或调整道德标签，用于审计选定人工智能系统和服务的设计者意图，包括收集超出公开声明的信息（例如某购物推荐平台的创建者声称其目的是帮助顾客找到最合适的产品，但潜在目的可能是让用户对使用该平台产生依赖甚至成瘾）。撰写审计发现的报告。 • **模拟运用伦理矩阵审查人工智能相关法规并提出调整建议：**邀请学生研究用于在人工智能相关法规中纳入相关利益相关方的伦理矩阵。指导学生构建可适应性伦理矩阵，以核心伦理原则作为列，相关利益相关方作为行（例如：AI创作者、监管机构、机构部署方及个人用户）。学生可运用其矩阵分析选定法规的相关条款，并撰写报告或审查草案，包括对法规进行进一步调整或迭代的建议。 如果当地没有相关法规，撰写一份关于制定新人工智能法规的提案，并为相关利益相关方概述条款。	

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
AI techniques and applications	**4.3.3 Creating AI tools** • Students are expected to be able to deepen and apply knowledge and skills on data and algorithms to customize existing AI toolkits to create task-based AI tools. Students are expected to integrate their human-centred mindset and ethical considerations into the assessment of the existing AI resources and the test of self-created AI tools. They are also expected to foster social and emotional skills needed to engage in creation with AI including adaptivity, complex communication and teamwork skills.	• **CG4.3.3.1 Challenge and enable advanced skills to develop task-based AI tools:** Provide task-based learning opportunities so students can transfer their values, knowledge and skills to crafting an AI tool based on existing AI models or toolkits. Support their mastery of advanced skills in critically analysing the relevance of existing AI tools to specific tasks, assessing its data collection and processing needs, deciding on whether a low-code approach will be adopted or AI algorithms and programming language are required, and carrying out the operational customization and/or programming. • **CG4.3.3.2 Enhance students' creativity in applying AI knowledge and skills to customize AI toolkits and coding:** Design tasks around customizing AI tools to solve authentic tasks. Guide students to acquire skills in leveraging AI-development platforms or toolkits, enhancing datasets, and modifying programming codes, including those based on open-source options; challenge and support students to explore and test creative ideas on the design of AI tools to solve variations of problems.	• **Task-based enhancement of datasets and programming codes for crafting an AI tool:** Organize students to modify a dataset or create a new one for real-world contexts, by drawing on an authentic task such as monitoring the energy consumption of local schools or households, forecasting weather for a specific location or route, or tracking an epidemic disease. Teach and facilitate students to leverage automatic data-collection tools (e.g. BeautifulSoup[8] for scraping information from webpages); apply AI programming skills to clean, encode and preprocess the data; and use the data to customize AI models or craft AI tools. • **AI application performance test lab:** Guide students to search for and adapt a free and/or open-source performance matrix for the testing of AI applications (e.g. accuracy, precision, F-1 score, confusion matrices and ROC curves). Let students experience the use of adapted tools to test the performance and technological robustness of the crafted AI application, and simulate users' feedback on ethical compliance. Use automated tools to generate visualized reporting and summarize recommendations on the optimization of the AI application.	• Locally accessible free and/or open-source online datasets, AI tools and programming libraries. • Locally accessible free and/or open-source data analytics tools. • Locally accessible cloud-based computing resources, locally hosted computing resources (e.g. a school server), or computing resources shared by trustable institutions or industry agencies.

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
人工智能技术及应用	**4.3.3 创建人工智能工具** • 学生需要能够深化并运用数据与算法知识技能，通过定制化改造现有AI工具包来开发任务导向型AI工具。在评估现有AI资源和测试自主开发的AI工具时，学生需将人文关怀意识与伦理考量融入其中。此外，学生还需培养与AI协作所需的社交情感技能，包括适应能力、复杂沟通技巧以及团队协作能力。	• **CG 4.3.3.1 挑战并赋能高级技能以开发任务型AI工具：**提供基于任务的学习机会，使学生能够将价值观、知识和技能迁移应用到基于现有AI模型或工具包开发AI工具中。帮助他们掌握以下高级技能：批判性分析现有AI工具与特定任务的相关性、评估其数据采集与处理需求、判断是否采用低代码方法或需要AI算法与编程语言支持，以及执行操作定制化和/或编程工作。 • **CG 4.3.3.2提升学生运用AI知识技能定制AI工具包和编程的创造力：**围绕定制AI工具设计任务解决真实任务。引导学生掌握利用AI开发平台或工具包、增强数据集、修改编程代码（包括基于开源选项的）等技能；挑战并支持学生探索和测试AI工具设计的创意想法，以解决各种问题。	• **基于任务的数据集和编程代码增强在开发AI工具时：**组织学生基于真实场景任务（如监测本地学校或家庭能耗、预测特定地点或路线的天气、追踪传染病传播等）来修改现有数据集或创建新数据集。指导并帮助学生熟练运用自动数据采集工具（例如BeautifulSoup [8]用于从网页中抓取信息）；应用AI编程技能清理、编码和预处理数据；并使用数据定制AI模型或制作AI工具。 • **人工智能应用性能测试实验室：**指导学生搜索并适配免费和/或开源的人工智能应用性能测试矩阵（例如准确率、精确度、F-1分数、混淆矩阵和ROC曲线）。让学生体验使用调整后的工具来测试精心设计的人工智能应用程序的性能和技术健壮性，并模拟用户对道德合规性的反馈。使用自动化工具生成可视化报告，并总结有关优化AI应用程序的建议。	• 本地可访问的免费和/或开源在线数据集、AI工具和编程库。 • 本地可访问的免费和/或开源数据分析工具。 • 本地可访问的基于云的计算资源、本地托管的计算资源（例如学校服务器）或由可信机构或行业机构共享的计算资源。

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
AI techniques and applications		• **CG4.3.3.3 Equip students with skills to test and optimize their self-crafted AI tools:** Support students to customize assessment methods and instruments for the testing of their self-crafted AI tools for robustness and ease of use, learn how to organize peer assessments and share feedback, and build collaborative skills as co-creators.	• **Comparing the creation of AI tools through customizing datasets and programming codes with the building of AI applications based on low-code development platforms:** Organize students to search for information on the steps and skills required to create AI tools by customizing the open-source datasets and programming codes of AI toolkits. Guide them to study skills in building AI applications based on low-code development platforms. Organize discussion on the difference between the two approaches in terms of human agency and human determination, the inclusion of data from local communities and reflection of local cultural diversity, and the scalability and reusability of the resulting tools. Discuss how to choose between the two approaches according to specific needs and situations.	
AI system design	**4.3.4 Iteration and feedback** • Students are expected to enhance and apply their interdisciplinary knowledge and practical methods to evaluate the humanistic appropriateness and methodological robustness of	• **CG4.3.4.1 Develop the skills to critique AI systems:** Provide project-based learning opportunities for students to practise skills in critically testing the technological robustness and critiquing the ethical appropriateness of an AI system through auditing whether the model enhances human capacities, agency and consciousness, or weakens them; checking the extent of its explainability and	• **Simulating the performance-test of an AI system:** Organize students to use adapted metrics to weigh whether an AI model enhances or weaken human capacities, agency and consciousness, and evaluate the extent of explainability of its method. Adapt performance metrics on machine learning and associated visualization tools including open-source options (e.g. the F1 score in machine learning, confusion	• Locally accessible online free and/or open-source AI tools including data analytics tools and programming libraries. • Locally hosted or locally accessible cloud computing resources. • Downloaded and adapted instruments for the ethical auditing

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
人工智能技术及应用		• **CG 4.3.3.3 赋予学生测试和优化其自制AI工具的技能：**支持学生为测试其自制AI工具的健壮性和易用性定制评估方法和工具，学习如何组织同伴评估和分享反馈，并作为共同创造者建立协作技能。	• **比较通过定制数据集和编程代码开发AI工具与基于低代码开发平台构建AI应用的差异：**组织学生搜集资料，了解通过定制开源数据集和编程工具包来创建AI工具的具体步骤与所需技能。引导他们学习基于低代码开发平台构建AI应用的技术要点。组织讨论这两种方法在人力参与度、人类决策主导性、融入本地社区数据体现文化多样性、工具可扩展性及复用性等方面的异同。探讨如何根据具体需求和情境选择合适的方法。	
AI系统设计	**4.3.4 迭代和反馈** • 学生应增强和应用他们的跨学科知识和实践方法，以评估人文的适当性和方法论的稳健性。	• **CG 4.3.4.1培养批判性技能** **人工智能系统：**为学生提供基于项目的学习机会，通过批判性测试人工智能系统的技术稳健性，并通过审计模型是否增强人类能力、能动性和意识，或削弱它们；检查其可解释性的程度，以及批判性地评估人工智能系统的伦理适宜性来实践技能。	• **人工智能系统性能测试模拟：**组织学生运用定制化评估指标，判断AI模型是增强还是削弱人类的能力、自主性和意识，并评估其方法的可解释性。调整机器学习相关指标及可视化工具（包括开源选项如机器学习领域的F1分数、混淆损失等），	• 本地可访问的在线免费和/或开源AI工具，包括数据分析工具和编程库。 • 本地托管或本地访问的云计算资源。 • 下载并调整用于道德审计的工具

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
AI system design	an AI model and its impact on individual users, societies and the environment. They should be able to acquire age-appropriate technical skills to improve the quality of datasets, reconfigure algorithms and enhance architectures in response to results of tests and feedback. They should be able to apply human-centred mindset and ethical principles in simulating decision-making on when an AI system should be shut down and how its negative impact can be mitigated. They are also be expected to cultivate their identities as co-creators in the larger AI community.	protection of data privacy; measuring the performance of the AI system; and studying users' feedback to evaluate its broader societal and environmental impact. • **CG4.3.4.2 Support the building of technical skills and social responsibilities in optimizing, reconfiguring or shutting down an AI system:** Offer simulation activities for students to understand corporate social responsibility and acquire interdisciplinary skills to make decisions on the iteration of an AI system based on the results of testing and users' feedback. The activities should involve development of students' technical skills for three possible scenarios: (1) optimization: optimizing the datasets, algorithms, model, design functionalities and/or interface; (2) reconfiguration: revisiting problem scoping and reconfiguring the AI system; and, (3) shutting down: where it is proven that the AI system violates human rights or harms vulnerable groups, students should learn to make decisions to shut down the AI model and quickly put remedial strategies in place. • **CG4.3.4.3 Foster students' self-identities as co-creators in the AI era:** Guide students to nurture the responsibilities of being	matrices and ROC curves) to measure the performance of the AI system. Design and apply research methods (e.g. gathering age-appropriate qualitative and quantitative market data) including feedback from (simulated) end users to study the societal implications and environmental impact of the adoption of the AI model. Synthesize the results and report them in a visual format. • **Simulating AI engineers' corporate decision-making on the iteration of an AI model:** Organize students to play the roles of AI engineers to integrate and interpret results from feedback, considering both AI system design and corporate social responsibility. Make an appropriate decision from multiple choices on the iteration of the AI model: (1) optimization, where the problem scoping is validated and the datasets, algorithms, AI model or interfaces may need to be optimized; (2) reconfiguration, where fundamental flaws are discovered through tests and/or users' feedback in the problem scoping and/or configuration of the architecture; or (3) shutdown, where it is proven that an AI model violates human rights or harms vulnerable groups. Support students to acquire technical skills for optimization and reconfiguration, and learn	and performance testing of AI models. • Access to applicable regulations on AI or governance frameworks. • Locally accessible online collaborative platforms to support resource sharing, peer learning, and the collaborative design and creation of AI tools (e.g. GitHub, arXiV or forum groups).

	学生能力	**课程目标** (AI课程或学习方案应该...)	**建议教学方法** （各机构和教师可考虑并调整以下学习方法。）	**学环境** （可提供并调整以下学习设置。）
AI系统设计	人工智能模型及其对个人用户、社会和环境的影响。 他们应该能够获得与年龄相符的技术技能，以提高数据集的质量，根据测试结果和反馈重新配置算法和增强架构。 他们应该能够运用以人为中心的思维方式和道德原则来模拟决策，即何时应该关闭人工智能系统，以及如何减轻其负面影响。他们还应该培养自己作为更大人工智能社区共同创造者的身份。	保护数据隐私；衡量人工智能系统的性能；研究用户的反馈，以评估其更广泛的社会和环境影响。 • **CG 4.3.4.2 支持在优化、重新配置或关闭人工智能系统时建立技术技能和社会责任：**为学生提供模拟活动，以了解企业社会责任，并获得跨学科技能，以便就迭代做出决策。 基于测试结果和用户反馈建立的AI系统。该活动应涵盖学生在三种可能场景下的技术技能培养：(1)优化： 优化数据集、算法、模型、设计功能和/或界面； (2) 重新配置：重新审视问题范围并重新配置AI系统；以及(3)关闭：当证明AI系统侵犯人权或伤害弱势群体时，学生应学会做出关闭AI模型的决定，并迅速采取补救策略。 • **CG 4.3.4.3在人工智能时代培养学生的共同创造者自我认同：**指导学生培养作为共同创造者的责任	通过矩阵分析和ROC曲线等指标评估人工智能系统的性能。设计并运用研究方法（例如收集适龄的定性与定量市场数据），包括模拟终端用户的反馈，以探究人工智能模型应用的社会影响和环境影响。 综合结果并以可视化格式报告。 • **模拟AI工程师在人工智能模型迭代中的企业决策：**组织学生扮演AI工程师的角色，整合并解读反馈结果，既要考虑AI系统设计，又要考虑企业社会责任。在人工智能模型迭代过程中，从多个选项中做出恰当的决策： (1) 优化，其中问题范围是经过验证的，数据集、算法、AI模型或接口可能需要优化； (2) (2)重构：通过测试和/或用户反馈，在架构问题界定和/或配置阶段发现根本性缺陷；或(3)终止：证实人工智能模型侵犯人权或危害弱势群体。支持学生掌握优化与重构的技术技能，并学习相关知识。	以及人工智能模型的性能测试。 • 适用的访问权限人工智能或治理框架方面的规定。 • 本地可访问的在线协作平台，以支持资源共享、同行学习以及人工智能工具的协作设计和创建（例如。GitHub、arXiV 或论坛群组）。

	STUDENT COMPETENCY	**CURRICULAR GOALS** (AI curricula or programmes of study should…)	**SUGGESTED PEDAGOGICAL METHODS** (Institutions and teachers can consider and adapt the following learning methods.)	**LEARNING ENVIRONMENTS** (The following learning settings can be provided and adapted.)
AI system design		a co-creator of AI tools and the 'driver' of the design of the next generation of AI technology. Develop their sense of belonging to the larger AI community, and encourage them to critically analyse the long-term impacts of AI systems on social relations and individual behaviours by drawing on real experiences of designing and building AI systems. Discuss how regulations or policies should be adapted or created to enhance the governance of AI.	to negotiate and make decisions about shutting down the AI model and what are the possible remedy strategies. • **Engagement with communities of AI creators:** Facilitate interested students to join local or online communities of AI co-creators. Encourage them to participate in online discussions or collaborative development of AI tools, and share open-source datasets and examples of algorithms or AI toolkits.	

	学生 能力	课程目标 (AI课程或学习方案应该...)	建议 教学方法 （各机构和教师可考虑并调整以下学习方法。）	学 环境 （可提供并调整以下学习设置。）
AI系统设计		作为人工智能工具的共同创造者，同时也是下一代AI技术设计的“领航者”。通过分享真实的人工智能系统设计与开发经验，帮助他们建立对更广阔AI社群的归属感，并鼓励他们批判性分析AI系统对社会关系及个人行为产生的长远影响。探讨如何调整或制定相关法规政策，以强化对人工智能的治理。	就关闭人工智能模型以及可能的补救策略进行谈判并做出决定。 **. 与人工智能创造者社区的互动：** 帮助感兴趣的学生加入本地或在线的人工智能联合开发者社区，鼓励他们参与在线讨论或协作开发人工智能工具，并分享开源数据集和算法或人工智能工具包的示例。	

Chapter 5: Applying the framework

This chapter provides some further guidance on the types of considerations that can feed into the successful development and deployment of curricula.

5.1 Aligning AI competencies as the foundation for national AI strategies

The development and implementation of national strategies for AI vary across countries. Around 70 countries have released strategy documents on AI, which often position education as the sector to build local human resources and talent in AI.

In countries with well-entrenched national strategies, the AI CFS can be aligned with existing policy frameworks as a foundation to foster the human-centred mindset and values needed to implement regulations on the ethics of AI, prepare people to be responsible AI users and citizens, and develop local communities of AI co-creators at scale.

Box 1: Recommendation on the Ethics of Artificial Intelligence

Member States should promote the acquisition of 'prerequisite skills' for AI education, such as basic literacy, numeracy, coding and digital skills, and media and information literacy, as well as critical and creative thinking, teamwork, communication, socio-emotional and AI ethics skills, especially in countries and in regions or areas within countries where there are notable gaps in the education of these skills.

Member States should promote general awareness programmes about AI developments, including on data and the opportunities and challenges brought about by AI technologies, the impact of AI systems on human rights and their implications, including children's rights. These programmes should be accessible to nontechnical as well as technical groups.

Source: UNESCO, 2022*a*, pp. 33–34

If a national strategy for AI is released and well-implemented, the implementation of the AI CFS and AI curricula for students should be planned and supported administratively and financially within the broad framework of the AI strategy. Such national strategies are usually triggered by policy responses to the wide-ranging and disruptive impact of AI on work, in terms of both AI-driven job displacement and AI-supported job creation, as well as the prospect of new employment skills that the adoption of AI may require. The foremost policy response to this disruption is system-wide strategies on AI competency development that are comprised of funding and incentive mechanisms as well as specific courses on AI that streamline different trajectories as appropriate for each sector, including school education, technical and

第五章：应用框架

本章提供了关于哪些类型的考虑因素可以为成功开发和部署课程提供进一步的指导。

5.1 将人工智能能力作为国家发展的基础人工智能策略

各国制定和实施人工智能国家战略的情况各不相同。约有70个国家发布了人工智能战略文件，这些文件通常将教育定位为培养当地人工智能人力资源和人才的领域。

在国家战略根深蒂固的国家，人工智能CFS可以与现有政策框架相结合，作为促进以人为核心的思维和价值观的基础，实施人工智能伦理法规，使人们成为负责任的人工智能用户和公民，并大规模发展当地的人工智能共同创造者社区。

方框1：关于人工智能伦理的建议

成员国应推动获取人工智能教育的“先决技能”，例如基础读写能力、数学能力、编程与数字技能、媒体与信息素养，以及批判性思维、创造力、团队协作、沟通技巧、社会情感技能和人工智能伦理技能，特别是在这些技能教育存在显著差距的国家和地区或国内特定区域。

会员国应推动关于人工智能发展的普遍认知方案，包括关于数据和人工智能技术带来的机遇和挑战、人工智能系统对人权及其影响（包括儿童权利）的方案。这些方案应面向非技术人员和技术人员群体。

资料来源：教科文组织，2022年*a*，第33-34页

若能制定并有效落实国家人工智能战略，那么在该战略的总体框架下，应当从行政管理和资金支持两方面规划并推动人工智能课程体系（CFS）及学生人工智能课程的实施。这类国家战略通常源于政策应对人工智能对就业产生的广泛且颠覆性影响——无论是AI驱动的岗位流失问题，还是由此引发的行业变革浪潮。

以及人工智能辅助的就业创造，还有采用AI可能需要的新就业技能前景。应对这一变革的首要政策回应是制定涵盖资金支持、激励机制以及针对各行业量身定制的AI专项课程的系统性人才培养战略，这些课程将根据不同领域需求优化发展路径，包括学校教育、技术培训等

vocational education and training (TVET), higher education, upskilling and reskilling for employees, and lifelong learning programmes for citizens. For countries without an adopted strategy, the AI CFS can serve as a trigger to raise awareness about the importance of national policies on AI in general, and on the development of AI competencies in particular.

The implementation of such strategies and policies is expected to start with the assessment of readiness and programme gaps. The processes and outcomes of the implementation are usually monitored and evaluated, and policy-makers should establish early and regular monitoring of AI competency development programmes when setting up overall mechanisms and methodologies to track implementation. To evaluate AI curricula or agile education programmes, it is particularly important to formulate criteria that cover: the readiness of students and teachers; deficiencies in training and support for teachers' professional development; gaps in curricular goals and content that need to be addressed to support the national AI vision; additions needed to the curricular content to meet immediate and near future needs of the markets; mechanisms for the mobilization and validation of intersectoral support; the degree of curriculum integration; readiness of learning environments; and the quality of the implementation of the curriculum.

职业教育与培训（TVET）、高等教育、员工技能提升与再培训，以及公民终身学习计划。对于尚未制定相关战略的国家，人工智能能力框架（AI CFS）可作为契机，提升对国家人工智能政策重要性的认知，特别是对培养人工智能能力的重视。

预计此类战略和政策的实施将从对就绪程度和方案差距的评估开始，通常对实施过程和结果进行监测和评价，决策者应尽早并定期监测人工智能能力发展方案

在建立跟踪实施情况的整体机制和方法时。

在评估人工智能课程或敏捷教育项目时，制定涵盖以下要素的标准尤为重要：师生的准备程度；教师培训及职业发展支持的不足之处；为实现国家人工智能愿景需填补的课程目标与内容空白；为满足市场近期需求而需补充的课程内容；跨部门支持机制的动员与验证流程；课程整合程度；学习环境的准备情况；以及课程实施的质量。

Box 2: Supporting human resource development: The Republic of Korea's *National Strategy for Artificial Intelligence*

The Republic of Korea's *National Strategy for Artificial Intelligence* has three main focus areas: (1) Establish reliable AI infrastructure, including to support human talent and improve technology; (2) expand the utilization of AI throughout the industrial and social sectors; and (3) respond proactively to social changes, including labour market needs. The strategy seeks to develop an AI ecosystem that results in the full-scale utilization of AI, and establishes the Republic of Korea as a global leader in people-centred artificial intelligence.

To support the achievement of this goal, the Republic of Korea has focused on revising regulations to create a more industry-friendly environment and nurture the productive use of data and AI innovations, the use of AI to streamline governance, the establishment of regulations on AI ethics, and the building of human capital in AI from as early as primary school. The strategy proposes an interdisciplinary AI curriculum and the definition of AI competencies based on the needs of four categories of populations: (1) the general public, who need to be able to use AI, as well as acquire basic AI and data literacy, including knowledge of AI ethics; (2) AI practitioners, who apply AI and software tools in 'AI + X' environments in the labour market; (3) AI professionals, who develop AI platforms and systems; and (4) AI talents, who will resolve AI issues and develop new AI models and algorithms.

In alignment with competency development for these four categories, the strategy suggests regulations to upskill and upgrade industry professionals to the level of professorships in AI, support the expansion of existing AI departments, and mobilize more departments to offer programmes related to AI, including through expanding the scale and diversity of education and research programmes in AI at the master's and doctoral levels and through creating interdisciplinary majors on AI.

As for school level, the strategy seeks to expand learning opportunities on AI with a focus on computational thinking. At the lower grades of primary school, students are offered experiential engagement with AI to foster their interest and curiosity; at the higher primary grades, students are supported to extend their knowledge and skills through applying AI in the learning of core subjects. Secondary-level students have the opportunity to attend AI-centred schools to complete a more advanced AI curriculum. Teachers are also supported to enhance their knowledge and skills on AI through integrating AI in their initial training programmes and providing new degrees on AI pedagogy integration.

Source: Ministry of Science and ICT, Republic of Korea, 2019

方框2：支持人力资源开发：大韩民国*人工智能国家战略*

大韩民国的人工智能国家战略有三个主要重点领域：
(1) 构建可靠的人工智能基础设施，包括支持人才发展与技术升级；(2)推动人工智能在工业和社会各领域的广泛应用；(3)积极应对社会变革需求，特别是劳动力市场变化。该战略旨在打造全面运用人工智能的生态系统，使韩国成为以人为本型人工智能领域的全球领军者。

为实现这一目标，韩国政府着力修订法规以营造更友好的产业环境，推动数据与人工智能创新的高效应用，利用AI优化治理流程，建立人工智能伦理规范，并从基础教育阶段就开始培养人工智能人才。该战略提出构建跨学科的人工智能课程体系，并根据四大群体需求定义AI能力：(1)普通民众需掌握基本AI技能与数据素养，包括人工智能伦理知识；(2) AI从业者需在劳动力市场中运用AI与软件工具进行“AI+X”创新实践；(3) AI专业人才需开发AI平台及系统；(4) AI专家需解决AI相关问题并研发新型AI模型与算法。

为配合这四个领域的专业能力发展，该战略提出以下举措：制定法规提升行业从业者的技能至人工智能教授级别，支持现有人工智能院系的扩展，并动员更多院系开设相关课程。具体措施包括：扩大硕士和博士阶段人工智能教育与研究项目的规模和多样性，以及创建跨学科的人工智能专业。

在教育层面，该战略致力于拓展人工智能学习机会，重点培养计算思维能力。小学低年级通过沉浸式体验激发学生对人工智能的兴趣与好奇心；高年级则通过将人工智能融入核心学科教学，帮助学生拓展知识体系与实践技能。中学生可选择就读人工智能特色学校，修读更进阶的课程体系。教师方面，通过将人工智能融入入职培训项目，并开设人工智能教学法整合新学位课程，系统提升师资队伍的专业素养。

资料来源：大韩民国科学和信息通信技术部，2019年

5.2 Building interdisciplinary core and cluster AI curricula for AI competency

The development of students' AI competency needs to integrate varied channels for learning and practice, including formal courses within the framework of the national curriculum, extracurricular programmes, and informal learning through engagement with families and local communities. While promoting the development and implementation of a national AI curriculum as the main channel for the implementation of the AI CFS, it is also important to consider whether the study programmes provided by the private sector or non-governmental channels are in compliance with the human-centred vision and ethical principles. Reviewing and steering the impact of informal learning channels including digital platforms is also essential, and can be enacted by mandating providers' accountability for safety and ethics if their programmes target students, especially children.

AI has an interdisciplinary nature and complex intrinsic conceptual and practical connections with mathematics, science, engineering, languages, social studies, art, civic and citizenship education, and history as well as various combinations of these subjects. AI also represents both an iterative step and a technological leap in the continuum of digital technologies. In this context, the AI CFS is built upon multidisciplinary knowledge and skills on data, programming, computing structures and the internet as well as the integrated set of conceptual knowledge and skills based on computing and engineering thinking, and scientific reasoning. In parallel, the fostering of a human-centred mindset and the ethics of AI are anchored in students' broad social and emotional skills.

It is therefore necessary to align the AI CFS to countries' general competency frameworks for students, and examine whether the latter need to be adapted or reformed to respond to the new requirements of the AI era. In countries where national digital or ICT competency frameworks for students have been adopted and implemented, an adaptive approach can be considered to integrate AI aspects into them. This requires a redefinition of digital competencies to cover the uncharted values, knowledge and skills required for new iterations or novel domains of AI, and their connections with previous generations of digital technologies.

A set of core AI curricula within formal education programmes is usually considered to be the main channel for providing inclusive opportunities for all students, particularly those who may not have access to AI other than at school. This will require the reconfiguration of national curricula to accommodate the time to be committed to AI courses. The cluster curricula related to AI should be adapted or reformed to enhance their connections with AI competencies, without losing their focus on students' other core competencies. These interdisciplinary core and cluster AI curricula can be integrated into agile structures that are appropriate to national or local educational contexts.

The UNESCO report *K-12 AI curricula: A mapping of government-endorsed AI curricula* (2022*b*) identified four main strategies for integrating AI curricula into K-12 education systems. These include the implementation of AI as a discrete subject; the integration of AI into other existing subjects (usually

5.2 构建跨学科核心课程和集群 AI课程 人工智能能力

培养学生的AI素养需要整合多元化的学习实践渠道，包括国家课程框架内的正规课程、课外项目，以及通过与家庭和社区互动开展的非正式学习。在推动制定并实施以国家AI课程为核心的CFS（公民基础技能）体系时，还需考量私营部门或非政府渠道提供的教育项目是否符合以人为本的理念和伦理准则。同时，对数字平台等非正式学习渠道进行审查和引导其影响也至关重要，可通过要求相关机构对其面向学生（尤其是儿童）的课程承担安全与伦理责任来实现这一目标。

人工智能具有跨学科的性质，与数学、科学、工程、语言、社会研究、艺术、公民教育和历史等学科以及这些学科的各种组合有着复杂的内在概念和实践联系。在数字技术的连续统一体中，人工智能既是一个迭代步骤，也是一个技术飞跃。

在此背景下，人工智能CFS（计算机科学与技术）的构建基于数据、编程、计算结构和互联网等多学科知识与技能，以及基于计算与工程思维、科学推理的整合性概念知识与技能。与此同时，培养以人类为中心的思维模式和人工智能的伦理学植根于学生广泛的社会和情感技能。

因此，有必要将人工智能能力框架（AI CFS）与各国学生通用能力框架相衔接，并研究是否需要对后者进行调整或改革以适应人工智能时代的新需求。在已采用并实施国家数字或信息通信技术能力框架的国家，可考虑采取适应性方法将其融入人工智能领域。这需要重新定义数字能力，涵盖新迭代或人工智能新兴领域所需的新价值、知识和技能，并阐明其与前代数字技术之间的关联。

在正规教育体系中，核心人工智能课程通常被视为为所有学生（尤其是那些在校外难以接触人工智能资源的学生）提供包容性教育机会的主要渠道。这需要对国家课程体系进行调整，以腾出时间用于人工智能课程的教学。与人工智能相关的集群课程应进行优化或改革，既要强化其与人工智能能力的关联性，又不能忽视对学生其他核心素养的培养。这些跨学科的核心课程和人工智能集群课程，可以整合到符合国家或地方教育环境需求的灵活教学框架中。

联合国教科文组织发布的《*K-12人工智能课程：政府认可课程图谱*》（2022年*b*）指出，将人工智能课程融入K-12教育体系主要有四大策略。这些策略包括：将人工智能作为独立学科实施；将其融入现有学科（通常

ICT); cross-curricular approaches in which AI outcomes are integrated into multiple cluster subjects; and AI as an optional, extracurricular or co-curricular activity (e.g. for an extra-curricular club). AI as a discrete subject may be mandated for all students and can be supported by a series of complementary courses in science, technology, mathematics, engineering and design, to meet the diverse abilities, backgrounds and learning needs of students. Under any one or combination of these approaches, the interdisciplinarity has double implications: the core AI curriculum should mobilize students' multidisciplinary values, knowledge and skills in relevant subjects, especially science, technology, engineering, arts and mathematics (STEAM), to act as the foundation of the AI curriculum as exemplified by the United Arab Emirates' Computing, Creative Design and Innovation curriculum (UNESCO, 2024); and the cluster AI curriculum should promote the intrinsic integration of key aspects of the AI competencies into the learning outcomes and navigate them at corresponding progression levels.

Box 3: The United Arab Emirates' interdisciplinary approach to K-12 AI curricula

'By covering computer science, engineering, design, sustainability and visual communication, the Ministry of Education's Computing, Creative Design and Innovation curriculum offers a comprehensive and concise educational framework. It prepares students to thrive in the dynamic and interconnected world by nurturing critical thinking, problem-solving abilities and innovation.'

The United Arab Emirates takes an interdisciplinary approach to its AI curriculum for K-12 schools by integrating it into a curriculum called Computing, Creative Design and Innovation (CCDI). By including a focus on AI, the CCDI curriculum encourages students to develop their creativity and problem-solving skills; build an awareness of ethics and ethical impacts; learn and rehearse fundamental AI principles and concepts; and cross-fertilize their knowledge across fields. The curriculum was first established in 2016 as a technology-focused subject area, over and above the already-existing computer science curriculum.

Since then, and with the recent developments in the field of AI, the CCDI has progressively integrated robotics, programming, 3D-modelling and electronics. In 2020 the curriculum was revised to cover five domains: (1) computer science, with a focus on computer systems, networks and the internet, data and analysis, algorithms and programming, and the impacts of computing; (2) engineering principles and systems, with a focus on electricity and electrons, robotics and systems, and embedded systems; (3) design and innovation, including entrepreneurship and the engineering design process; (4) sustainability, with an emphasis on the sustainable society; and (5) visual communication, concentrating on graphics for design, computer-aided design and design realization.

Source: UNESCO, 2024

人工智能教育包含三大路径：一是跨学科整合模式，将AI成果融入多个学科领域；二是将AI作为选修课、课外活动或辅修项目（如课外俱乐部）；三是设立独立学科，要求所有学生必修，并通过配套的科学、技术、数学、工程与设计课程体系，满足不同学生的能力水平、背景差异及学习需求。无论采用哪种单一路径或组合方案，这种跨学科融合都具有双重意义：其一是核心AI课程体系应调动学生在相关学科（特别是科学、技术、工程、艺术与数学，简称STEAM）中的跨学科价值观、知识和技能，将其作为人工智能课程的基础——阿联酋的计算、创意设计与创新课程（联合国教科文组织，2024年）便是典型范例；同时，集群式人工智能课程应推动核心AI能力要素的内在整合，将其融入学习成果，并根据相应学习阶段进行循序渐进的引导。

方框3：阿拉伯联合酋长国在K-12人工智能课程方面的跨学科方法

教育部推出的计算、创意设计与创新课程体系，通过涵盖计算机科学、工程设计、可持续发展及视觉传播等领域的知识模块，构建起全面而精炼的教育框架。该课程致力于培养学生的批判性思维能力、问题解决技巧与创新精神，助力他们在瞬息万变的互联世界中脱颖而出。

阿拉伯联合酋长国在K-12学校的人工智能课程中采取跨学科教学法，将其整合到名为“计算、创意设计与创新”（CCDI）的课程体系中。该课程通过聚焦人工智能领域，旨在培养学生创造力和解决问题能力，培养对伦理及其影响的认知，学习并实践人工智能基础原理与概念，并促进跨学科知识融合。该课程体系于2016年首次设立，作为技术导向的学科领域，补充了原有的计算机科学课程体系。

自那时起，随着人工智能领域的最新发展，CCDI逐步整合了机器人技术、编程、三维建模和电子学。2020年课程体系进行了全面修订，涵盖五大核心领域：(1)计算机科学，重点包括计算机系统与网络、互联网、数据与分析、算法与编程，以及计算技术的影响；(2)工程原理与系统，聚焦电力与电子技术、机器人系统及嵌入式系统；(3)设计与创新，包含创业精神与工程设计流程；(4)可持续发展，着重构建可持续社会；(5)视觉传达，主要涉及设计图形、计算机辅助设计及设计实现。

资料来源：教科文组织，2024年

5.3 Framing future-proofing and locally feasible AI domains as carriers of the curriculum

After determining the interdisciplinary alignment structure of core and cluster AI curricula, curriculum developers will need to integrate the AI CFS into national or institutional core AI curricula. The framing of the core AI curriculum is built on interlinked key aspects of the AI competencies, subdomains of AI under each aspect, and specific AI systems to act as carriers of the curriculum. Decisions about making the curriculum compulsory or elective is framed by at least three factors: the foundational value of different aspects, the future-proofing potential of AI knowledge and skills, and the feasibility of implementation in local schools. The feasibility of AI domains and systems is determined by the AI readiness of teachers and students, and the local availability and affordability of generic AI systems and specific hardware, software, programming languages and essential applications for the majority of schools.

As explained in Chapter 4, the human-centred mindset, AI ethics, and AI techniques and applications are crucial to all students' lives and work in the AI era, and thus should be included in all AI curricula. Some domains, such as AI system design, may be more appropriate for students who have a strong interest and ability in AI. Assessing the extent of local AI readiness can inform decisions on whether AI system design should be defined as a set of thinking skills that can be merged into other aspects or should be taught as a discrete domain if the necessary databases, computing resources and AI models are available.

Within the framework of a selected aspect or domain of AI, the next step is the scoping of the subdomains of AI techniques and technologies to be covered, and the specific AI systems to recommended as carriers of the curriculum or learning practices. This is more pronounced for the aspect of AI techniques and applications. The range of techniques is vast, including logic systems or algorithms crafted from general deductive principles to solve specific problems (e.g. human-coded decision trees, alpha-beta pruning and minimax), as well as models trained on large amounts of data (e.g. deep learning and generative AI). Curriculum developers need to choose subdomains from a large list of exemplar AI techniques and specify their relations, such as classical AI or 'rule-based AI', machine learning, deep learning and generative AI models. The range of AI technologies and human-facing products and services is expanding rapidly, and it's more challenging to choose from AI technologies being developed across sectors, including from the categories of computer vision, natural language processing, automated speech recognition, and automated planning and scheduling (AI planning). Following the selection and scoping of subdomains of AI techniques and technologies, examples of AI systems and tools should be considered, with a view to being agnostic towards commercial brands or products as much as possible. As stated in Principle 5 of Chapter 2, rigorous public validation mechanisms should be applied to prevent the use of AI systems that discriminate against marginalized groups or produce bias(es) related to gender, ability, socio-economic status, language and/or culture. The principle of inclusivity should be upheld when choosing AI tools.

5.3 将未来防御和本地可行的人工智能领域框架化课程的承载者

在确定核心课程与集群式人工智能课程的跨学科衔接结构后，课程开发者需要将人工智能核心框架（CFS）整合到国家或机构层面的核心人工智能课程体系中。核心课程框架的构建基于三个关键要素：人工智能能力的核心要素、各要素下的子领域，以及作为课程载体的具体人工智能系统。关于课程设置为必修或选修的决策，需综合考量三大因素：不同要素的基础价值、人工智能知识技能的前瞻性潜力，以及地方学校实施的可行性。人工智能领域的可操作性取决于师生的人工智能素养水平，以及大多数学校能否负担通用人工智能系统、专用硬件、软件、编程语言及基础应用的使用成本。

正如第四章所述，在人工智能时代，以人类为中心的思维方式、AI伦理以及相关技术和应用对所有学生的生活和工作都至关重要，因此应当纳入所有AI课程体系。某些领域（如AI系统设计）可能更适合对AI有浓厚兴趣且具备相应能力的学生。评估本地AI发展水平有助于决策：当具备必要数据库、计算资源和AI模型时，是否应将AI系统设计定义为可与其他学科融合的思维技能集合，或作为独立学科进行教学。

在选定的人工智能领域框架下，下一步需要界定人工智能技术与应用的子领域范围，并推荐特定AI系统作为课程或学习实践的载体。这一需求在人工智能技术与应用领域尤为突出。该领域的技术涵盖范围极为广泛，包括基于通用演绎原则构建的逻辑系统或算法，这些工具专门用于解决特定问题（例如：人类编码的决策树、α-β剪枝法和极小极大优化算法，以及基于海量数据训练的模型（如深度学习和生成式人工智能）。课程开发者需要从大量典型人工智能技术中筛选子领域，并明确其关联关系，例如经典人工智能与“规则型人工智能”、机器学习、深度学习及生成式人工智能模型。随着面向人类的AI技术及产品服务范围快速扩展，从计算机视觉、自然语言处理、自动语音识别、自动化规划调度(AI规划）等跨领域技术中进行选择变得愈发具有挑战性。在选定并界定AI技术的子领域后，应尽可能避免对商业品牌或产品产生偏见，转而重点考察各类AI系统和工具的可行性。如第2章原则5所述，应采用严格的公共验证机制，以防止使用歧视边缘化群体或产生与性别、能力、社会经济地位、语言和/或文化相关的偏见（es）的人工智能系统。在选择人工智能工具时，应坚持包容性原则。

Furthermore, which AI domains should be defined as compulsory and which can be elective will be determined by the national context, including the aims and ambitions of relevant policies and readiness as stated above. The depth and breadth of domain-specific AI knowledge and skills should be defined based on the typical readiness and abilities of the target cohorts of students. It is imperative for all students to reach the first two levels of Human-centred mindset, Ethics of AI, and AI techniques and applications, but it is less necessary for them to reach the third level, 'Create', especially for AI system design. Therefore, it might be useful to consider an agile or contextualized implementation strategy, in which both compulsory and elective subjects or courses will be designed and offered to students for different AI techniques and key domains of AI knowledge.

By anchoring AI competencies in a human-centred mindset and embodied and social knowledge and skills in ethics, the AI CFS aims to prepare students to collaborate with future-oriented AI in a range of contexts. The systemic AI design thinking, knowledge and skills are intended to foster an open knowledge schema that can support students to understand, use and create future generations of AI systems. The AI CFS emphasizes the importance of transferable knowledge and skills under the aspect of AI techniques and applications that can help the majority of students to be ready for the further iterations of AI tools. While efforts have been made to ensure that this curriculum framework responds to emerging technologies, new tools and innovations will emerge after it is published, and the example tools and activities may become obsolete or dated. The curriculum itself will need to include content that can be adjusted going forward in order to remain relevant and 'future-proof'. A modular curriculum design is suggested, in which multiple modules based on AI domains or different AI systems or tools can be developed and recommended to local educational institutions. A modular structure allows the curriculum to be reviewed and updated more dynamically, as it is not necessary to change the entire curriculum to add or remove a specific tool, domain concept or other content. On the other end of the spectrum, future-proofing can involve schools and students co-designing AI curricula. This means encouraging the drafting of school-based AI curricula and teachers' contextual adaptations of specific domains or tools selected for general competency development. To enact this framework, curriculum developers should consider the dynamism of an AI curriculum and make efforts to future-proof the learning process.

5.4 Tailoring age-appropriate spiral curricular sequences

The AI CFS naturally entails a paradigm shift towards competency-based education. A competency-based education aims to transition from models of fixed time and flexible learning (implying completing instruction within a fixed curricular schedule regardless of whether all students have reached the expected mastery level) to more flexible time and fixed learning (implying that flexible learning schedules are allowed so that students of all abilities can reach the expected mastery level). With competency-based education, students are expected to demonstrate performance-based knowledge, skills and values that constitute the competencies, and students who do not

此外，哪些人工智能领域应被定义为必修课，哪些可以选修，将由国家背景决定，包括相关政策的目标和雄心以及上文所述的准备程度。特定领域人工智能知识和技能的深度与广度应根据目标学生群体的典型准备程度和能力来定义。

所有学生都应掌握以人类为中心的思维模式、人工智能伦理学以及AI技术应用这两个基础模块，但第三阶段“创造”能力的培养则相对次要，特别是在AI系统设计领域。因此，采用灵活的情境化教学策略可能更为适宜——通过设置必修与选修课程相结合的方式，让学生系统学习不同AI技术及核心知识领域的相关课程。

人工智能能力框架（AI CFS）通过将AI能力扎根于以人为本的思维模式，融合实践性与社会性知识技能，并融入伦理规范，旨在培养学生在多元场景中与面向未来的AI协同工作的能力。系统化的AI设计思维、知识体系与技能培养，将构建开放的知识框架，助力学生理解、运用并开发新一代AI系统。

人工智能CFS强调了在人工智能技术和应用方面可转移的知识和技能的重要性，这可以帮助大多数学生为人工智能工具的进一步迭代做好准备。

尽管已作出努力，确保本课程框架对新兴技术作出反应，但本框架发布后，新的工具和创新将出现，示范工具和活动可能过时或陈旧。课程本身需要包括以下内容：为了保持课程的时效性和未来适应性，未来可对现有体系进行调整。建议采用模块化课程设计模式，即根据人工智能不同领域或系统工具开发多个模块，并向地方教育机构推荐。这种模块化结构能实现更灵活的课程更新——无需因添加或删除特定工具、领域概念等而全面调整课程体系。另一方面，未来适应性培养可引导师生共同设计人工智能课程，具体包括：鼓励制定校本化人工智能课程，并指导教师根据实际教学需求对选定的特定领域或工具进行情境化调整，以促进学生综合能力发展。为落实这一框架，课程开发者应当考虑人工智能课程的活力，并努力使学习过程具有前瞻性。

5.4 量身定制适合年龄的螺旋式课程序列

人工智能CFS自然需要向基于能力的教育模式转变。

基于能力的教育模式旨在实现从固定时间与灵活学习（即在固定课程安排内完成教学，不论学生是否达到预期掌握水平）到更灵活时间与固定学习（允许弹性学习时间，使不同能力水平的学生都能达到预期掌握水平）的转变。在这种教育模式下，学生需要展示构成能力的知识、技能和价值观，而未能达到这些标准的学生

meet these minimal standards are provided with additional support until they do (Patrick and Sturgis, 2017).

This framework does not break down the progression of learning or activities by grade level, focusing instead on the exit-level outcomes which systems should seek to achieve for all students. Curriculum developers will therefore need to leverage the framework and its components to develop a scaffolded spiral learning pattern across all four aspects, allowing for students to start the learning of AI with the domains and difficulty level that match their abilities and the readiness of their schools. The spiral curricular pattern should provide spaced and iterated engagement with a set of foundational AI knowledge that will encourage both memory retrieval and cyclically upgraded practices to deepen their understanding and associations with problem-solving contexts. This design helps ensure a transfer of information from the working memory to the long-term memory to support sustained learning gains, as well as enable students to leverage existing schemas to learn novel AI knowledge, or adapt application skills to solve problems in varied contexts. Conversely, a curriculum developed and delivered as a one-off over a short period of time (e.g. for hackathons or bootcamps) may spark interest but is less likely to lead to sustained AI competency.

The work of curriculum developers will be to outline the main elements of AI ethics, foundational knowledge and skills as well as system design thinking, and then identify appropriate levels of difficulty, breadth and depth of these elements for different grade levels. This will enable them to create spiral iterations of lessons and project-based tasks that help students to progressively advance and expand their learning and practice.

Box 4: The spiral curricular sequence of 'Day of AI' courses

The AI curriculum developed by MIT's RAISE[9] initiative, Day of AI, adopted the spiral design approach by clustering curricular content around key topics such as 'What AI is, and what AI does well and what AI does not do as well', 'How AI works', 'How a machine learns' and 'How a machine creates'. Students at different ages were given opportunities to continuously engage in topics such as 'What is AI?', while being gradually exposed to novel or upgraded knowledge and skills such as algorithms and AI programming, teachable machines and generative AI. Cross-cutting topics around ethics, including AI biases, human rights, human–AI interaction and the social impact of AI were tailored to students at different age levels.

For more information: https://dayofai.org

达到这些最低标准的人会得到额外的支持，直到他们做到为止（Patrick和Sturgis，2017）。

该框架并未按年级划分学习进程或活动，而是聚焦于教育系统应为全体学生实现的最终成果。课程开发者需运用该框架及其组成部分，在四大维度构建分层螺旋式学习模式，使学生能根据自身能力与学校准备情况，从与其匹配的领域和难度级别开始学习人工智能。这种螺旋式课程模式应通过间隔式和迭代式接触基础AI知识，既促进知识记忆提取，又推动循环升级实践，从而深化学生对问题解决情境的理解与关联。这种设计有助于确保信息从工作记忆向长期记忆的迁移，从而支持持续的学习进步。同时帮助学生利用现有认知框架学习新型人工智能知识，或调整应用技能以解决多样化情境中的问题。反之，那些作为一次性短期活动（如黑客马拉松或训练营）开发并实施的课程，虽然能激发兴趣，但较难培养出持久的人工智能能力。

课程开发者的任务是系统阐述人工智能伦理的核心要素、基础知识与技能体系，以及系统设计思维，进而为不同年级制定各要素的难度分级、知识广度和深度要求。通过这种分级设计，他们能够构建螺旋式迭代的教学方案和项目化学习任务，帮助学生循序渐进地深化学习内容，拓展实践能力。

方框4：“人工智能日”课程的螺旋式课程序列

麻省理工学院RAISE [9]计划开发的人工智能课程《人工智能日》采用螺旋式设计法，围绕“人工智能的本质、优势与局限”、“工作原理”、“机器学习机制”及“生成式AI应用”等核心主题构建课程体系。针对不同年龄段的学生，课程设置了持续探索“人工智能是什么”的模块，同时逐步引入算法与编程、可教机器学习、生成式AI等前沿知识。课程还特别设计了涵盖伦理议题的跨学科模块，包括人工智能偏见、人权保障、人机交互规范及社会影响分析等内容，并根据学生年龄阶段量身定制教学内容。
详细信息请访问：https://dayofai.org

5.5 Building enabling learning environments for AI curricula

While the required resources for the implementation of AI curricula may vary depending on the breadth and depth of expected curricular goals and overall digital readiness in local schools, a basic learning environment is required to meet minimum standards for effective study of the essential aspects and domains of AI to the basic mastery level. According to UNESCO's report *K-12 AI curricula: A mapping of government-endorsed AI curricula* (2022*b*), implementation for school students requires the following essential conditions, ranked by importance: teacher training and support, teaching resources on AI, needs analysis and school-based research, updated digital infrastructure in schools, and the provision of AI resources including through procurement of hardware and software as well as engagement with the private or third sector to share AI devices and systems. If these conditions are not provided, the curriculum is unlikely to be implemented as intended or achieve its anticipated learning and competency objectives. The report highlighted typical learning environments that had been set up by the 11 countries that were implementing their own governmental K-12 AI curricula as of 2022, detailed below.

Box 5: Typical enabling learning environment set up by governments' AI curricula

- **Hardware and robotics:** The hardware needed for AI curricula may include computers, tablets, laptops and internet access. Not all AI curricula include content on robots or robotics. When the learning on robots is required, curricula can leverage free online virtual applications or locally affordable kits. Devices like Raspberry Pi are used by some curricula that require students to create programs and test them using low-cost devices.
- **Software:** The Ubuntu[10] open-source operating systems were used by some curricula as less expensive alternatives to other operating systems.
- **Programming languages:** National AI curricula have often leveraged free programming languages such as HTML, Javascript, Python, Micropython, NumPy, R and Scratch.
- **Tools for learning AI techniques:** A number of tools have been developed or made accessible free of charge to facilitate understanding and allow the exploration of complex concepts and AI techniques, with the following mentioned in the 11 governmental AI curricula: MachineLearningForKids (an educational tool for teaching kids about machine learning by letting them train a computer to recognize text, pictures, numbers, sounds or other inputs),[11] Teachable Machine (a platform developed by Google to train a computer to recognize the user's own images, sounds and poses),[12] TensorFlow (an end-to-end platform for machine learning),[13] and Keras (deep learning for humans).[14]

Source: UNESCO, 2022*b*, p. 47

5.5 为人工智能课程建立学习环境

虽然实施人工智能课程所需的资源可能因当地学校预期课程目标的广度和深度以及整体数字化准备情况而有所不同，但需要一个基本的学习环境来满足有效学习人工智能基本方面和领域的最低标准

人工智能基础掌握水平。根据联合国教科文组织*K-12人工智能课程：政府认可的人工智能课程图谱*（2022 *b*）报告，实施面向中小学生的AI课程需要满足以下基本条件，按重要性排序为：教师培训和支持措施包括：提供人工智能教学资源、开展需求分析与校本研究、更新校园数字基础设施，以及通过采购软硬件设备、与私营或第三方机构合作共享AI设备系统等方式提供相关资源。若无法满足这些条件，课程计划很可能无法按预期实施，也无法实现预期的教学目标和能力培养。报告重点介绍了截至2022年已推行政府K-12人工智能课程的11个国家所建立的典型学习环境，具体如下。

方框5：政府人工智能课程设置的典型支持性学习环境

- **硬件和机器人：**AI课程所需的硬件可能包括电脑、平板、笔记本电脑和网络连接。并非所有AI课程都包含机器人或机械工程内容。当需要学习机器人相关知识时，课程可以利用免费的在线虚拟应用或本地经济实惠的套件。例如树莓派（Raspberry Pi）这类设备，就被一些课程用于让学生使用低成本设备编写程序并进行测试。
- **软件：**一些课程使用Ubuntu [10]开源操作系统，作为其他操作系统的较便宜的替代品。
- **编程语言：**国家人工智能课程经常利用免费的编程语言，如HTML、Javascript、Python、Micropython、NumPy、R和Scratch。
- **人工智能学习工具：**为帮助人们理解复杂概念并探索相关技术，目前已有多种工具被开发或免费开放使用。以下工具在政府人工智能课程中被重点提及：机器学习儿童版（通过让孩子们训练计算机识别文本、图片、数字、声音或其他输入方式，从而教授儿童机器学习知识）、[11]可教机器（谷歌开发的平台，用于训练计算机识别用户自身的图像、声音和姿势）、[12] TensorFlow（端到端机器学习平台）[13]以及Keras（面向人类的深度学习框架）。[14]

资料来源：教科文组织，2022年*b*，第47页

To provide enabling learning environments for AI competency development and the implementation of an AI curriculum in particular, governments should commit to universal access to internet connectivity for all schools and students, including through agile 'online + offline' solutions, to engage with online or mobile AI systems, customizable applications, basic and extendable learning resources, and peer learners or co-creators. The prerequisite digital infrastructure also includes a modest number of well-functioning digital devices with basic connectivity as well as a minimum amount of software or applications for students to learn operational skills, practise programming, and train virtual machine or AI models.

Where these essential conditions are not yet realized, but the government is determined to initiate an AI curriculum at the earliest possible stage, alternative options should be considered in the provision of enabling learning environments. With regard to the AI CFS, most objectives under the first two aspects, Human-centred mindset and Ethics of AI, can be engaged with, at least partially, through online and offline solutions, which are also defined as unplugged solutions. For the aspect of AI techniques and applications, some well-designed unplugged activities have been made available by academic and non-profit organizations to demonstrate conceptual knowledge on AI tools and the understanding of AI techniques (e.g. the unplugged AI activities designed by Everyday AI,[15] AI Unplugged,[16] and the International Society for Technology in Education).[17] Even in fully connected learning settings, unplugged solutions have value by providing students with opportunities to retreat from algorithm-controlled information cocoons and interactions with digital platforms to practise independent, autonomous contemplation, which is critical for the progressive construction and deepening of conceptual knowledge on AI.

5.6 Promoting the professionalization of AI teachers and streamlining their support

As stated above, the most important preconditions for the implementation of AI curricula for school students are teacher training and support as well as the provision of teaching resources on AI. The achievement of the goals outlined by the AI CFS will require teachers, particularly those in ICT or AI, to continuously develop and update their subject knowledge and pedagogical capacities in designing and facilitating age-appropriate learning activities on AI. National and institutional strategists need to plan and implement an integrated approach to the reform of pre-service programmes to prepare qualified AI teachers, design and provide competency-based training and long-term support for in-service ICT or AI teachers, and enhance upskilling for teachers in other core subjects to foster interdisciplinary AI competency. All these training and support programmes aim to strengthen the competencies of teachers who are tasked with teaching AI or implementing the national AI curriculum, implying a trend toward the professionalization of AI teachers. This professionalization includes setting up frameworks specifically for AI teachers, or alternative and more agile mechanisms, that define and develop a set of professional competencies to fully realize the goals of the AI curriculum for students. As ICT and AI are often categorized as marginal subjects

为构建促进人工智能能力发展的学习环境并落实相关课程体系，各国政府应确保所有学校和学生都能普遍接入互联网，可通过灵活的“线上+线下”解决方案实现这一目标。具体措施包括接入在线或移动AI系统、使用可定制应用程序、配备基础且可扩展的学习资源，以及组织同伴学习者或共创者参与。数字基础设施的必备条件还包括：数量适中的功能完备设备（具备基本网络连接），以及为学生提供学习操作技能、编程实践和训练虚拟机/AI模型所需的基础软件或应用程序。

当这些必要条件尚未实现，但政府决心尽早启动人工智能课程时，在构建支持性学习环境方面应考虑替代方案。就人工智能课程框架而言，前两个维度——人文关怀思维与人工智能伦理——的大部分目标，至少可以通过线上线下结合的方式部分达成，这类解决方案也被定义为“离线教学方案”。在人工智能技术应用维度，学术机构和非营利组织已推出精心设计的线下活动，旨在展示人工智能工具的概念知识，并帮助理解相关技术原理（例如：由每日人工智能、[15]人工智能不插电[16]和国际教育技术协会设计的不插电人工智能活动。[17]即使在完全互联的学习环境中，不插电解决方案也有价值，因为它为学生提供了从算法控制的信息茧中退缩的机会。

与数字平台的互动来实践独立、自主的沉思，这对人工智能概念知识的逐步构建和深化至关重要。

5.6 促进人工智能专业化教师和简化他们的支持

如前所述，实施面向中小学生的AI课程体系需要满足三大核心条件：教师培训与支持体系的完善、AI教学资源的充分供给。要实现人工智能课程标准（AI CFS）设定的教学目标，关键在于持续提升教师队伍的专业素养——特别是信息通信技术（ICT）与人工智能领域的教师，使其能够设计并开展符合学生年龄特征的AI学习活动。国家和教育机构的战略规划者需制定系统性改革方案：既要培养合格的AI教师，又要设计基于能力的培训体系并为在职ICT或人工智能教师提供长期支持；同时要提升其他核心学科教师的跨学科教学能力，推动知识体系的深度融合。

人工智能能力培养。所有这些培训和支持计划旨在提升负责教授人工智能课程或实施国家人工智能课程的教师的专业水平，这反映出人工智能教师职业化趋势的形成。这种专业化包括为人工智能教师建立专门的培养框架，或开发更灵活的替代机制，通过明确界定并培养专业能力体系，从而充分实现人工智能课程对学生目标的达成。由于信息通信技术和人工智能常被视为边缘学科

in school curricula, the professional status of ICT and AI teachers has not been fully recognized. The professionalization of AI teachers also means that AI should be classified as one of the core subjects and AI teachers should be entitled to the same professional status as teachers in other core subjects, with their teaching hours and performance being equally recognized in personnel management systems.

Box 6: An AI competency framework for AI subject teachers in China

In China, an AI competency framework for AI subject teachers was developed by the National Institute for Education, East China Normal University and Tencent. Even though it's not a government-driven national AI competency framework, it is a clear indication of the professionalization of AI teachers. It defines a comprehensive set of competencies for AI teachers, which encompasses six dimensions: understanding and awareness, basic knowledge, basic skills, problem-solving capability, teaching practices, and ethics and security. Accordingly, teachers must grasp AI's foundational conceptual logic and societal impact, appreciating the distinctions between human and machine intelligence, and the significance of human-machine collaboration, with a view to AI's educational roles. Unlike the UNESCO *AI competency framework for teachers*, the framework is aimed at AI teachers; the aspects of human-centred mindset and professional development are not covered, and no progression levels are provided.

For more information: http://www.jyb.cn/rmtzcg/xwy/wzxw/202203/t20220325_686401.html

In countries where public teacher education institutions do not have sufficient capacities to upskill teachers to keep pace with the rapid changes of AI technologies, public–private partnerships for the development and provision of AI curricula are often mobilized to leverage the human and material resources of the private AI industry or NGOs to partly or fully substitute for a public AI curriculum and ICT or AI teachers. As these resourceful AI companies and NGOs have a strong interest in reinforcing their presence and dominance in the teaching of AI based on their own brands, this approach risks the de-professionalization of public AI teachers. It is recommended that public–private partnerships are mobilized with a clear purpose of contributing to the preparation of upskilling public AI teachers and supporting their continuous professional development. Moreover, the comprehensive competency frameworks for AI teachers to meet the needs of implementing the AI CFS and national AI curriculum should be used to define a rigorous set of criteria to validate whether the AI courses and trainers developed by the AI industry are trustworthy, anti-bias, relevant for AI competency development and sufficiently brand-agnostic. Such frameworks should also help verify how the AI courses can be properly integrated into school curriculum systems to supplement rather than replace the public curriculum. The accountability of public schools for continuously improving teachers' capacities in implementing the AI curriculum should be prioritized instead of being weakened.

在学校的课程中，ICT和AI教师的专业地位还没有得到充分的承认。人工智能教师的专业化也意味着人工智能应该被归类为核心学科之一

人工智能教师应当享有与其他核心学科教师同等的专业地位，在人事管理制度中对其教学时数和业绩予以同等认可。

方框6：中国人工智能学科教师的人工智能能力框架

在中国，华东师范大学国家教育科学研究院与腾讯公司共同制定了面向人工智能学科教师的人工智能能力框架。虽然该框架并非政府主导的国家级人工智能能力标准，但其出台充分彰显了人工智能教师职业化的趋势。该框架从认知理解、基础知识、核心技能、问题解决、教学实践及伦理安全六大维度，为教师构建了完整的能力体系。根据要求，教师需掌握人工智能的基础理论逻辑与社会影响，理解人机智能的本质区别及人机协同的重要价值，从而更好地发挥人工智能在教育中的作用。值得注意的是，与*联合国教科文组织发布的教师人工智能能力框架*不同，本框架专为人工智能教师量身打造，既未涉及以人为本的教学理念与职业发展内容，也未设置分级进阶体系。
详细信息请访问：http://www.jyb.cn/rmtzcg/xwy/wzxw/202203/t20220325_686401.html

在公共教师培训机构缺乏足够能力提升教师技能以适应人工智能技术快速变革的国家，政府常通过公私合作模式开发AI课程。这种模式借助私营人工智能企业或非政府组织的人力物力资源，部分或完全替代公立学校的AI课程及信息通信技术（ICT）或人工智能教师。然而，这些资源丰富的AI企业和非政府组织出于自身品牌推广的考量，往往试图在AI教育领域扩大影响力，这种做法可能导致公立AI教师的专业性流失。建议通过公私合作明确目标，重点提升公立AI教师的技能水平，并为其持续专业发展提供支持。

此外，应通过制定人工智能教师综合能力框架来满足实施AI课程标准（CFS）和国家人工智能课程体系的需求。该框架需建立严格标准，用以验证人工智能行业开发的课程及培训师是否具备可信度、无偏见且符合能力培养需求，并确保其具备足够的品牌中立性。此类框架还应帮助确认如何将人工智能课程有效融入学校课程体系，实现对公共课程的补充而非替代。公立学校应优先承担起持续提升教师实施人工智能课程能力的责任，而非被弱化这一职责。

To promote the professionalization of public AI teachers, it is also important to adopt the requirement of implementing the AI CFS as a benchmark to streamline pre-service and in-service training and continuing support for teachers' professional development, to ensure they are aligned with a set of clearly defined competencies and are complementary in scaffolding teachers' progressive improvement throughout their career. Special attention should be given to the engagement, review and adaptation of continuing education initiatives for teachers and school-based support for their professional development according to the value orientation, knowledge and practical skills required to teach the national AI curriculum.

5.7 Guiding the cohort-based design and organization of pedagogical activities

AI competency development is a three-helix bundle spanning the social and emotional learning of values and ethical principles, self-directed and collaborative construction of conceptual knowledge on AI, and practical skills to apply and co-create AI tools. A combination of innovative pedagogical methodologies is required in order to help students progress through the three helixes of competencies altogether, bridging between what they know and what they can do as well as transferring their prior knowledge and skills to novel concepts and new problem-solving contexts in the AI-rich workplaces and social spaces of the future.

The pedagogical innovations that are tailored to the particularities of AI domains and varied abilities of students can be unlocked through the design and organization of activities based on a cohort of students who are enrolled in a certain AI course or share an interest in the same domain of AI. In this cohort-based approach to the design and organization of learning scenarios or projects, a certain cohort of students may be grouped together from different classes and grade levels. This approach does not represent any particular learning theory, and typically involves a wide range of pedagogical methods and practice-orientated learning scenarios including interactive activities, collaborative projects and peer support. Students build a community of practice and their learning often follows a curricular schedule where they share accountability and motivate and coach each other, and work with their teachers to get feedback. In this way, they deepen their understanding and tackle challenging questions together; collaborate in hands-on projects to apply knowledge and skills in practical ways; and exchange views and engage in debates on the societal impact and ethical issues of AI to enhance social construction.

When choosing or designing pedagogical methodologies for the understanding, application and creation of different aspects of the AI CFS, it is also important to consider the domain-specific needs for pedagogical practices:

- The nurturing of human-centred values and mindset, by nature, is built upon social and emotional learning processes, and requires conflict-based opinion-taking, social construction and social interactions.
- The learning of ethics is a process of understanding abstract principles and regulatory rules through practical

为提升公共AI教师的专业化水平，应以实施人工智能课程标准（CFS）为基准，优化职前与在职培训体系，持续支持教师专业发展。需确保这些措施既符合明确界定的核心能力标准，又能为教师的职业成长提供阶梯式支持。特别要重视持续教育项目的参与度、评估机制及调整方案，同时结合国家AI课程教学所需的价值取向、知识体系和实践技能，完善校本支持体系，助力教师专业成长。

5.7 指导基于队列的设计和组织教学活动

人工智能能力培养是一个涵盖三大维度的螺旋式体系：其一涉及价值观与伦理准则的社会情感学习，其二包含自主探索与团队协作构建人工智能概念知识，其三则是应用与共创AI工具的实践技能。要帮助学生完整贯通这三个能力螺旋，需要创新教学方法的有机结合——既要架起已知知识与实践能力之间的桥梁，又要将既有知识与技能迁移至未来人工智能密集的工作场景和社会空间中应对新概念和新型问题解决情境。

通过设计和开发，可以解锁针对人工智能领域的特殊性和学生不同能力量身定制的教学创新。

这种学习模式以特定人工智能课程或共同领域兴趣的学生群体为基础进行组织。在基于群体的学习场景设计中，不同班级和年级的学生会被归入同一学习单元。该方法不局限于任何特定教学理论，通常包含互动活动、协作项目和同伴互助等实践导向型学习场景。学生们构建起实践社群，遵循课程安排共同承担责任，互相激励指导，并与教师合作获取反馈。通过这种方式，他们深化理解、共同攻克难题；在实践项目中运用知识技能解决问题；就人工智能的社会影响及伦理问题展开观点交流与辩论，从而促进社会建设。

在选择或设计用于理解、应用和创造AI CFS不同方面的教学方法时，还应考虑教学实践的领域特定需求：

- 培养以人为中心的价值观和心态，本质上是建立在社会和情感学习过程之上的，需要基于冲突的意见表达、社会建构和社会互动。
- 道德学习是一个通过实践来理解抽象原则和规范规则的过程

case studies, scenario-based critical evaluations, contextual application and collaborative rule-making.

- AI techniques and applications represents a domain that seamlessly blends the practice-oriented construction of conceptual knowledge on AI with authentic task-based application, and requires real AI tools as the basis for constructing knowledge schema on AI techniques and technology, problem-based learning and practices of transferable application and scenario-based inquiry, and a deepened understanding of the values and ethics underlying AI tools and their uses.
- AI system design simulates real-world engineering projects, involving the life cycle of the creating, realizing and iterating AI systems to practise engineering thinking processes and foster integrated problem-solving skills. It requires teachers to design and organize project-based learning to allow students to identify and delineate the problems that can and should be solved by AI; assess needs for data and plan methods of data collection; configure the architecture of AI models; and train AI models or create prototypes, tests and iterations of them.

As AI competency is a three-helix bundle, specific pedagogical practices can potentially cover multiple aspects of AI competency within one lesson or unit. This requires instructional planners or teachers to infuse and navigate various pedagogical methods so students can engage with multiple aspects of the learning and practice of AI. The real-world research and development of AI technology and applications often leverages intensive and continuous conceptualization of AI methods and iterative programming, configuration and optimization. This prerequisite for developing practical AI competencies has been validated by the effectiveness of the pedagogical methodologies practised at hackathons and bootcamps using AI applications. To improve the efficacy of pedagogy in schools, opportunities should be scheduled for students to be engaged in more intensive units of lessons or activities that align with the formal AI curriculum.

The national or institutional AI curriculum should frame recommendations or guidance on pedagogical methodologies around the principles of engaging shared accountability and peer learning in the target cohort of students and the specificity of the AI domain and expected learning outcomes. When updated or novel pedagogical methodologies are introduced in AI curricula, sufficient training, practical guidance and instantly responsive services (e.g. online chatbots) should be made available for teachers. Locally relevant incentive mechanisms should be planned and implemented to review, validate and recognize practices in pilot testing and scaling up pedagogical innovations.

案例研究、基于场景的批判性评估、上下文应用和协作规则制定。

- 人工智能技术与应用是一个将基于实践的人工智能概念知识建构与真实任务应用无缝融合的领域，需要以真实的人工智能工具为基础，构建关于人工智能技术与技术、基于问题的学习以及可迁移应用和场景的技术知识图谱
基于探究，以及对人工智能工具及其使用背后的价值观和伦理的深入理解。

- 人工智能系统设计通过模拟真实工程项目的全生命周期（包括创建、实现和迭代阶段），帮助学生实践工程思维流程，培养综合解决问题能力。教师需要设计并组织项目式学习，引导学生识别并界定适合用人工智能解决的问题；评估数据需求并规划采集方法；配置AI模型架构；以及训练AI模型或开发原型，进行测试与迭代优化。

由于人工智能能力是一个三螺旋结构，特定的教学实践可能涵盖人工智能的多个方面

在一节课或单元内的能力。
这要求教学策划者或教师需要整合并运用多种教学方法，让学生能够全方位参与人工智能的学习与实践。现实中的AI技术研发和应用往往需要持续深入的概念化探索，以及迭代编程、配置优化等流程。这种培养实用型AI能力的必要性，已通过黑客松和训练营中运用AI技术的教学方法成效得到验证。为提升学校教育质量，应安排更多深度课程单元或实践活动，使其与正规AI课程体系形成有机衔接。

国家或机构的人工智能课程体系应当围绕以下原则制定教学方法建议：在目标学生群体中建立共同责任机制与同伴学习机制，同时结合人工智能领域的特殊性及预期学习成果。当课程中引入更新或创新的教学方法时，应为教师提供充分的培训、实践指导及即时响应服务（如在线聊天机器人）。需制定并实施符合地方特色的激励机制，用于审查、验证和认可试点测试及推广教学创新中的实践案例。

Box 7: Pedagogical methodologies in the MIT curriculum on the ethics of AI for middle school students

An ethics of artificial intelligence curriculum for middle school students was created by Blakeley H. Payne with support from the MIT Media Lab Personal Robots Group, directed by Cynthia Breazeal (Payne, 2019). The curriculum is designed to be implemented online and/or offline with students aged 12 to 14 who are early in their AI learning journeys. The curriculum focuses on improving students' understanding of AI and the relationships between humans, technology and society. Parts of this curriculum have also been integrated into the MIT DAILy Curriculum,[18] and into How to Train Your Robot: A Middle School AI and Ethics Curriculum. Research into the latter demonstrated the potential for such a curriculum to be delivered even by teachers with a limited computer science background (Williams et al., 2021).

This curriculum exemplifies a student-centred and inquiry-based approach, with learning outcomes that are aligned to enable a cycle of: initial orientation or information-gathering that supports students to build knowledge schemas on a new topic; conceptualization, where students begin to form a hypothesis around the purpose(s) of AI; investigation, in which students delve deeper into the different perspectives, benefits, values and risks of AI for different populations, and design potential solutions for the problems that emerge; and finally, the development of a potential solution prototype using a project-based approach. Throughout, discussion and reflection are leveraged to deepen understanding and thinking about the problem.

The curriculum includes six core goals, which are pursued through different online or offline activities depending on the context. The chart below outlines the goals as well as example activities for teachers or other facilitators that can help to achieve them

Learning outcomes	Example activities and pedagogical advantages
Understand the basic mechanics of artificial intelligence systems. This learning outcome includes sub-outcomes such as recognizing AI uses in everyday life; understanding algorithms as a process of input, changes to input and output; and understanding AI as a specific type of algorithm with a dataset, learning and prediction.	**Play 'AI Bingo' with AI systems**. Using a worksheet, each student tries to find another classmate who has used or experienced various AI applications (for example, a tool that suggests emojis to replace words or an app that maps a route to a destination). Together the pair must determine the dataset used and prediction made by each different type of AI system until one student has completed five in a row. This represents an example of gamification, which can increase student interest and motivation, and is designed to support recall in order to begin building knowledge schemas around core AI concepts.

方框7：麻省理工学院中学生人工智能伦理课程的教学方法

麻省理工学院媒体实验室个人机器人研究组在辛西娅·布雷泽尔教授指导下，由布莱克利·H·佩恩开发了一套面向中学生的AI课程伦理体系（佩恩，2019)。这套课程专为12至14岁刚接触人工智能的青少年设计，支持线上线下的混合教学模式，重点帮助学生理解AI技术本质及其与人类、科技和社会的关系。课程部分内容已融入[18]麻省理工学院日常课程体系，并成为《如何训练你的机器人：中学生工AI伦理课程》的重要组成部分。对后者的研究表明，即使是由计算机科学背景有限的教师授课，这种课程也有潜力（Williams et al.，2021）。

本课程采用以学生为中心的探究式教学模式，其学习成果设计形成完整的知识构建循环：首先是信息导入阶段，帮助学生建立新课题的知识框架；其次是概念化阶段，引导学生围绕人工智能的核心价值形成初步假设；接着是深度探究阶段，让学生全面分析人工智能对不同群体的影响、优势与风险，并针对出现的问题设计解决方案；最后通过项目制方法开发出具有实践价值的解决方案原型。在整个过程中，讨论和反思被用来加深对问题的理解和思考。

课程包含六个核心目标，根据具体情境通过不同的线上或线下活动来实现。下表概述了这些目标以及可供教师或其他指导者使用的示例活动，以帮助实现这些目标。

学习成果	示例活动和教学优势
掌握人工智能系统的基本运行机制。该学习成果包含以下子成果：识别人工智能在日常生活中的应用；理解算法作为输入、修改输入和输出的过程；理解人工智能是一种特定类型的算法，具有数据集、学习和预测功能。	**与AI系统玩“AI宾果游戏”** 。通过工作表，每位学生寻找其他同学使用或接触过的人工智能应用（例如能用表情符号替代文字的工具、提供路线规划的应用程序）。两人需要共同找出不同AI系统使用的数据集和预测结果，直到其中一方连对五个为止。这种游戏化设计能有效提升学生兴趣与学习动力，旨在帮助记忆知识点，从而逐步构建关于核心AI概念的知识体系。

Learning outcomes	Example activities and pedagogical advantages
	Write an algorithm to make the 'best' peanut butter and jelly sandwich (or noodle, rice or tamale dish, or another locally-relevant food the children are familiar with). This can be undertaken individually or as a group. The core of the activity requires students to practise recall through accessing knowledge on what an algorithm is and how it is structured, and apply this to a specific mandated problem framed in a familiar context. **Identify the AI systems on the YouTube platform as a group**. In this recall-and-identification activity, students engage in recalling, reflection on and building of knowledge schemas. In this curriculum, this activity forms foundational schemas for more advanced reflective and creative collaborative problem-solving in the later stages in the curriculum. **Build a classifier in Google's Teachable Machine**. In this activity, students are asked to build an AI in Teachable Machine that will sort pictures of cats and dogs, but are given a biased dataset that does not yield consistent results. This is an example of facilitated experiential learning, where students leverage a knowledge base about AI and develop practical skills through hands-on, guided exploration. They need to reflect on the outcome of their work and determine the causes of the inconsistencies (bias). Confirmation design, in which students are provided with a question and methodology to confirm a known result, can be used. At more advanced levels, students can generate explanations of their results.
Understand that all technical systems are socio-technical systems, and that socio-technical systems serve political agendas and are not neutral sources of information. Students engage concepts such as the stated and hidden goals of algorithms, algorithmic bias and human agency.	**Create an ethical matrix of the stakeholders and their values invested in the student's peanut butter and jelly sandwich (or other food item)**. Undertaken as a group or individual activity, this builds on earlier recall/identification tasks by requiring students to engage in reflection and early critical analysis as they identify different stakeholders and their potentially conflicting interests and values. This enables students to develop procedural knowledge that can then be applied to more complex challenges and even ill-defined problems.

学习成果	示例活动和教学优势
	编写算法制作最佳花生酱果冻三明治（或面条、米饭、玉米卷等儿童熟悉的本土食物）。该活动可单独进行也可小组合作完成。核心环节要求学生通过学习算法定义及其结构原理，将所学知识应用于具体教学情境中的指定问题解决。 **将YouTube平台上的AI系统作为一个整体进行识别** 。在这个回忆与识别活动中，学生参与知识图式的回忆、反思和构建。在本课程中，该活动为后续阶段更高级的反思性及创造性协作问题解决能力奠定了基础性知识框架。 **在谷歌的Teachable Machine中构建分类器**。在这个活动中，学生被要求建造一个 在《可教机器》课程中，人工智能系统本应能对猫狗图片进行分类，但实际使用时却因数据集存在偏差导致结果不一致。这种教学案例体现了引导式体验学习法——学生通过掌握人工智能基础知识，在导师指导下开展实践探索，逐步培养应用技能。需要反思实验结果并分析偏差成因。此外，采用验证设计法时，教师会提供问题和方法论指导学生验证已知结论。在进阶阶段，学生还能自主构建实验结果的解释体系。
理解所有技术系统都是社会技术系统，社会技术系统服务于政治议程，不是中立的信息来源。 学生将接触算法的公开和隐藏目标、算法偏见和人类行为等概念。	**建立利益相关方及其价值观的伦理矩阵，分析这些因素如何影响学生选择花生酱果冻三明治（或其他食品）**。该活动可作为小组或个人任务开展，通过要求学生在识别不同利益相关方及其潜在利益冲突与价值观时进行反思和初步批判性分析，从而深化先前的回忆/识别任务。 这使学生能够发展程序性知识，然后可以应用于更复杂的挑战甚至模糊的问题。

Learning outcomes	Example activities and pedagogical advantages
	Using YouTube as an example, students construct an ethical matrix around the YouTube Recommender Algorithm. This activity exemplifies a student-centred critical thinking exercise which pushes students to connect classroom learning (both procedural and content) to their lived realities.
Recognize that there are many stakeholders in a given socio-technical system and that the system can affect these stakeholders differently. Students identify AI stakeholders and their values, and the goals that systems should have in order to meet those stakeholders' needs.	**Students reflect on the stakeholders for a range of technologies such as generative adversarial network (GANs), emotional recognition and speech-to-text software**. In this exercise, students demonstrate the ability to transpose the procedural knowledge gained from the ethical stakeholder matrix example for the food item and YouTube to other technologies, an important step in developing translational skills.
Apply both technical understanding of AI and knowledge of stakeholders in order to determine a just goal for a socio-technical system.	**Students brainstorm and redesign the YouTube algorithm to support new goals. They identify the datasets and design features necessary to reflect the new goals they have set**. This project-based group learning approach leverages constructivist principles as well as technical knowledge gained from the course to date, in order to work through the early stages of a design thinking process (up to the prototype stage) and co-create a solution to, in this case, a given problem of creating a different ethical stakeholder profile for YouTube. Sharing designs facilitates co-learning and reflection across groups, and a second cycle of iteration can be used to give students opportunities to leverage feedback or knowledge gained from peers.
Consider the impact of technology on the world.	**Students interact with different technologies and respond to creative writing and/or discussion prompts, reflecting on their direct and extended impacts**. In addition to following an inquiry approach and leveraging design thinking for project-based learning, the curriculum seeks to engage learners experientially in a range of AI technologies, and foster debate, discussion and reflection on the interactions between the technology, people who use it, broader society and the environment.

Source: Adapted from Payne, B. H. 2019. Available under CC BY-NC 4.0

学习成果	示例活动和教学优势
	以YouTube为例，学生围绕YouTube推荐算法构建了一个伦理矩阵 。这项活动体现了以学生为中心的批判性思维训练，促使学生将课堂学习（包括程序和内容）与现实生活联系起来。
认识到在给定的社会技术系统中有许多利益相关者，而系统可以对这些利益相关者产生不同的影响。学生确定人工智能的利益相关者及其价值，以及系统应该具有哪些目标，以满足这些利益相关者的需求。	**学生们反思了生成对抗网络（GANs）、情感识别和语音转文字软件等各类技术的利益相关者** 。在这项练习中，学生展示了将从食品和YouTube的伦理利益相关者矩阵案例中获得的程序性知识迁移至其他技术领域的能力，这是培养转化技能的重要一步。
应用对AI的技术理解以及利益相关者的知识，以确定社会技术系统的公正目标。	**学生们集思广益并重新设计了YouTube算法以支持新目标。他们确定数据集并设计必要的功能特性，以反映所设定的新目标** 。这种基于项目的小组学习方法运用了建构主义原则，并结合课程迄今所获得的技术知识，旨在完成设计思维过程的早期阶段（直至原型阶段），共同为创建YouTube不同伦理利益相关者画像这一既定问题制定解决方案。设计分享促进了跨小组的协同学习与反思，而第二轮迭代循环则可让学生有机会利用来自同伴的反馈或知识。
想想科技对世界的影响。	**学生通过接触各类技术，参与创意写作和讨论任务，在实践中反思技术的即时与长远影响** 。课程采用探究式教学法，运用设计思维开展项目式学习，同时通过沉浸式体验让学生接触多种人工智能技术，促进他们就技术应用、使用者群体、社会环境等多维度展开辩论、探讨与深度思考。

*来源：*改编自Payne，B. H. 2019年。根据CC BY-NC 4.0许可协议提供

5.8 Constructing competency-based assessments on the progression of key AI aspects

The assessment of students' AI competencies naturally requires the use of competency-based assessments that need to be adapted to the specificity and integration of multiple aspects of AI. Methodologies and instruments designed for such assessments are essential to benchmark students' starting point, measure their mastery levels of the key aspects of AI, and provide references for evaluating the effectiveness of teaching practices and overall implementation of the AI curriculum. However, few attempts have been made to develop these sorts of instruments for assessing comprehensive AI competencies cross-cutting multiple progression levels. Therefore, the implementation of the AI CFS or the local AI curriculum needs to include the construction of a competency-based assessment system encompassing purpose and objectives, authentic tasks and methodologies, benchmarking standards or indicators, and domain-appropriate criteria associated with a corresponding grading scale.

Frame criterion-referenced assessments to measure the mastery of AI competencies

The primary purpose of competency-based assessments is to measure students' mastery level against predefined standards or benchmarking frameworks, implying the use of criterion-referenced assessments. As stated above, competency-based education aims to support all students to achieve the minimum mastery level of competencies, meaning the fixed learning outcomes with more flexible time schedules. Under these models, students who do not meet the minimum standards within a certain timeframe should be given additional support until they can reach them. To support this aim, a set of reference criteria should be defined to diagnose students' mastery levels compared with the predefined standards, and to recommend further learning experiences. In the context of the cohort-based design and organization of pedagogical activities, the criterion-referenced ipsative assessment of a single student or a target cohort of students should be implemented to diagnose the gaps between their mastery level and the minimum standard as well as their progressive performance over time. While the ipsative assessment of learning may help tailor students' personalized experiences, the emphasis on the criterion reference can prevent the loss of targeted achievement of AI competencies. This can be extended to students' self-assessment and setting of personal curricular goals.

The AI CFS interprets AI competencies into measurable learning outcomes and outlines expected exit-level behavioural performance for each competency block. These can be used as a basis for framing predefined benchmarking standards, against which a repository of criterion-referenced assessment items can be created to measure the mastery level of the cohort of students, including, more specifically, the aspects, domains or specific topics they have mastered and any areas in need of improvement.

Norm-referenced assessments, which compare individual students to the rest of the cohort on the same course, are not the main focus of the competency-based assessments in the AI curriculum. However, national or institutional agencies in charge of AI curricula may consider building a

5.8 构建基于能力的评估关键AI方面的进展

评估学生的人工智能能力自然需要采用基于能力的评估体系，这种评估方式必须根据人工智能多维度特性和综合应用进行调整。为此设计的评估方法和工具，对于衡量学生的基础水平、检测其掌握人工智能核心要素的程度，以及为教学实践效果和课程整体实施提供参考都至关重要。然而，针对跨不同学习阶段的综合性人工智能能力评估工具开发尝试仍属凤毛麟角。因此，在实施人工智能课程框架（CFS）或地方化人工智能课程时，必须构建包含教学目标、真实任务与方法论、基准标准或指标、以及对应评分体系的领域适配性标准的基于能力的评估体系。

框架标准参照评估，以衡量对人工智能能力的掌握

能力评估的主要目的是衡量学生对预定义标准或基准框架的掌握程度，这意味着使用标准参照评估。

如上所述，基于能力的教育旨在支持所有学生达到能力的最低掌握水平，即固定的学习成果和更灵活的时间安排。在这些模式下，学生对于未能在规定时间内达到最低标准的学生，应当提供额外支持直至达标。为实现这一目标，需要制定一套参考标准来诊断学生相对于预设标准的掌握水平，并推荐后续学习方案。在基于群体的教学设计与活动组织中，应当实施针对单个学生或目标群体的标准参照性自评评估，以诊断其掌握水平与最低标准之间的差距，并追踪其随时间推移的进步表现。虽然学习的自评机制有助于量身定制个性化教学体验，但过分强调标准参照可能削弱人工智能能力培养的针对性。这一原则同样适用于学生的自我评估与个人课程目标设定。

AI能力框架（AI CFS）将人工智能核心能力转化为可量化的学习成果，并为每个能力模块制定了预期的毕业行为表现标准。这些标准可作为构建预设基准体系的基础，通过建立一系列标准参照评估题库，能够精准衡量学生群体对各能力模块的掌握程度——具体包括他们已掌握的领域、学科方向及特定知识点，以及需要改进的薄弱环节。

与课程体系相匹配的评估方式，即通过将学生个体与同门课程的其他学员进行对比来实施的标准化评估，并非人工智能课程中能力型评估体系的核心内容。不过，负责人工智能课程的国家级或院校级主管部门可能会考虑建立相应的评估机制。

set of dynamically adjusted norms of students' competency development in key aspects or domains of AI through the long-term tracking of students' performance. The norm-referenced assessments can also provide a comprehensive view of a student's abilities compared to their peers, and a benchmarking of local students' competencies compared to same-age students in other countries. The mean of the norm should be measured against the predefined standards of AI competencies to monitor whether the learning outcomes of the majority of students exceed, meet or are below the minimum standards. Finally, the performance of different groups of students compared to the norms should be disaggregated and analysed by age, gender or demographic background, to help provide evidence for policies or strategies that enable remedial or supplementary support for students who are disadvantaged in learning AI.

Adapt performance scenarios to assess overt performance and latent competencies

AI technology is designed to address real-world problems, and its practice-orientated nature requires the use of real-world scenarios and authentic tasks to measure students' performance in applying their mindset, ethical principles, skills and knowledge, and to psychometrically validate students' development of multiple aspects of AI. The competency-based assessment should fully leverage tasks showing students' measurable or overt behavioural performance (what they can do), which is often termed 'performance-based assessment'. However, to fully meet the needs of assessing both observable behaviours and latent competencies involving the human-centrality of mindset and ethics, transferability of conceptual knowledge, adaptivity of practical skills, and creativity in AI system design, the objectives and methods for assessing performance should be adapted as follows:

- **Assess both observable performance and latent competencies:** Move from pure assessment of observable behaviours (what students already do) to the psychometric testing or validation of students' latent knowledge schema on AI techniques and application abilities (what they can potentially do), human-centred critical thinking and ethical evaluation and selection of AI tools to serve specific purposes (how they apply ethics to their use of AI).
- **Shift from assessing rote learning to testing transferability, adaptivity and creativity:** Assessment methods should move from the measurement of fixed, repetitive operations to the design and use of varied tasks to assess how students can transfer knowledge and skills across contexts (how students can transfer knowledge and skills) and adapt to novel situations. Methods should also shift (how students can adapt); move from a limited focus on the fluency of operating existing AI tools to how students can critically evaluate existing tools and collaboratively craft or co-create new AI tools (what students can co-create).
- **Balance domain-specific and integrative AI competency assessments:** Building upon the domain-specific assessments of

通过长期跟踪学生的表现，动态调整学生在人工智能关键方面或领域的能力发展规范。
常模参照评估不仅能全面反映学生与同龄人的能力对比，还能为本地学生的能力水平与其他国家同龄学生进行基准比对。通过将平均常模值与人工智能能力预设标准进行对照，可监测大多数学生的学习成果是否达到、超过或低于最低标准。最后，需要按年龄、性别或人口统计学背景对不同学生群体的常模表现进行细分分析，为制定针对人工智能学习困难学生的补救措施或支持策略提供依据。

调整绩效场景，以评估显性绩效和潜在能力

人工智能技术旨在解决现实世界中的问题，其实践导向的特性要求通过真实场景和实际任务来评估学生在应用思维方式、伦理准则、技能与知识方面的表现，并通过心理测量学方法验证学生在人工智能多维度能力的发展。基于能力的评估应充分运用能够展示学生可测量或显性行为表现（即他们能做什么）的任务，这种评估方式通常被称为“表现型评估”。然而，要全面满足评估可见行为与潜在能力的需求，涉及人工智能系统设计中的人类中心性思维模式与伦理道德、概念性知识的可迁移性、实践技能的适应性、创造力等要素，其评估性能的目标与方法应作如下调整：

- **既要评估显性表现，也要考察潜在能力：**从单纯评估学生已掌握的显性技能（他们已经能做什么），转向对人工智能技术应用能力、潜在知识图式（学生可能具备的能力）的心理测量测试与验证，以及在具体场景中运用人工智能工具时的人文关怀式批判性思维、伦理评估与选择（学生如何将伦理准则应用于人工智能的使用）。
- **从评估死记硬背到测试可转移性、适应性和创造力：**评估方法应从测量固定、重复的操作
通过设计多样化任务来评估学生知识技能的迁移能力（即学生如何在不同情境中运用所学知识与技能）以及适应新环境的能力。教学方法也应与时俱进（即学生如何灵活调整策略）：从单纯关注现有AI工具的操作熟练度，转向培养学生对现有工具的批判性评估能力，并通过协作设计或共同创造新AI工具的能力（即学生具备的协同创新能力）。
- **平衡领域特定的和综合的人工智能能力评估：**在领域特定的评估基础上

mindset, understanding and practices of ethics, knowledge and skills, design and use authentic project-based testing to assess students' integral competencies to blend and integrate ethical principles, AI knowledge and skills, and computational and engineering thinking to critically evaluate AI tools, redesign algorithms or co-create AI systems. These project-based assessments of how students can integrate AI competencies to solve problems require curriculum developers or teachers to design open and authentic tasks; the breadth of the required competencies should be adapted to the different progression levels, and appropriate grading scales need to be designed to reflect the measurement of open and multilayered competencies.

- **Configure authentic assessment tasks and grading scales for AI competencies:** The design of assessment items can be framed by the detailed specifications of each competency block provided in Chapter 4. The configuration of assessment tasks, methods of administering assessment and formats of responses should be aligned with the requirements of each domain (mindset, ethics, conceptual knowledge on AI, operational AI skills and comprehensive AI system design). This means the specific assessment tasks should be tailored according to the cognitive and behavioural performance that can psychometrically validate the mastery of 'Understand', 'Apply' and 'Create'. For the 'Understand' level, the tasks may focus more on the comprehension of the concepts and ethical principles underlying performance, with less focus on concrete practical skills, while tasks at the 'Apply' level can centre on problem-based practical skills and adaptivity in coping with task variation. For 'Create', the measurement tasks might be more about synthesis and algorithmic programming on the conceptualization of new ideas, design of virtual or physical prototypes of new AI tools or systems, the knowledge and skills to test and optimize AI models, the comprehensive computational skills and engineering demonstrated in the co-creation of AI, as well as the human-centred mindset and ethical principles underlying the design and testing.

在伦理观念、知识技能的理解与实践方面，通过设计并运用真实的项目式评估来衡量学生的核心能力——即如何将伦理准则、人工智能知识技能与计算工程思维相结合，从而批判性评估AI工具、重新设计算法或共同开发AI系统。这类项目式评估要求课程开发者或教师设计开放且真实的任务，所需能力的广度应根据不同学习阶段进行调整，并需制定相应的评分标准来体现对开放且多层次能力的评估。

- **配置人工智能能力真实评估任务及评分标准：**评估题项的设计可参照第四章对各能力模块的具体规范要求，评估任务的配置、实施方式以及答题格式应与每个领域的要求一致(思维模式、伦理、概念人工智能领域的知识、操作技能及系统设计能力。这意味着具体评估任务需要根据认知与行为表现进行定制化设计，通过心理测量学方法验证对“理解”、“应用”和“创造”三个层面的掌握程度。在“理解”层级，任务可着重考察对相关概念及行为伦理原则的把握，其中较少关注具体的实践技能，而任务在“应用”评估体系可聚焦于基于问题的实践技能与应对任务变化的适应能力。在“创造”维度，测评任务可能涉及以下方面：新创意概念的整合与算法编程、新型人工智能工具或系统的虚拟/实体原型设计、测试优化AI模型所需的知识技能、协同开发过程中展现的综合计算能力与工程实践，以及贯穿设计与测试过程的人本思维和伦理准则。

The focuses of domain-specific assessments divided by three progression levels are recommended as follows for further deliberation, and a non-exhaustive list of examples of assessment items is provided in **Table 5** to inspire configurations of assessment instruments that cover all topics and progression levels of the local curriculum.

1. Human-centred mindset:
1.1 Conflict-based opinion taking
1.2 Conflict-based critical evaluation
1.3 Conflict-based social actions

2. Ethics of AI:
2.1 Scenario-based ethical value orientation
2.2 Scenario-based ethical behaviour
2.3 Scenario-based rule-making

3. AI techniques and applications:
3.1 Problem-based AI knowledge and understanding
3.2 Tool-based conceptual insights and transferable operation
3.3 Task-based tool crafting

4. AI system design:
4.1 Project-based design thinking
4.2 Project-based system configuration
4.3 Project-based iteration

The three forms of assessment under AI system design are based on the virtual environment of Teachable Machine and a simulation project on the design, training, testing and optimization of an AI system. The project should be defined around themes relating to the real-world needs of promoting social inclusion, and using data on local languages or cultural features when training AI models. One critical aspect of the integrated AI competency is the comprehensive ability to iterate AI systems based on feedback, and therefore traditional methods such as paper-based testing should be expanded upon to include metrics that capture a student's ability to conduct technological conceptualization, and create prototypes and processes for improvements, together with their technical expertise demonstrated in the projects.

按三个进度等级划分的领域特定评估的重点建议如下，以供进一步审议，并在**表5**中提供了评估项目的非穷尽性示例列表，以启发覆盖当地课程的所有主题和进度等级的评估工具配置。

1. 以人为本的思维方式：
1.1 基于冲突的意见
1.2 基于冲突的批判性评价
1.3 基于冲突的社会行动

2. 人工智能伦理：
2.1 基于场景的伦理价值取向
2.2 基于场景的道德行为
2.3 基于场景的规则制定

3. 人工智能技术及应用：
3.1 基于问题的AI知识和理解
3.2 基于工具的概念性见解和可转移操作
3.3 基于任务的工具制作

4. AI系统设计：
4.1 以项目为基础的设计思维
4.2 基于项目系统配置
4.3 基于项目的迭代

人工智能系统设计中的三种评估形式，均基于可教机器的虚拟环境及一个关于AI系统设计、训练、测试与优化的模拟项目。该项目应围绕促进社会包容性的真实需求主题展开，并在训练AI模型时采用当地语言或文化特征数据。综合型AI能力的核心要素在于能够根据反馈迭代AI系统，因此传统方法如纸笔测试需要拓展维度，需纳入衡量学生技术概念化能力、原型开发流程构建能力以及项目中展现的技术专长等指标。

Table 5. Examples of assessment tasks

COMPETENCY ASPECTS	PROGRESSION LEVELS		
	Understand	**Apply**	**Create**
Human-centred mindset	**1.1 Conflict-based opinion taking** **1.1.0** An integral paper and/or computer-based test on the main points of 'Human agency'. **1.1.1** Can AI be used in supporting human decisions on values and social issues? Name a weakness of current AI technologies in supporting decisions in relation to values, social issues and personal emotional reactions. **1.1.2** What will happen if humans don't take accountability in the conceptualization and design of AI systems? **1.1.3** Will machine agency become stronger than human agency, and take over more and more human agency? Explain your opinion.	**1.2 Conflict-based critical evaluation** **1.2.0** An integral paper and/or computer-based test on the main points of 'Human accountability'. **1.2.1** The media reported that artificial general intelligence will arrive by 2030 and will overpower humans in almost all areas, while some AI experts have said AGI may never emerge. Who is correct? Evaluate whether some selected media reports of AI go beyond the genuine capabilities of AI technologies. **1.2.2** In the future, will all minutes of daily meetings and administrative reports be drafted by AI? Do the next generation of students still need to learn how to synthesize materials and draft reports? Assess whether a particular problem in life or subject learning can and/or should be solved with AI methods.	**1.3 Conflict-based social interactions** **1.3.0** An integral paper and/or computer-based test on the main points of 'Social responsibility'. **1.3.1** Will AI eventually help humans remove the drivers of climate change and protect the planet's well-being? Should human societies mobilize all resources to unlimitedly train AI models? Or has the training of AI models generated irreversible impacts on climate change? Analyse how some AI systems can affect environments and climate change, and how their methods could be optimized. **1.3.2** Will AI become indispensable and trustworthy co-workers of humans or will AI threaten the safety, inclusion, equity, justice and other social norms of human societies? Critically reflect on the potential impact of AI on human societies. **1.3.3** Will AI create jobs for all groups of people equally or will the deployment of AI cause more inequality in economic development in the connection of global markets and your local context? Critically evaluate why AI has become increasingly important and how it may affect your local economy and job market. **1.3.4** AI companies have claimed that they are developing AI tools for all. Will AI enhance or threaten inclusion and equity? Critically evaluate the implications of the wide adoption of AI for inclusion and equity in your local context.

表5.评估任务示例

能力方面	进度等级		
	了解	**申请**	**创建**
以人为本的思维方式	**1.1 基于冲突的意见** **1.1.0** 一篇关于“人类行为”的要点的完整论文和/或计算机测试。 **1.1.1** 人工智能是否可用于支持人类在价值观和社会问题上的决策？请指出当前人工智能技术在支持价值观、社会问题和个人情绪反应方面的决策时存在的弱点。 **1.1.2** 如果人类在人工智能系统的概念和设计中不承担责任，将会发生什么？ **1.1.3** 机器的能动性会变得比人的能动性更强，从而取代越来越多的人的能动性吗？请解释你的观点。	**1.2 基于冲突的批判性评价** **1.2.0** 关于“人类责任”的要点的综合论文和/或计算机测试。 **1.2.1** 媒体报道，人工通用智能将于今年到来到2030年，人工智能将在几乎所有领域压倒人类，而一些人工智能专家表示，AGI可能永远不会出现。谁是对的？评估一些精选的人工智能媒体报道是否超出了人工智能技术的真实能力。 **1.2.2** 未来，日常会议纪要和行政报告是否都由AI来起草？下一代学生是否还需要学习如何整合资料和撰写报告？评估生活或学科学习中的特定问题是否能够和/或应该用AI方法来解决。	**1.3 基于冲突的社会互动** **1.3.0** 关于“社会责任”要点的综合论文和/或计算机测试。 **1.3.1** 人工智能最终能否帮助人类消除气候变化的推手，守护地球家园？人类社会是否应该不计代价地投入所有资源来无限训练AI模型？或者，这些AI模型的训练过程是否已经对气候变化产生了不可逆转的影响？本文将剖析某些AI系统如何影响生态环境与气候变化，并探讨如何优化其训练方法。 **1.3.2** 人工智能会成为人类不可或缺的、值得信赖的伙伴，还是会对人类社会的安全、包容、公平、正义等社会规范构成威胁？请深入思考人工智能对人类社会可能产生的影响。 **1.3.3** 人工智能会为所有人群创造平等的工作机会，还是说人工智能的部署会在全球经济市场与本地环境的联系中造成更大的经济发展不平等？请重点评估为什么人工智能变得越来越重要，以及它可能如何影响本地经济和就业市场。 **1.3.4** 人工智能公司声称正在为所有人开发人工智能工具。人工智能会增强还是威胁包容性和公平性？请批判性地评估人工智能在您所在地区的广泛应用对包容性和公平性的影响。

COMPETENCY ASPECTS	PROGRESSION LEVELS		
	Understand	**Apply**	**Create**
Ethics of AI	**2.1 Scenario-based ethical value orientation** **2.1.0** An integral paper and/or computer-based test on the main points of 'Ethical principles'. **2.1.1** You have never expressed consent to the use of your personal data to train AI models, so are your personal data protected and safe? Describe how personal online data have been collected and used without consent. **2.1.2** You have only entered your personal data in the prompt to request a 'trustworthy' generative AI system to help you draft a recommendation letter. Can you be sure your private data won't be disclosed? Describe how sensitive personal data may be collected through prompts or interactions with AI systems. **2.1.3** Video-sharing platforms such as YouTube and TikTok look as if they can understand what sorts of videos the users may like and know how to recommend videos that will be of interest to users. Please identify ethical issues around the video-recommendation algorithms used by video platforms.	**2.2 Scenario-based ethical behaviours** **2.2.0** An integral paper and/or computer-based test on the main points of 'Safe and responsible use'. **2.2.1** Explain why data security must be considered when developing and using AI applications. **2.2.2** If we want to benefit from the useful services offered by an AI system, is it necessary to forego some of our personal privacy to enjoy the benefits? Explain why data privacy must be considered when developing and using AI applications. **2.2.3** 'I have tried many AI platforms and they always provided service exceeding my expectations, so I don't need to be provided with the explanation on how these AI models work?' Evaluate this statement and describe the concept of explainable AI. **2.2.4** 'I used a photo of one of my friends to generate a video using a generative AI tool and it looks very real, and I posted it online for fun; I used a generative AI system to author essays based on my 'creative' prompts and I published them in my name.' Evaluate one or both of these statements and describe potential legal problems that may arise when using AI-generated content or claiming it as 'your' work.	**2.3 Scenario-based rule-making** **2.3.0** An integral paper and/or computer-based test on the main points of 'Co-creating ethical rules'. **2.3.1** Has your country or school (district) developed regulations on the use of AI (or generative AI)? If yes, critically evaluate the regulations against core principles of UNESCO's *Recommendation on the Ethics of AI* and/or with the EU AI Act. If no, develop a proposal to justify the necessity of regulations and outline the main points they should cover. **2.3.2** Co-create ethical guidance for yourself and your peers on the use of video-recommendation platforms or generative AI systems. **2.3.3** Co-create a set of ethical rules for the safe and responsible use of AI in your schools and at home. **2.3.4** Co-create regulatory rules for the brain-computer interface (BCI) technology

能力方面	进度等级		
	了解	**申请**	**创建**
人工智能伦理	**2.1 基于场景的伦理价值取向** **2.1.0** 关于“伦理原则”的要点的综合论文和/或计算机测试。 **2.1.1** 您从未表示同意使用您的个人数据来训练AI模型，那么您的个人数据是否受到保护和安全？描述在线个人数据是如何在未经同意的情况下被收集和使用的。 **2.1.2** 您仅在提示中输入了个人信息，系统就会请求您使用“值得信赖”的生成式AI系统来帮您起草推荐信。您确定您的私人数据不会被泄露吗？请描述通过提示或与AI系统的交互可能收集到的敏感个人信息类型。 **2.1.3** 像YouTube和抖音这样的视频分享平台似乎能够理解用户可能喜欢的视频类型，并知道如何推荐用户感兴趣的视频。请指出视频平台所使用的视频推荐算法中存在的伦理问题。	**2.2 基于场景的道德行为** **2.2.0** 关于“安全和负责任的使用”的要点的完整论文和/或计算机测试。 **2.2.1** 解释为什么在开发和使用AI应用程序时必须考虑数据安全。 **2.2.2** 如果我们想从人工智能系统提供的有用服务中获益，是否有必要放弃一些个人隐私才能享受这些好处？解释为什么在开发和使用人工智能应用程序时必须考虑数据隐私。 **2.2.3** ‘我尝试过很多AI平台，它们提供的服务总是超出我的预期，所以我不需要提供这些AI模型如何工作的解释？’ 评估这个陈述并描述可解释AI的概念。 **2.2.4** “我用一个朋友的照片，用一个生成式AI工具生成了一个视频，看起来非常真实，我把它发布到网上是为了好玩；我使用生成式AI系统根据我的“创意”提示撰写文章，并以我的名义发布。请评估以下一个或两个陈述，并描述使用AI生成内容或将其作为“你的”作品时可能产生的潜在法律问题。	**2.3 基于场景的规则制定** **2.3.0** 一篇关于“共同制定道德规则”要点的完整论文和/或计算机测试。 **2.3.1** 贵国或所在学区是否制定了人工智能（含生成式AI)使用规范？若有，请对照联合国教科文组织《*关于人工智能伦理的建议书》核心原则*或欧盟《人工智能法案》对规范进行严格评估。若尚未制定相关规范，请提出制定规范的必要性论证方案，并概述规范应包含的主要内容。 **2.3.2** 为自己和同伴创建有关使用视频推荐平台或生成式AI系统的道德指导。 **2.3.3** 共同制定一套道德规则，确保在学校和家里安全、负责任地使用人工智能。 **2.3.4** 共同制定脑机接口（BCI）技术的监管规则

COMPETENCY ASPECTS	PROGRESSION LEVELS		
	Understand	**Apply**	**Create**
AI techniques and applications	**3.1 Problem-based AI knowledge and understanding** **3.1.0** Competency-based or criterion-referenced examination on key conceptual knowledge on AI. **3.1.1** Describe or exemplify (using tools) what AI is and is not; or exemplify personal, school-based or public tools that are supported by AI. **3.1.2** Explain the difference between strong AI and weak AI. **3.1.3** Describe the basic concept of big data; give a couple of examples of misusing big data. **3.1.4** Explain how machine-learning models are trained, tested and optimized; explain why data play an important role in the training, development and further iterations of an AI model. **3.1.5** Explain how deep learning relates to machine learning. **3.1.6** Define the term 'artificial neural network' (or other key concepts applicable for the 'Understand' level).	**3.2 Tool-based conceptual insights and transferable operation** **3.2.0** Criterion-referenced, computer-based examination on the fluency, transferability and adaptability of operational skills on data, algorithms and programming. **3.2.1** Exemplify applications which use any of the following: natural language processing, computer vision, speech recognition, image recognition, autonomous agent systems, emotion detection, data-based prediction or generative AI. **3.2.2** Explain how supervised learning, unsupervised learning and reinforcement learning work on a basic level. **3.2.3** Exemplify typical AI algorithms under the categories of supervised learning, unsupervised learning and reinforcement learning; exemplify tools that use some of these typical algorithms. **3.2.4** Explain what AI algorithms are used and integrated by a given generative AI system. **3.2.5** Exemplify two to three open-source datasets and libraries of AI algorithms; explain the advantages and limitations of open-source datasets and algorithm libraries.	**3.3 Task-based tool crafting** **3.3.0** Computer-based individual or group work to customize existing AI toolkit(s) to create a task-based AI tool. **3.3.1** Explain how sensors, crawling software, and other tools are used by AI researchers and designers to collect data that can be used to train AI models. **3.3.2** Explain and/or demonstrate by operation how to find and reuse open-source datasets and libraries of AI algorithms; evaluate the benefits and risks in comparison with AI options from proprietary enterprises. **3.3.3** Draft a design-and-development plan on a task-based AI tool to address real-world needs in and beyond the local context. The plan should cover the following criteria on an age-appropriate level: critical analysis of existing AI tools, assessment of need for data, methods to collect and process data, appropriate AI algorithms and programming languages, open-source AI tools or systems that can be customized or fine-tuned, and parameters for the testing of the AI tools.

能力方面	进度等级		
	了解	**申请**	**创建**
人工智能技术及应用	**3.1 基于问题的AI知识和理解** **3.1.0** 基于能力或标准参照的考试，涉及人工智能的关键概念知识。 **3.1.1** 描述或举例说明（使用工具）人工智能是什么和不是什么；或者举例说明个人、学校或公共工具，这些工具由人工智能支持。 **3.1.2** 解释强人工智能和弱人工智能之间的区别。 **3.1.3** 描述大数据的基本概念；给出几个大数据误用的例子。 **3.1.4** 解释机器学习模型如何训练、测试和优化；解释为什么数据在AI模型的训练、开发和进一步迭代中扮演着重要的角色。 **3.1.5** 解释深度学习与机器学习之间的关系。 **3.1.6** 定义术语“人工神经网络”（或“理解”级别适用的其他关键概念）。	**3.2 基于工具的概念性见解和可转移操作** **3.2.0** 以计算机为基础的、以标准为参照的考试，对数据、算法和编程方面的操作技能的流畅性、可转移性和适应性进行评估。 **3.2.1** 举例说明使用以下任何一种的应用程序：自然语言处理、计算机视觉、语音识别、图像识别、自主代理系统、情绪检测、基于数据的预测或生成式AI。 **3.2.2** 解释监督学习、无监督学习和强化学习在基本层面上是如何工作的。 **3.2.3** 举例说明监督学习、无监督学习和强化学习等典型AI算法学习：举例说明使用这些典型算法的工具。 **3.2.4** 解释一个给定的生成式AI系统使用和集成的人工智能算法是什么。 **3.2.5** 举例说明两到三个开源数据集和AI算法库，解释开源数据集和算法库的优点和局限性。	**3.3 基于任务的工具制作** **3.3.0** 基于计算机的个人或团队工作，以定制现有AI工具包，从而创建任务型AI工具。 **3.3.1** 解释人工智能研究人员和设计师如何使用传感器、爬虫软件和其他工具来收集可用于训练人工智能模型的数据。 **3.3.2** 通过操作说明和/或演示如何查找和复用开源数据集和AI算法库；与专有企业的AI选项相比，评估其收益和风险。 **3.3.3** 制定一份面向任务型人工智能工具的设计与开发方案，旨在满足本地及更广泛区域的实际需求。该方案需按适龄标准涵盖以下核心要素：对现有AI工具的批判性分析、数据需求评估、数据采集与处理方法、适用的AI算法及编程语言、可定制或微调的开源AI工具系统，以及AI工具测试参数设置。

COMPETENCY ASPECTS	PROGRESSION LEVELS		
	Understand	**Apply**	**Create**
AI system design	**4.1 Project-based design thinking** **4.1.0** Simulated tests on problem-scoping for AI system design. Request that students produce a report and/or oral defence on problem scoping or on a project proposal. The report can be evaluated according to the following criteria: why AI should be used for the problem based on a checklist; and the problem statement including key requirements or features of the AI systems such as algorithms, datasets and functionalities. **4.1.1** Explain why a specific real-world challenge (given by teachers) should not be solved by an AI tool. **4.1.2** Computer-based test on data preprocessing techniques, drawing on open-source datasets including adjusting the data augmentation, handling outliers, analysing dataset skew or imbalance, training the model based on modified datasets, and observing how data preprocessing affects the model's performance compared to the given dataset.	**4.2 Project-based system configuration** **4.2.0** Computer-based tests on the architectural configuration of AI. The simulated operation can be evaluated using the following criteria: assessment and selection of frameworks for AI architectures; evaluation and choice of solutions for the layers and components of the AI architecture; the configuration of a prototype architecture; and the presentation of the configuration. **4.2.1** Explain how open-source datasets and libraries of AI programming can be leveraged to build an AI system including locally accessible cloud computing platforms or operating systems, and software needed by the training of machine-learning models. **4.2.2** Explain what criteria should be considered to optimize for efficiency and minimize computational resource waste when configuring AI architecture. **4.2.3** Calculate the selected AI model's consumption of computing resources, and design strategies for improving the efficiency of AI methods to reduce its environmental impact.	**4.3 Project-based iteration** **4.3.0** Computer-based simulated optimization of a simple AI model, including operational optimization of the datasets, algorithms and parameter adjustment, and the design of functionalities and interfaces; and/or reconfiguration of the architectures, including modifying the problem-scoping. **4.3.1** Design a set of metrics for the performance-testing of an exemplar AI system. Explain what metrics can be designed or adapted to support the measurement of the system's performance and to collect feedback from end users on the societal implications and environmental impact. Exemplify open-source tools that can conduct and report on the performance-testing of an AI system. **4.3.2** Draft a report to explain what decision should be taken on an AI system and why, based on the findings of simulated performance tests and user feedback. Include explanations of decisions to optimize, reconfigure and shut down the system; present the plan for optimization or reconfiguration, or for mitigation strategies if the AI system has the potential to cause harm. **4.3.3** Exemplify locally accessible online communities of AI co-creators; explain what a student can do in these communities.

能力方面	进度等级		
	了解	申请	创建
AI系统设计	**4.1 以项目为基础的设计思维** **4.1.0** 针对人工智能系统设计的问题界定开展模拟测试。要求学生撰写报告或进行口头答辩，内容涉及问题界定或项目提案。报告评估标准包括：根据检查清单说明为何应采用人工智能技术解决问题；以及需明确AI系统的核心需求或功能特性，例如算法、数据集和具体功能。 **4.1.1** 解释为什么一个特定的实际挑战（由教师给出）不应该被AI工具解决。 **4.1.2** 基于计算机的数据预处理技术测试，利用开源数据集，包括调整数据增强、处理异常值、分析数据集偏斜或不平衡、基于修改后的数据集训练模型，并观察数据预处理如何影响模型性能与给定数据集的对比。	**4.2 基于项目系统配置** **4.2.0** 基于计算机的AI架构配置测试。模拟运行可通过以下标准进行评估：AI架构框架的评估与选择；AI架构各层及组件解决方案的评估与选择；原型架构的配置；以及配置的展示。 **4.2.1** 解释如何利用开源数据集和AI编程库来构建AI系统，包括本地可访问的云计算平台或操作系统，以及机器学习模型训练所需的软件。 **4.2.2** 解释在配置AI架构时，应该考虑哪些标准来优化效率并最小化计算资源浪费。 **4.2.3** 计算所选AI模型的计算资源消耗，并设计提高AI方法效率的策略，以减少其环境影响。	**4.3 基于项目的迭代** **4.3.0** 基于计算机的简单AI模型模拟优化，包括数据集、算法和参数调整的操作优化，以及功能和界面的设计；和/或架构的重新配置，包括修改问题范围。 **4.3.1** 为典型人工智能系统设计一套性能测试指标体系。说明可设计或调整哪些指标来支持系统性能评估，并收集终端用户对社会影响和环境影响的反馈。举例说明可用于开展AI系统性能测试并生成报告的开源工具。 **4.3.2** 起草一份报告，说明应基于模拟性能测试结果和用户反馈对人工智能系统做出何种决策以及原因。包括对优化、重新配置和关闭系统的决策进行解释；如果人工智能系统有可能造成伤害，则提出优化或重新配置的计划，或者缓解策略。 **4.3.3** 举例说明当地可访问的在线AI联合创造者社区；解释学生在这些社区中可以做什么。

Agile formats of concrete assessments and corresponding grading scales that fit neatly into different assessment items and objectives should be designed, tested and optimized. These may include formative and peer assessments in the form of reflective essays, oral presentations or reports of users' tests of AI tools; and summative examinations on paper and/or via computer-based or unplugged design, including prototypes of AI tools or drawing of algorithms, essays about case studies on AI's ethical issues, technical reports on the design and development of AI tools or systems, the fine-tuning or simulated training of AI models, and the assembling or creation of hardware.

This large array of concrete methods should be examined in a nuanced manner against the specific needs of aspects and infused flexibly in the implementation of the AI CFS.

The use of AI tools for assessments also emerges as a new supplementary method of assessment, for example automating the collection of data on learning processes and formative mastery directly from students or learning management systems, personalizing assessments for students according to their ability or linguistic and cultural background, or facilitating teachers' decision-making on teaching strategies. While the opportunities being enabled by AI to enhance assessments should be dynamically reviewed and properly leveraged, it is critical to examine and regulate ethical issues concerning the collection and use of students' data; the risks of using AI recommendations and predictions in assessments, especially those with high stakes; and the reduction of teachers' agency in assessments, particularly the opportunities for teachers to gain insights from analysing learning processes.

需要设计、测试并优化符合不同评估项目和目标的具体评估格式及配套评分标准。这些评估形式可能包括：以反思性论文、口头报告或用户测试AI工具报告等形式进行的形成性评估与同伴互评；以及采用纸质、计算机化或非数字化设计形式的总结性考核，例如AI工具原型设计或算法绘制、关于AI伦理问题的案例研究论文、AI工具或系统的设计开发技术报告、AI模型微调或模拟训练，以及硬件组装或开发等。

这一系列具体方法应根据各方面具体需求进行细致研究，并灵活地融入到人工智能CFS的实施中。

人工智能工具在评估中的应用正成为一种新型辅助评估手段，例如通过自动化方式直接从学生或学习管理系统中收集学习过程数据和形成性掌握情况，根据学生的语言文化背景或能力特点进行个性化评估，以及辅助教师制定教学策略。尽管人工智能为提升评估质量带来的机遇需要动态审视与合理利用，但必须重点探讨和规范以下伦理问题：学生数据采集与使用的合规性；在高风险评估中采用AI推荐和预测的潜在风险；以及教师在评估过程中自主权的削弱——特别是通过分析学习过程获取教学洞见的机会被压缩。

Conclusion

The *AI competency framework for students* charts an action-oriented programme based on three basic assumptions about the role of education in responding to the pervasive adoption of AI in today's world. The first is that the education sector, rather than merely adapting to AI systems and tools, must be proactive in developing the competencies required to shape ethical and environmentally-friendly AI. Second, that students should be equipped with the competencies to act both as critical and responsible users and co-creators of AI, as well as leaders in defining and designing the next generation of AI technologies. The third assumption is that students' AI competencies are to be constructed around the convergence of a human-centred mindset and attitudes, internalized ethics of AI, transferable conceptual knowledge and skills on AI, as well as future-proof thinking relative to AI system design. As AI competency development goes far beyond mere technical skills associated with learning to code or to operate AI tools, the integration of AI-related learning requires an interdisciplinary approach to curricular integration spanning subjects related to science, technology, engineering, art and mathematics, to social studies and citizenship education.

This AI competency framework for students is the first attempt to provide a global blueprint to steer a human-centred integration of AI-related learning in curriculum. Informed by expertise and consultations at the international level, the framework serves as a global reference to be adapted across diverse local educational contexts. It is only through adapting and testing the framework among teachers and teacher educators in diverse settings, and surfacing insights from their contextualized practice, that the global framework can be further refined. As such, the framework is a living document which will need to be continuously reviewed on the basis of analysis of practice in a diversity of contexts, as well as in response to new iterations of AI technologies that will emerge.

结

*面向学生的AI能力框架*基于三大核心理念构建了行动导向的培养方案，旨在应对当今世界人工智能的广泛应用。首先，教育领域不应被动适应AI系统和工具，而应主动培养塑造道德环保型AI所需的能力。其次，学生既要具备批判性思考与责任感，成为AI的负责任使用者和共同创造者，更要成为引领下一代AI技术定义与设计的主力军。

第三个假设认为，学生的人工智能能力应建立在以下要素的融合之上：以人为本的思维方式与态度、内化的人工智能伦理观、可迁移的AI概念知识与技能，以及面向未来的人工智能系统设计思维。由于人工智能能力培养已超越单纯学习编程或操作AI工具的技术技能范畴，因此需要将人工智能相关学习内容进行系统整合。需要跨学科的方法来整合课程，涵盖与科学、技术、工程、艺术和数学有关的学科，以及社会研究和公民教育。

这套面向学生的AI能力框架，是全球首个旨在指导课程中以人类为中心的人工智能相关学习整合的蓝图。该框架基于国际专家共识与多方咨询制定，可作为适用于不同本土教育环境的全球性参考框架。只有通过在不同场景中对教师和教师培训师进行框架调整与实践检验，并提炼出基于具体情境的教学经验，才能使这一全球性框架得到持续优化。因此，该框架始终是动态发展的文件，需要根据不同场景下的教学实践分析，以及对即将涌现的AI技术新版本的响应，不断进行修订完善。

References

IEA. 2022. *World Energy Statistics and Balances*. Paris, International Energy Agency (IEA). Available at: https://www.iea.org/data-and-statistics/data-product/world-energy-statistics-and-balances (Accessed 26 July 2024.)

—. 2024. *Electricity 2024*. Paris, International Energy Agency (IEA). Available at: https://www.iea.org/reports/electricity-2024 (Accessed 26 July 2024.)

Ministry of Science and ICT, Republic of Korea. 2019. "IT 강국을 넘어 AI 강국으로!" 범 정부 역량을 결집하여 AI 시대 미래 비전과 전략을 담은 'AI 국가전략 발표 *["Beyond an IT powerhouse, to an AI powerhouse!" Announcement of the 'AI National Strategy' containing the vision and strategy for the future of the AI era by consolidating the capabilities of the entire government].* Sejong-si, Ministry of Science and ICT, Republic of Korea. (In Korean.) Available at: https://doc.msit.go.kr/SynapDocViewServer/viewer/doc.html?key=3035e1e0a5df-4f1a9395b5284512a908 (Accessed 17 July 2024.)

Patrick, S. and Sturgis, C. 2017. *An Introduction to the National Summit on K-12 Competency-Based Education*. 2017. Arlington, Aurora Institute. Available at: https://aurora-institute.org/wp-content/uploads/CompetencyWorks-AnIntroductionToTheNationalSummitOnK12CompetencyBasedEducation.pdf (Accessed 26 July 2024.)

Payne, B. H. 2019. *An Ethics of Artificial Intelligence Curriculum for Middle School Students*. Cambridge, MIT Media Lab. Available at: https://thecenter.mit.edu/wp-content/uploads/2020/07/MIT-AI-Ethics-Education-Curriculum.pdf (Accessed 26 July 2024.)

UNESCO. 2019. *Beijing Consensus on Artificial Intelligence and Education*. Paris, UNESCO. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000368303 (Accessed 26 July 2024.)

—. 2021. *Reimagining our futures together: a new social contract for education*. Paris, UNESCO. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000379707 (Accessed 16 July 2024.)

—. 2022*a*. *Recommendation on the Ethics of Artificial Intelligence*. Paris, UNESCO. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000381137 (Accessed 16 July 2024.)

—. 2022*b*. *K-12 AI curricula: a mapping of government-endorsed AI curricula*. Paris, UNESCO. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000380602 (Accessed 26 July 2024.)

—. 2024. *AI in the United Arab Emirates' computing, creative design and innovation K-12 curriculum: a case study*. Paris, UNESCO. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000388652 (Accessed 26 July 2024.)

Williams, R., Kaputsos, S. P. and Breazeal, C. 2021. Teacher Perspectives on How To Train Your Robot: A Middle School AI and Ethics Curriculum. *Proceedings of the AAAI Conference on Artificial Intelligence*, Vol. 35, No. 17. Washington, DC, Association for the Advancement of Artificial Intelligence (AAAI), pp. 15678–15686. Available at: https://doi.org/10.1609/aaai.v35i17.17847 (Accessed 26 July 2024.)

World Bank. 2023. *Green Digital Transformation: How to Sustainably Close the Digital Divide and Harness Digital Tools for Climate Action. Climate Change and Development Series*. Washington, DC, World Bank. Available at: http://hdl.handle.net/10986/40653 (Accessed 26 July 2024.)

World Bank and ITU. 2024. *Measuring the Emissions & Energy Footprint of the ICT Sector: Implications for Climate Action*. Washington, DC, World Bank and Geneva, International Telecommunication Union (ITU). Available at: https://www.itu.int/hub/publication/d-ind-clim-2023-01 (Accessed 26 July 2024.)(Accessed 26 July 2024.)

参考文

IEA. 2022. *世界能源统计和平衡*。巴黎，国际能源机构（国际能源署）。网址：https://www.iea.org/data-and-statistics/data-product/world-en ergy-statistics-and-balances（访问日期：2024年7月26日）。

—。2024年。*电力2024*。巴黎：国际能源机构（IEA）。可从以下网址获取：https:// www.iea.org/reports/electricity-2024（访问日期：2024年7月26日）

大韩民国科学和信息通信技术部。2019 年 。 "IT ㄱ ㅏ ㅇ ㄱ ㅜ ㄱ ㅇ ㅡ ㄹ ㄴ ㅓ ㅁ ㅇ ㅓ人工智能 ㄱ ㅏ ㅇ ㄱ ㅜ ㄱ ㅇ ㅡ ㄹ ㅗ ! " ㅂ ㅓ ㅁ ㅈ ㅓ ㅇ ㅂ ㅜ ㅇ ㅓ ㄱ ㄹ ㅏ ㅇ ㅇ ㅡ ㄹ ㄱ ㅕ ㄹ ㅈ ㅣ ㅂ ㅎ ㅏ ㅇ ㅓ 人工智能 ㅅ ㅣ ㄷ ㅐ ㅁ ㅣ ㄹ ㅐ ㅂ ㅣ ㅈ ㅓ ㄴ ㄱ ㅘ ㅈ ㅓ ㄴ ㄹ ㅏ ㄱ ㅇ ㅡ ㄹ ㄷ ㅏ ㅁ ㅇ ㅡ ㄴ ‘人工智能 ㄱ ㅜ ㄱ ㅏ ㅈ ㅓ ㄴ ㄹ ㅏ ㄱ ㅂ ㅏ ㄹ ㅍ ㅆ [*"超越IT强国，成为人工智能强国！"《人工智能国家战略》的发布，整合了政府各部门的能力，为人工智能时代的未来指明了方向*。韩国科学技术信息通信部《世宗战略》。（韩文原版）访问地址：https://doc.msit.go.kr/SynapDocViewServer/viewer/doc.html? key=3035e1e0a5df-4f1a9395b5284512a908（访问日期：2024年7月17日）

Patrick，S. 和 Sturgis，C.，2017。*国家K-12能力教育峰会简介*。2017年，阿灵顿，极光研究所。可从以下网址获取 https://auro ra-institute.org/wp-content/uploads/CompetencyWorks-简介Na cation.pdf（访问日期：2024年7月26日）

Payne，B. H. 2019. *面向中学生的AI课程伦理学*。剑桥，MIT媒体实验室。可从以下网址获取：https://thecenter.mit.edu/wp-content/uploads/2020/07/MIT-AI Ethics-Education-Curriculum.pdf（访问日期：2024年7月26日）

联合国教科文组织。2019年。*人工智能与教育北京共识*。巴黎，联合国教科文组织。可从以下网址获取：https://unesdoc.unesco.org/ark：/48223/pf0000368303（访问日期：2024年7月26日）

—。2021年。*重新构想我们的共同未来：教育的新社会契约*。巴黎，联合国教科文组织。可从以下网址获取：https://unesdoc。unesco.org/ark：/48223/pf0000379707（访问日期：2024年7月16日）

—。2022 *a* 。人工智能伦理建议书。巴黎，联合国教科文组织。可从以下地址获取：https://unesdoc.unesco.org/ark：/48223/pf0000381137（访问日期：2024年7月16日）

—。2022 *b* . *K-12人工智能课程：政府认可的人工智能课程图谱*。巴黎，联合国教科文组织。可从以下网址获取： https://unesdoc。unesco.org/ark：/48223/pf0000380602（访问日期：2024年7月26日）

—，2024。*阿拉伯联合酋长国的计算机、创意设计和创新课程中的人工智能：一个案例研究*。巴黎，联合国教科文组织。可从以下网址获得：https://unesdoc.unesco.org/ark：/48223/pf0000388652（访问日期：2024年7月26日）

Williams，R.，Kaputsos，S. P.和Breazeal，C. 2021.教师视角下的机器人训练指南：中学人工智能与伦理课程。*人工智能协会会议论文集*，第35卷，第17期。华盛顿特区，人工智能协会（AAAI），第15678–15686页。可获取于：https://doi.org/10.1609/aaai.v35i17.17847（2024年7月26日访问）。

世界银行，2023年。*绿色数字化转型：如何可持续地消除数字鸿沟并利用数字工具实现气候行动。气候变化与发展系列*。华盛顿特区，世界银行。可从以下网址获取：http://hdl.handle.net/10986/40653（访问日期：2024年7月26日）

世界银行和国际电联。2024年。*信息通信技术部门排放量和能源足迹计量：对气候行动的影响*。华盛顿特区、世界银行和日内瓦国际电信联盟（ITU）。可从以下网址查阅：https://www.itu.int/hub/publication/d-ind-clim-2023-01（访问日期：2024年7月26日）。（访问日期：2024年7月26日）

Endnotes

1 The principle of proportionality in AI encompasses the idea that AI systems should be designed and deployed in a manner that appropriately balances risks and benefits, respects human rights, and aligns with societal values and interests. See the *Recommendation on the Ethics of AI* (UNESCO, 2022*a*) for more on the proportionality of AI.
2 See http://yann.lecun.com/exdb/mnist
3 See https://www.cs.toronto.edu/%7Ekriz/cifar.html
4 See https://www.image-net.org/index.php
5 See https://teachablemachine.withgoogle.com
6 See https://pytorch.org
7 See https://keras.io
8 See https://pypi.org/project/beautifulsoup4
9 RAISE stands for 'Responsible AI for Social Empowerment and Education'
10 See https://ubuntu.com
11 See https://machinelearningforkids.co.uk
12 See https://teachablemachine.withgoogle.com
13 See https://www.tensorflow.org
14 See https://keras.io
15 See https://everyday-ai.org/resources/search?f%5B0%5D=tools%3A201
16 See https://www.aiunplugged.org
17 See https://iste.org/blog/3-unplugged-activities-for-teaching-about-ai
18 See https://raise.mit.edu/daily

尾注

1 人工智能的相称性原则包含这样一种理念，即人工智能系统的设计和部署应当以适当平衡风险与收益、尊重人权并符合社会价值观念和利益的方式进行。有关人工智能相称性的更多信息，请参见*关于人工智能伦理的建议*（联合国教科文组织，2022年*a*）。

2 见http://yann.lecun.com/exdb/mnist

3 见https://www.cs.toronto.edu/%7Ekriz/cifar.html

4 见https://www.image-net.org/index.php

5 见https://teachablemachine.withgoogle.com

6 见https://pytorch.org

7 见https://keras.io

8 见https://pypi.org/project/beautifulsoup4

9 RAISE代表“为社会赋权和教育负责的人工智能”

10 见https://ubuntu.com

11 见https://machinelearningforkids.co.uk

12 见https://teachablemachine.withgoogle.com

13 见https://www.tensorflow.org

14 见https://keras.io

15 见https://everyday-ai.org/resources/search？f%5B0%5D=tools%3A201

16 见https://www.aiunplugged.org

17 见https://iste.org/blog/3-unplugged-activities-for-teaching-about-ai

18 见https://raise.mit.edu/daily

unesco
United Nations
Educational, Scientific
and Cultural Organization

AI competency framework for students

The *AI competency framework for students* presented here is based on an ambitious vision that extends well beyond popular notions of AI literacy. It aims to support students to grow towards being not only effective and ethical users of AI tools, but also co-creators in the design of more inclusive and environmentally sustainable AI. The framework defines the values, as well as the foundational knowledge and transferable skills, required to critically understand and use AI systems in a safe, effective and meaningful manner at different levels of mastery. The framework also proposes detailed specifications on what AI topics can be covered and what pedagogical methods may be deployed to facilitate students' understanding, application, and creation of AI. It further provides guidance for the curricular integration of AI-related learning, the organization of learning sequences, and the design of competence-based assessments. Seen as an integral set of capabilities required for responsible citizenship in the era of AI, the competencies outlined in this framework are based on principles of inclusivity, the centrality of human agency, non-discrimination, and respect for linguistic and cultural diversity.

9 789231 007095

4 QUALITY EDUCATION

Sustainable Development Goals

unesco
United Nations
Educational, Scientific
and Cultural Organization

人工智能能力框架

为学生

这里提出的*学生人工智能能力框架*基于一个雄心勃勃的愿景，远远超出了人们对人工智能素养的普遍概念。该框架旨在培养学生不仅是AI工具的有效且道德使用者，更要成为设计更具包容性和环境可持续性AI的共同创造者。它明确了在不同掌握程度下，批判性理解并安全、高效、有意义地使用AI系统所需的价值观、基础知识和可迁移技能。框架还详细规定了可涵盖的AI主题范围及促进学生理解、应用和创造AI的教学方法。此外，它为AI相关课程整合、学习序列组织以及基于能力的评估设计提供了指导。这些能力被视为人工智能时代负责任公民必备的核心素养，其制定基于包容性原则、人类能动性的核心地位、非歧视性以及对语言文化多样性的尊重。

9 789231 007095

4 QUALITY EDUCATION

可持续发展目标