CONTENTS

UNIT 1

Manufacturing the future

Learning objectives

After studying this unit, you will be able to:

- discuss how intelligent manufacturing contributes to the sustainable development of society;
- use tables for note-taking in academic listening;
- use the structure-proposition-evaluation (SPE) strategy in academic reading;
- write a research proposal on how intelligent manufacturing contributes to sustainability.

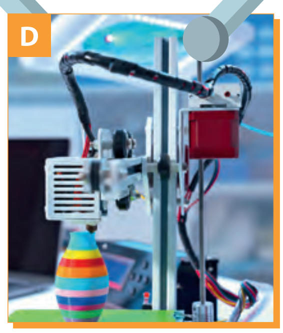
Setting

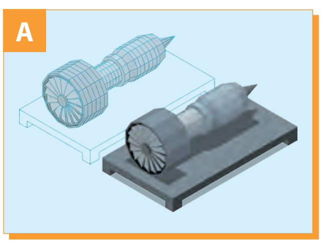
Intelligent manufacturing or smart manufacturing refers to the use of advanced technologies to optimize production processes and enhance efficiency. It has been gaining momentum across various industries, from automotive and aerospace to health care and consumer electronics. In the long run, intelligent manufacturing is crucial to achieving sustainable development due to its environmental friendliness. In recent years, China has established a leading position in intelligent manufacturing, which is driven by the government's policies to promote innovation and technological development. China has determined to move its manufacturing sector toward higher-end, smarter, and greener production. As we explore the topic of intelligent manufacturing, we should consider one critical question: **How can intelligent manufacturing contribute to a more sustainable economy while promoting social and environmental well-being?**

Leading in

Match the pictures of technologies used in intelligent manufacturing with the technical terms. You can look up these terms online if necessary. Are there any other technologies employed in intelligent manufacturing? Work in pairs and share your ideas.

1 Augmented reality
2 Digital twin
3 Additive manufacturing
4 The Internet of Things

D


A


B


C


Exploring

VIEWING

Pre-viewing

Nowadays, intelligent manufacturing is gaining popularity and importance. Work in pairs and discuss how intelligent manufacturing benefits production compared with traditional methods. Consider factors such as increased productivity and energy efficiency.

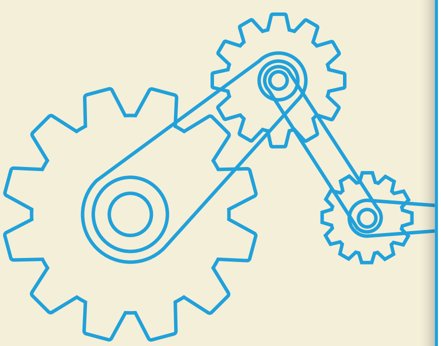
Analytical viewing

Scan the code. Watch the video and complete the following exercises. You can do more comprehension exercises on Ucampus.

Viewing and understanding

How do the companies in Changsha embrace intelligent manufacturing? Complete the table with information from the video. You can refer to the Academic listening skill on the next page.

Company	Innovation	Impact
An environmental equipment producer	5G plus AI	Faster 1) ________ of the sanitation robot cluster
A smart energy metering and management company	• The 100% automatic 2) ________ • Use of robots	• Lower costs • Better quality control • Products complying with customers' 3) ________ completely
An aerial work platform company	Intelligent assembly lines	• Tripled 4) ________ • More efficient and skilled workers • Improved product quality



Word bank

cluster /ˈklʌstə/ *n.* [C]（人、物集中出现的）一群，一组
automatically /ˌɔːtəˈmætɪkli/ *ad.* 自动地
automation /ˌɔːtəˈmeɪʃən/ *n.* [U] 自动化
authority /ɔːˈθɒrəti/ *n.* [C, usu. pl.] 官方
consultancy /kənˈsʌltənsi/ *n.* [U] 咨询服务
step (sth.) up 使…增加
assembly /əˈsembli/ **line** *n.* [C] 装配线
free (sb. / sth.) up 使…可用（于…目的）

Thinking beyond

At the end of the video, Jeffrey Moeller says, "Intelligent manufacturing is poised to reshape the manufacturing sector." Work in groups and discuss how the shift from "Made in China" to "Intelligent Manufacturing in China" impacts the manufacturing industry, focusing on the industrial landscape, social responsibility commitments, and the image of Chinese products.

Academic listening skill

Using tables for note-taking

Using tables for note-taking is helpful for academic listening comprehension. It involves creating a table or chart to systematically record and organize information from a spoken source, such as a lecture or seminar.

This method promotes active listening, helps organize information, and improves information retention. By structuring data in a visual format, listeners can quickly comprehend and review complex content. This method enhances critical thinking and the ability to identify key points in academic lectures or presentations. Here are some tips on using tables for note-taking:

Label columns

Start by focusing on the title and the introduction made by the speaker, which often provide clues about the key themes to be discussed. Create a table with columns labeled with the themes. This ensures your table is structured in a way that aligns with the lecture's content from the start, enabling you to organize information efficiently as you listen.

Fill in the table

Actively listen to the important information related to the key themes. Jot down the information in the appropriate columns. Use bullet points, short phrases, or keywords to capture the essence of the content.

Remain flexible

As you delve deeper into the topic, you might encounter sub-topics or details that aren't apparent from the start. Be prepared to add more columns or adapt your current ones to accommodate this new information.

Scan the code and learn more about the skill on Ucampus.

Language focus

Scan the code and complete the language exercises on Ucampus.

READING

Log on to Ucampus for interactive learning.

Pre-reading

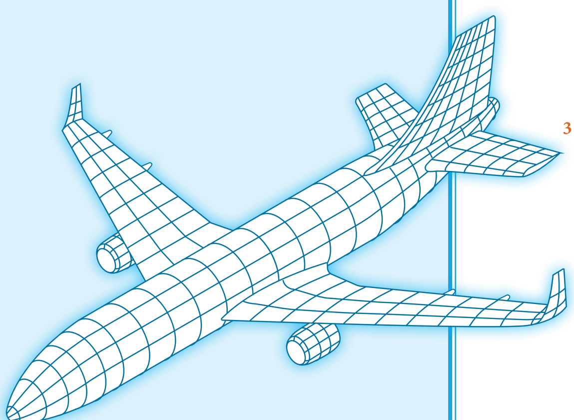
Look at the word cloud about sustainability. Discuss in groups how intelligent manufacturing might connect with these concepts.

renewables
environment
efficiency conservation
resources recycling

How intelligent manufacturing interconnects with sustainability

1 Did you know that 2022 was the 50th anniversary of the sustainability movement? Back in 1972, a group of climate scientists predicted the current climate crisis in a book. At the time, the study was described as "another **whiff** of **doomsday**". Nowadays, the prediction of these early pioneers has been **validated**. In 2023, the annual average global temperature was 1.45 ± 0.12 °C above pre-industrial levels. A recent study suggests a 2 °C increase in the average global temperature, compared to pre-industrial levels, could **displace** about 1.5 billion people.

2 But every prediction contains the word "if"; even when it is not directly **asserted**, it is implied. There is room for optimism because fixing problems and improving the world are deeply human characteristics. The instinct to expand our horizons and shape the environment around us will never stop, but we need to change the way we do it.



3 For a long time, we thought that humans were the only species capable of creating and utilizing tools to improve their standard of living. Now we know of a great many other species that do the same. **Nevertheless**, our **specialty** is the ability to use tools to create other, more sophisticated and

advanced ones. Perhaps **Homo sapiens** is no longer the right name for our species. In light of the Fourth Industrial Revolution, we could consider adopting the name Homo factorem (Man the maker).

4 What happens when Homo sapiens meets Homo factorem? The makers of the world rise to the challenge with the tools they need to make better products in new ways. They bring their ideas to life faster, harnessing their intelligence to find greater efficiencies with lower environmental impact. In this context, it becomes evident that intelligent manufacturing and sustainability are closely **intertwined**.

5 Intelligent manufacturing, at its core, is about collecting and sharing information in innovative and **revolutionary** ways. This allows us to develop new technologies and improve the manufacturing process. Efficient resource utilization is a fundamental principle of intelligent manufacturing, and digital twin technology is a **prime** example of this.

6 Digital twins are virtual replicas of physical assets, such as vehicles or machines, eliminating the need for physical testing and prototyping. This reduces the consumption of raw materials and minimizes waste generation, leading to significant environmental benefits. For example, in the automotive industry, digital twins can **simulate** vehicle crash tests, saving materials and resources while avoiding energy consumption and emissions from manufacturing and disposal processes. Similarly, in aviation, digital twins can simulate test flights, reducing the need for costly and resource-intensive physical testing.

7 To **attain** genuine sustainability, designers must consider various factors **transcending** the product production. They need to adopt a comprehensive approach that encompasses the entire value chain. Digital twin technology plays a crucial role in optimizing sustainability performance at every stage, from raw material **extraction** to end-of-life disposal. The CNC (**computer numerical control**) and CMM (**coordinate measuring machine**) **simulator** is an example demonstrating how

smart digital solutions can train staff at a much lower cost. This simulator has recently been developed for simulating CNC, CMMs, and the manufacturing processes. It provides a cost-effective training method that eliminates material waste, machine **downtime**, or the risk of damage to expensive equipment.

8 Another **noteworthy** example involves the utilization of AI to optimize machine maintenance schedules. This technology plays a crucial role in what is known as predictive maintenance. The purpose of **predictive** maintenance is to anticipate potential failures and then schedule repairs **proactively**, preventing issues before they occur. This proactive approach enables companies to address issues early on, minimize machine downtime, enhance efficiency, and extend the equipment's lifespan.

9 Sustainability, similar to intelligent manufacturing, begins with data. Data provide valuable **insights** into resource usage, energy consumption, waste generation, and other crucial factors. By **amassing** and analyzing these data, targeted strategies for improvement can be developed, minimizing inefficiency and waste. As we welcome the era of Industry 4.0 with open arms, sustainability is **revolutionizing** global commerce and becoming an essential component of every manufacturer's digital transformation initiative.

10 The triple-bottom-line model provides an effective framework for understanding sustainability. This model emphasizes three pillars for long-term success: Planet (environmental sustainability), Profit (economic sustainability), and People (wider social responsibility). Each pillar holds equal importance in achieving sustainability.

11 The "Planet" dimension focuses on minimizing the negative impact on the environment, conserving natural resources, and alleviating climate change effects. It highlights the importance of adopting practices that promote eco-friendly operations, such as reducing carbon emissions and waste generation, using renewable energy sources, and practicing sustainable resource management.

12 The "Profit" aspect considers economic sustainability by ensuring that business activities are financially **viable** and generate profits while maintaining long-term **viability**. Strategies like cost optimization, efficient resource allocation, and sustainable business models **prioritize profitability** without compromising the **welfare** of future generations.

13 The "People" component recognizes the social responsibility of organizations toward various stakeholders. This includes **equitable** labor practices, ethical sourcing, diversity and inclusion, community engagement, and product safety and quality. Prioritizing the well-being and satisfaction of the people involved contributes to building sustainable and **resilient** societies.

14 The "People" element is crucial for both sustainability and intelligent manufacturing. Neglecting the human aspect in intelligent manufacturing would be a serious mistake, as it overlooks two essential assets: creativity and **empathy**. While automation, robotics, and AI are important in intelligent manufacturing, they cannot fully replace human involvement. Human creativity drives innovation, improves processes, and effectively addresses challenges. Empathy helps people understand the needs of customers, employees, and stakeholders, leading to the development of products and services that meet their requirements. Recognizing and valuing the human element fosters a harmonious integration of technology and human capabilities, contributing to successful and sustainable intelligent manufacturing practices.

15 As we move forward into the future, it is **imperative** to **acknowledge** the importance of sustainability and its interconnected relationship with intelligent manufacturing. By embracing intelligent manufacturing practices and integrating them with sustainable principles, we have the opportunity to create a world where economic growth, environmental responsibility, and social well-being are harmoniously **interwoven**. The responsibility lies with us to seize this opportunity and pave the way for a brighter and more sustainable future for generations to come.

Analytical reading

Reading and understanding

1 How do intelligent manufacturing and sustainability relate to each other? Read the text and complete the diagram. You can refer to the Academic reading skill on the next page.

Intertwined

Intelligent manufacturing

- Intelligent manufacturing is fundamentally about 1) ________________ in innovative and revolutionary ways.
- 2) ________________ is a fundamental principle of intelligent manufacturing.

Examples

Digital twin technology

- It creates 3) ________________ of physical assets to reduce raw material consumption and minimize waste generation.
- It is crucial for maximizing sustainability performance at 4) ________________.

5) ________________

It uses AI to optimize machine maintenance schedules.

⟺

Sustainability

- 6) ________________ play a vital role in achieving sustainability.
- Sustainability is now a critical part of every manufacturer's 7) ________________.

The triple-bottom-line model

- The "Planet" aspect emphasizes minimizing 8) ________________ on the environment.
- The "Profit" aspect makes sure that business activities can both make profit and maintain 9) ________________.
- The "People" aspect recognizes 10) ________________ of organizations.

↓

The "People" element, with the assets of 11) ________________, is also essential to intelligent manufacturing.

⇓

Integrating intelligent manufacturing with sustainability is vital for creating a brighter and more sustainable future.

2 What is the author's main argument in the text? How does the author effectively support his argument? Work in pairs and share your ideas.

Scan the code and complete more comprehension exercises on Ucampus.

Thinking beyond

Humans have played a significant role in the manufacturing industry. In the era of Industry 4.0, how have their roles changed, and what new requirements has the industry imposed on them?

Step 1 Work in groups. Summarize the key points in the text that support the necessity of involving humans in intelligent manufacturing. Then consider other reasons why humans are essential to intelligent manufacturing.

Step 2 Discuss what changes intelligent manufacturing brings to people working in the manufacturing industry, compared with traditional methods of production. You may consider the following aspects:

- Changes related to the role played by people in the production process
- Changes related to the skills people need

…

Step 3 Present your ideas and engage in a question-and-answer session.

Academic reading skill

Using the structure-proposition-evaluation (SPE) strategy

The structure-proposition-evaluation (SPE) reading strategy is an approach to reading complex texts. It involves breaking down a text into its structural components, identifying the key propositions, and evaluating the content critically. This approach helps the reader extract essential information and think critically about the material. Here are the three steps of the strategy:

Structure
Examine the organization of the text through headings, subheadings, and any other structural elements. You can also skim the text, especially the opening or closing paragraphs, for signs of the main contention that helps you understand the overall structure.

Proposition
Identify the main propositions in each section of the text by looking for topic sentences in paragraphs or overarching arguments presented. Then try to figure out their logical relationships.

Evaluation
Assess the author's arguments, evidence, and reasoning critically. You may consider validity, credibility, relevance, consistency, and alternative perspectives.

Scan the code and learn more about the skill on Ucampus.

Language focus

Scan the code and complete the language exercises on Ucampus.

Producing

Write a research proposal: How intelligent manufacturing contributes to sustainability

Your university has decided to fund research projects that explore how intelligent manufacturing can contribute to a more sustainable economy while fostering social and environmental well-being. Your research team is going to write a research proposal to secure funding for your project.

Academic writing skill

Writing a research proposal

A research proposal is a piece of academic writing that outlines the research you intend to carry out. A well-structured research proposal typically includes the following sections:

Introduction

The introduction explains what you want to research and why the research is worth doing. It introduces the topic, describes the background and the broader context of the research, and clearly presents the problem statement and the research question.

Literature review

In this section, you should analyze and integrate previous studies to fit your proposed research into the larger picture of what has been studied in the past. This convinces the reader that your project has a solid foundation in existing knowledge or theory.

The literature review should also prove that you aren't just repeating previous studies. By critically assessing previous research, you highlight a gap in knowledge that your research aims to fill.

Research design and methodology

The section describes the overall approach and practical steps you will take to address your research question. You need to include the following content:

- The specific research method, e.g. qualitative or quantitative research, or combined
- The data collection method, e.g. systematic reviews or interviews; if undertaking your own study, you should make it clear when and where you collect data, how you select subjects or sources, etc.
- The data analysis method, e.g. thematic analysis or content analysis

Expected outcomes and implications

This section includes your research's expected outcomes, potential impacts, and its contribution to the field.

References

This section includes a comprehensive list of all the sources you cited in your research proposal.

Scan the code and learn more about the skill on Ucampus.

Step 1 **Read the existing literature**

- Read the texts in this unit and relevant literature to understand the current state of intelligent manufacturing, particularly in relation to the focus of the research project.
- Identify gaps or areas where further research is needed.

Step 2 **Consider the content of the proposal**

- Work in groups and share the information you have gathered.
- Discuss and decide on the main content of your research proposal.

- The knowledge gap you want to fill

  ____

  ____

- The research question you intend to address

  ____

  ____

- The methodology you choose

  ____

  ____

- The outcomes and implications you anticipate

  ____

  ____

Step 3 **Write the proposal**

Write the first draft of your research proposal based on your group discussion.

Step 4 **Refine the proposal**

Review and polish your research proposal to ensure grammatical accuracy, clarity, logical consistency, and overall coherence.

Did you complete the project efficiently? Scan the code and assess your performance by completing the project checklist on Ucampus.

Reading more

READING 1

Log on to Ucampus for interactive learning.

The mainstreaming of additive manufacturing

1 In a popular **ensemble** comedy movie, the lead characters use 3-D printing technology to create realistic replicas. "Replicators", which generate food or tools from basic raw materials, have been a staple of science fiction in film and TV for generations. Yet while the film industry has been quick to seize on the potential of additive manufacturing (AM), the world of manufacturing has unfortunately been slow on the **uptake**.

2 Compared with traditional production approaches, AM technologies offer four potential sources of value. First, their ability to generate almost any 3-D shape allows designers the **flexibility** to create parts that are superior to conventional alternatives. Second, with no need for molds or fixed tooling, every part produced by a machine can be unique, which paves the way for mass-scale **customization**. Third, eliminating time-consuming toolmaking and **fabrication** operations accelerates both product development and production, reducing time to market. Finally, AM technologies can simplify product maintenance and support, reducing the need for spare-parts **inventories** by enabling on-demand production of items from digital files.

3 Rapid innovation is driving major improvements in the performance of AM technologies. The newest generations of machines are overcoming many of the perceived limitations of their **predecessors**, such as by allowing the production of **overhanging** parts without the need for elaborate printed support structures or creating stronger parts by controlling the alignment of fiber **reinforcements** using magnetic fields. The **assortment** of materials available for AM systems continues to expand, including high-strength aluminum **alloys** and medical-grade **polymers**.

4 AM systems are also advancing in terms of speed. A recent technology, for example, uses as many as one million laser **diodes** to accelerate the production of parts. Improvements to software and post-processing technologies are further **streamlining** the journey from concept to finished component. AM technologies pair very well with generative-design systems, which use AI techniques to define and optimize the geometry of parts. This **synergy** between AM and generative design enables manufacturers to develop **intricate** and optimized components faster.

5 In many sectors, AM has become widely accepted as the fastest, most **versatile**, and most cost-effective way to produce functional prototypes during product development and testing. AM technologies are also being applied in a growing range of "indirect" applications, including tooling, spare parts, and fixtures for conventional manufacturing machines.

6 Yet while companies have experimented with using AM technologies for the direct manufacture of final

products, large-scale adoption of the approach remains limited. Manufacturers have cited four significant barriers **obstructing** their use of AM technologies:

7 Hardware. The slow speed and limited build volume available in most AM machines restrict the range of possible applications. Such machines have also proven tricky to integrate into the production **workflow**. An industrial AM production cell may require the user to combine manufacturing, post-processing, and material-handling equipment from different vendors.

8 Software. The smooth functioning of AM equipment is often **contingent** on vendor-specific control software, and there is limited integration between different machines or between the equipment and production-control systems used in the wider plant.

9 Materials. Today, even common engineering materials are more expensive when supplied in a form suitable for processing with AM equipment. Converting metal alloys into powder form for AM machines increases costs. Moreover, the **certification** of AM materials, particularly polymers, for critical end-use applications is still limited.

10 Services. Industrial users express **dissatisfaction** with the level of technical support provided by equipment vendors in the AM industry. They desire more assistance beyond installation and commissioning, particularly in refining component designs for specific manufacturing processes and improving the quality, productivity, and **reliability** of the machine.

11 Despite the limitations, some industrial users have made significant progress in direct production using AM technologies, developing knowledge and capabilities along the way that will serve them well as the industry evolves. One particular sector that has managed to move beyond these perceived limitations is the medical-device industry. AM technologies are now applied routinely and at scale to produce a wide range of products, including artificial body parts and **implants**, surgical guides, and **anatomical** models. These applications have succeeded because they are highly customized and offer benefits to patients and medical professionals that conventional manufacturing technologies cannot match. Instead of dedicating time to shaving bones or shaping a standard **orthopedic** implant, for example, a surgeon can simply install a custom device manufactured to match the individual patient's **morphology**.

12 Manufacturers in other sectors, meanwhile, will not be able to exploit the benefits of AM until they take a more holistic approach to AM technologies. That will typically require them to develop novel product designs, manufacturing flow, and business models. In this area, the medical-device sector is **blazing** a trail.

13 There is a framework which can assist companies in developing AM capabilities. The core of this approach is an "AM center of competence", which consolidates the organization's AM efforts in one place and serves as a **hub** of capabilities, knowledge, and best practices. At the outset, it can be a small, dedicated team, but ideally, it should engage with **external** partners to develop knowledge and share insights with engineers and stakeholders across the organization.

14 Led by the center of competence, the organization's first **forays** into AM can be quick and low-risk, designed to develop understanding of the available technologies. The ability to produce prototype

parts is the most common AM starting point, while the manufacture of tooling for assembly can help to create excitement among production engineers and **shop floor** personnel.

15 While experimenting with these simple applications, the center of competence can also simultaneously begin identifying opportunities for the more systematic application of AM technologies. This could be done via the **identification** of critical points along the value chain where AM could help, such as by eliminating **scrap**, simplifying assembly, reducing inventory, or improving the next generation of products.

16 As it moves the most promising AM applications into production, the organization enters a build-and-transfer phase. To **ascertain** further potential applications more quickly, companies can **codify** their growing AM knowledge into design tools, for example. These might include total cost of ownership (TCO) models that make it easy to quantify the costs and benefits of shifting to AM for common applications within the business.

17 Once it has gained some experience in direct production using AM technologies, the organization can move into the scale-and-sustain phase, incorporating AM fully into its **portfolio** of manufacturing technologies.

18 After decades as a **bit player**, AM is on the verge of achieving widespread recognition and success. Faster machines, better materials, and smarter software are helping to make AM a realistic solution for many real-world production applications. As the technical barriers fall, the **onus** is on manufacturers to improve their understanding of these rapidly evolving technologies, building the skills, processes, and business models needed to make AM shine in the industrial world.

Analytical reading

The text mentions the medical-device industry's success with AM. Can you think of other industries where AM could have a transformative impact and how it could achieve this? Work in groups and share your ideas.

Scan the code and complete the comprehension and language exercises on Ucampus.

READING 2

Soft robots could transform many aspects of human life. What is their current state of development and what impact do they have? Scan the code for more reading on Ucampus.

Evaluating

Rate your performance based on what you have learned in this unit.			
	Fair	**Good**	**Excellent**
I can discuss how intelligent manufacturing contributes to the sustainable development of society.			
I can use tables for note-taking in academic listening.			
I can use the structure-proposition-evaluation (SPE) strategy in academic reading.			
I can write a research proposal on how intelligent manufacturing contributes to sustainability.			

Answer the following questions.

1 What do you need to improve?

2 How do you plan to improve it?

Vocabulary

Scan the code and learn the vocabulary on Ucampus.

Unit test

Scan the code and take the unit test on Ucampus.