

TCSL-70130 Lecture 10: IoT in Education 大數據之教育應用

Shiow-yang Wu 吳秀陽

CSIE 資訊工程學系
NDHU 國立東華大學

2

Lecture Topics

- What is IoT?
- Overview of IoT technologies
- Elements of IoT
- Applications of IoT
- IoT in education
- IoT educational use cases

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

3 **What is Internet of Things?**

- ▶ The term **Internet of Things (IoT)** was first suggested by **Kevin Ashton** in **2009**.
- ▶ It is used to refer to **uniquely identifiable objects** and their **virtual representations** in an **internet-like structure**.
- ▶ If all the objects and people have **identifiers**, they could be **managed** and **inventoried** by computers.
- ▶ The world where all objects and people have identifiers and are connected by an internet-like structure is called the **Internet of Things**.

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

4 **Major Subject of 5G (2020-2030)**

**Connection of
7 Billion of People and
7 Trillion Things**

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

5

Will have Internet of Things

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

6

and Internet of Underground Things

► Yes! IoT is **underground** now!

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

7 even Internet of Underwater Things

Even **underwater IoT!**

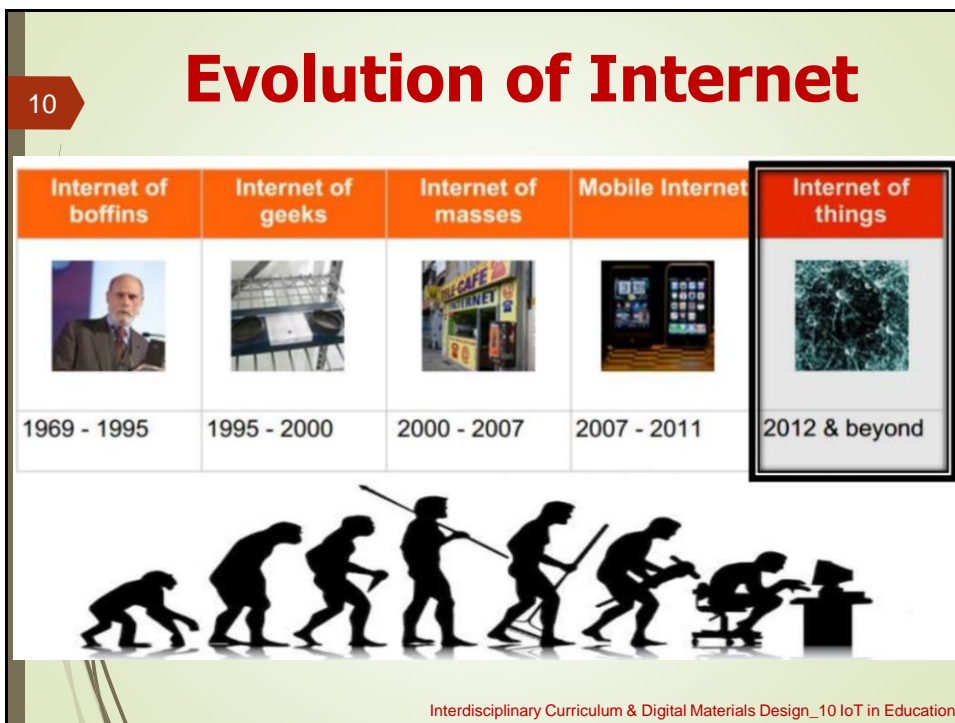
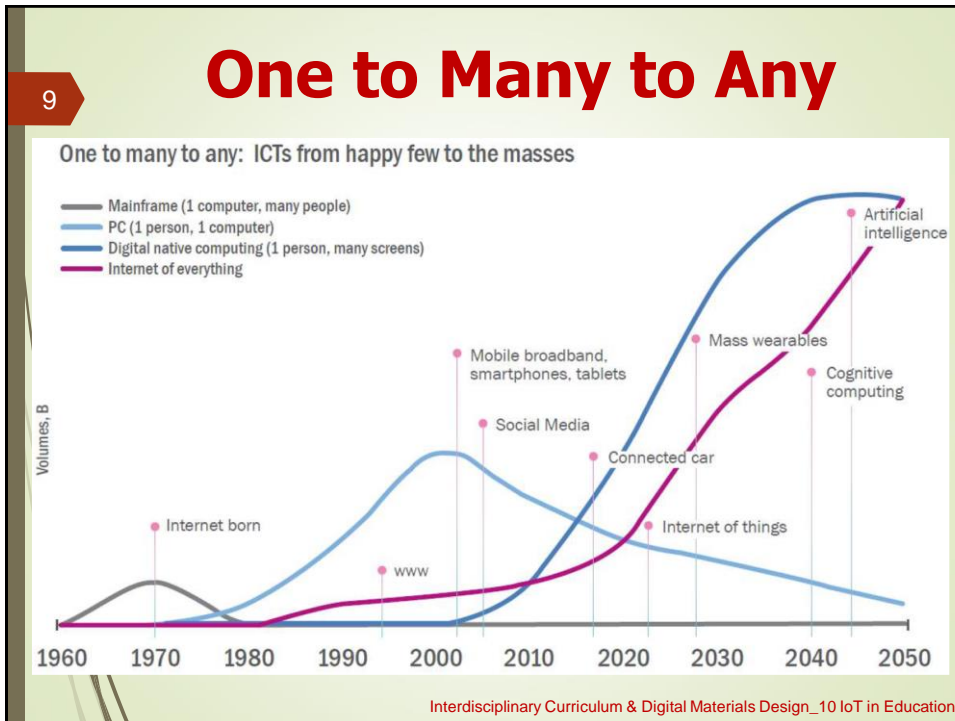
Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

8 IoT Devices

1 SENSORS & ACTUATORS

We are giving our world a **digital nervous system**. Location data using GPS sensors. Eyes and ears using cameras and microphones, along with sensory organs that can measure everything from temperature to pressure changes.

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education



11

Internet of Boffins

- 1969: ARPANET carried its first data packet. It was the first network to use TCP/IP.
- 1970: Mark I Network by Davis (a packet switched network)
- 1973: Mark II Network
- 1974: Telenet (an American commercial packet-switched network)
- 1980: Ethernet
- 1990: GOSIP(Government Open Systems Interconnection Profile)
- 1994: first full text Web search engine
- A stage of **early evolution** and **research**.

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

12

Internet of Geeks

- 1995: IPv6 proposed (makes IoT possible)
- 1995: Amazon started its 1st online retail service
- 1995: eBay provided online auction and shopping services
- 1996: Hotmail offered free Web based email service
- 1998: Google Search engine officially launched
- 1998: PayPal started 1st Internet payment service
- **Internet penetration** was low until 2000.

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

13

Internet of Masses

- 2000: Dot-com bubble burst, high growth in stock markets, people across the globe started using the Internet, social networking sites emerged
- 2001: Wikipedia started
- 2004: Facebook started
- 2005: YouTube started
- 2006: Twitter started, WikiLeaks started
- The era with **high growth**, **mass services**, and **social network/media**

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

14

Mobile Internet

- The first mobile phone call was made on April 3, 1973 with a phone weighed 1.1kg (2.5 pounds) and sized 228.6x127x44.4mm.
- 1996: Nokia 900 Communicator was the 1st commercial mobile phone with internet connection
- Mobile internet was available in **2007** when Apple released the 1st gen iPhone.
- 2007~2011 was the era of **mobile internet**.



Nokia 9000 Communicator

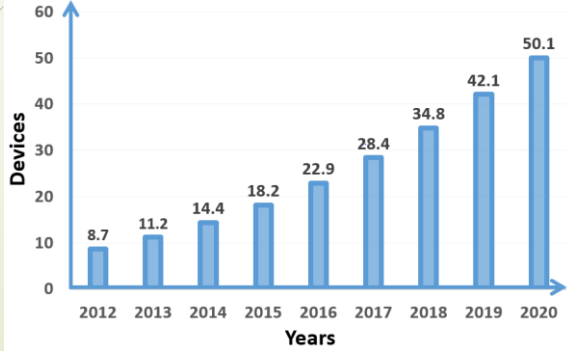


Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

Internet of Things

15

- Since 2012, the number of IoT devices has been increasing each and every day.
- From 2012 to 2020, the number grows from 8.7 billions to 50.1 billions.



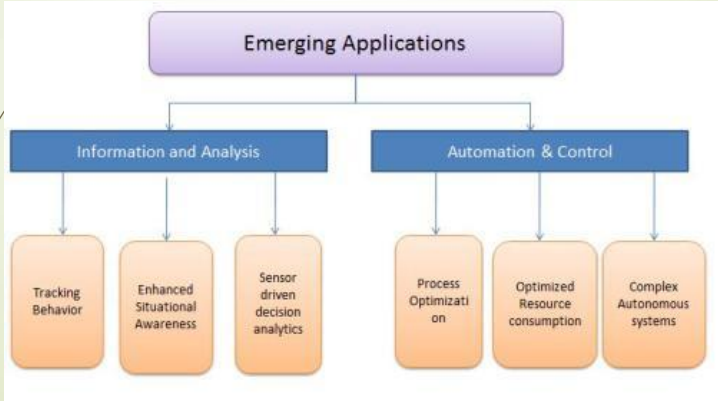
Year	Number of Devices (Billions)
2012	8.7
2013	11.2
2014	14.4
2015	18.2
2016	22.9
2017	28.4
2018	34.8
2019	42.1
2020	50.1

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

Emerging Applications

16

- The emerging applications of IoT:
 - **Informaton & Analytics**
 - **Automation & Control**



```

graph TD
    EA[Emerging Applications] --> IA[Information and Analysis]
    EA --> AC[Automation & Control]
    IA --> TB[Tracking Behavior]
    IA --> ESA[Enhanced Situational Awareness]
    IA --> SDDA[Sensor driven decision analytics]
    AC --> PO[Process Optimization]
    AC --> ORC[Optimized Resource consumption]
    AC --> CAS[Complex Autonomous systems]
    
```

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

17

Applications Domains

IoT has deployed in many application domains.

INTERNET OF THINGS

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

18

3 Dimensions of IoT

IoT is to provide **Any TIME**, **Any PLACE**, and **Any THING** connections.

Any TIME connection

- On the move
- Outdoors and indoors
 - Night
 - Daytime

Any PLACE connection

- On the move
 - Outdoors
 - Indoors (away from the PC)
- At the PC

Any THING connection

- Between PCs
- Human-to-Human (H2H), not using a PC
- Human-to-Thing (H2T), using generic equipment
- Thing-to-Thing (T2T)

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

19 **More Dimensions and 6Cs**

➤ More dimensions and the 6Cs

Convergence
Anything
Any device

Anytime
Any context

Computing
Anyone
Anybody

Connectivity
Any place
Anywhere

Internet
Of
Things

Content
Any Service
Any Business

Communication
Any path
Any Network

Collections

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

20 **IoT Elements**

➤ Several **elements** are required to deliver the functionality of IoT.

6. Semantics

1. Identify

2. Sense

3. Communication

4. Compute

5. Services

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

21

IoT Elements - Identification

- Need to offer **explicit identity** for each object.
- Two processes in identification: **naming** and **addressing**.
- **Naming** provides **names** of objects for referencing
- **Addressing** offers **unique address** of specific obj
- Two ore more objects may have **same name** but always **different** and **unique address**.
- **Naming methods**: Electron Products Codes(EPC), Bar codes, QR codes, Digital watermarking, ...
- **Unique addressing** is assigned by **IPv6**.

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

22

IoT Elements - Sensing

- **Sensing** is the process of collecting information from objects.
- The collected info is sent to the **storage media**.
- There are many **sensing devices**:
 - RFID tags
 - Smart sensors
 - Wearable sensing devices
 - Actuators
 - ...

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

23

IoT Elements - Communication

- **Communication** is essential for different objects to be **connected** to each other and **communicate**.
- In communication, objects may **send** and **receive messages, files, and other information**.
- Many technologies to facilitate communication:
 - RFID (Radio Frequency Identification)
 - NFC (Near Field Communication)
 - Bluetooth
 - Wi-Fi
 - LTE (Long Term Evolution)

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

24

IoT Elements - Computation

- **Computation** is performed on the collected info
- Provide **processing power** for IoT applications.
- Many HW/SW **platforms** are available.
- **Hardware platforms**: Audrino, Rasperry Pi, Intel Galileo, Nvidia Jetson Nano, ...
- **Software platforms**: Android, Tiny OS, Lite OS, ROS (Robot Operating System), ...
- **Stream processing platforms**: Kafka, Flume, Spark, Storm, S4, Google Cloud IoT, AWS IoT, Azure IoT, IBM Watson IoT, Salesforce IoT, ...

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

IoT Elements - Services

25














- **Identity-related services:** get identity of objects
- **Information aggregation:** collect info from objects
- **Collaborative services:** integrate info sources, make decisions, send appropriate responses, ...
- **Ubiquitous services:** offer immediate responses without rigidity of time and place.
- **IoT platforms:** platforms for hosting, connecting, and integrating IoT services. (next slide)

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

IoT Platforms

26

➤ **IoT platforms** play the role of **middleware** between hardware/devices and applications.

APPLICATION	 Data storage/analytics	 Consumer application	 Industrial application	 Business application	 Your application		
MIDDLEWARE	 IOT PLATFORM						
HARDWARE	 Mobility	 Tags / beacons	 Sensors	 Health and fitness devices	 Consumer electronics	 Automotive	 Embedded hardware

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

IoT Elements - Semantics

27

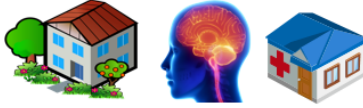


- The **brain** of IoT
- **Coordinating** all other elements to **facilitate** users
- **Collect** and **integrate** all information
- **Determine** the **meaning** of the data
- **Make** appropriate **decisions**
- **Send responses** to the devices
- **Record** and **evaluation**
- **Improve effectiveness** by machine learning
- **Adjust/personalize** to individual user

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

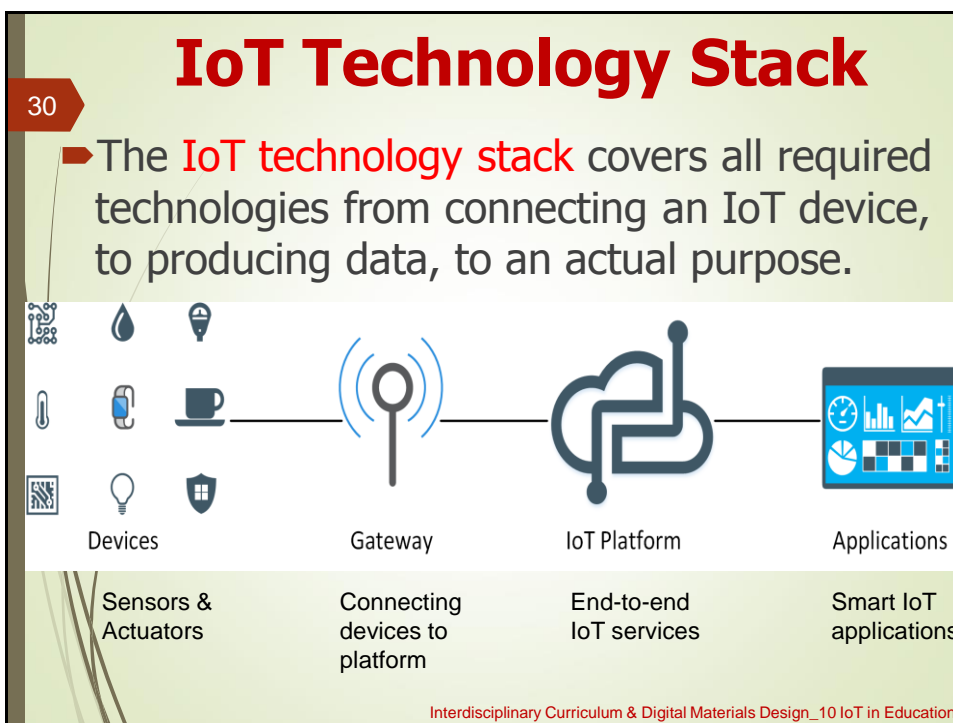
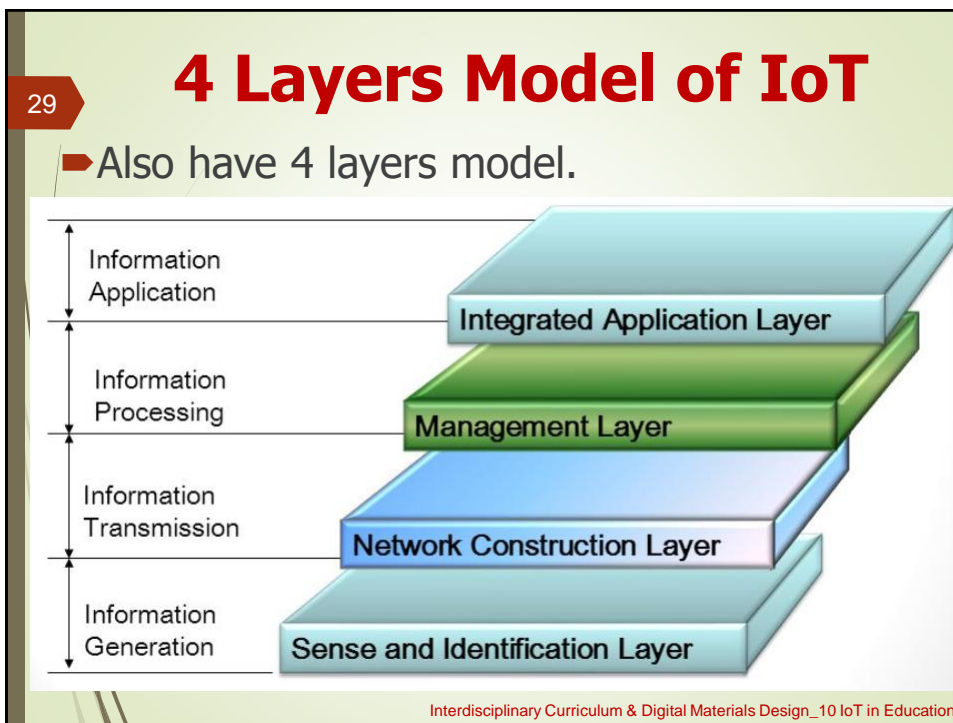
Layered Architecture of IoT

28

➤ The most fundamental **architecture** of IoT consists of **three layers**.

Application Layer	 Smart Home, Wearable Device, Hospital
Network Layer	 Wireless and Wired Networks
Perception Layer	 RFID, WSNs, Surveillance Camera

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education



Security in IoT

31

- ▶ IoT devices are much closer to people's every day life than any other devices.
- ▶ **Security/privacy issues** are much more important in IoT since it may affect personal health or even life.
- ▶ No benefits of IoT can be provided without proper management of security and privacy.
- ▶ Different mechanisms are proposed for different layers of the IoT architecture.

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

Challenges of IoT

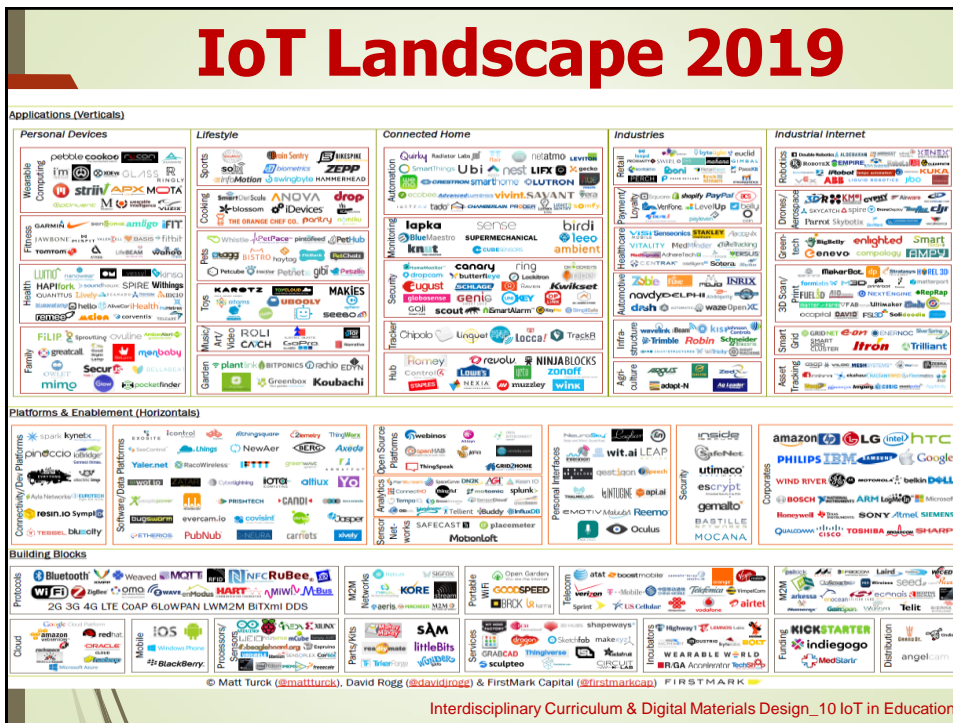
32

▶ There are many **research challenges** ahead.

```

graph TD
    A[Internet of Things] --> B[Poor Management]
    A --> C[Big Data]
    A --> D[Energy Efficient]
    A --> E[Security]
    A --> F[Privacy and Trust]
    E --> G[Unauthorized]
    E --> H[Identity Management]
    E --> I[Data Communication]
    E --> J[Storage]
    E --> K[Network]
    
```

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education



IoT in Education

34

- IoT has the potential to transform education by profoundly **altering how** schools, colleges and universities **gather data, interface** with users and **automate** processes.
- IoT enables institutions to:
 - Create **new ways** for students to **learn**
 - Change how **teachers deliver lessons** and **test** achievement
 - **Simplify operations** for school **administrators**
 - Provide a **safer environment** for students and teachers

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

IoT in Education Market

35

➤ According to MarketsandMarkets, the global IoT educational market size is expected to grow from \$4.8 billion in 2018 to \$11.3 billion by 2023.

Attractive Opportunities in IoT Education Market

Year	Market Size (USD Billion)
2018-e	4.8
2023-p	11.3

CAGR
18.8%

- The global IoT in education market size is expected to grow from USD 4.8 billion in 2018 to USD 11.3 billion by 2023.
- The increasing use of connected devices to improve the education quality is expected to drive the market during the forecast period.
- The classroom management segment is expected to offer lucrative opportunities for vendors in the market.

Source: Secondary Research, Expert Interviews, and MarketsandMarkets Analysis

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

IoT Scenarios in School

36

- **Smart white boards** and other **interactive digital media**
- Solutions such as **smart temperature sensors** and smart heating, ventilation and air condition equipment
- **Smart student ID cards**, attendance-tracking devices, school bus tracking systems and parking sensors
- Wireless door **locks**, connected **surveillance cameras** and **facial recognition** systems
- **Research** programs

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

37 Challenges of IoT Deployment

- Provide a simple, automated process for IoT device onboarding.
- Supply the correct network resources for the IoT system to run properly and efficiently.
- Provide proper and rich IoT services/applications for teaching and learning
- Provide a secure environment against cyberattack and data loss.

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

38 Security/Privacy is Crucial

- IoT in education brings an **explosion** of **security** and **privacy** threats.
- The **proliferation** of sensors and connected devices greatly **expands** the **network attack surface** and potential **privacy** invasion.
- **Many IoT devices** are manufactured **without security/privacy** in mind.
- IoT systems are increasingly the **weak link** for **network security** and **privacy** protection in educational institutions.

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

39

IoT Education Applications

IOT Education Applications

- Interactive Gaining of Knowledge
- Poster Boards into IoT Enabled Boards
- Learning at Anytime and Anywhere
- Superior Safety Features
- Bye Bye to Chalk boards
- Attendance Monitoring Systems

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

40

IoT 21st Century School

Cyber School with IOT 21st Century School

Learning and Innovation Skills, Core Subjects, Standards and Assessment, Career and Instruction, Professional Development, Learning Environments, Smart IoT Infrastructure

- Smart School Office
- Smart School Transportation
- Smart School Building Management
- Smart Student Health
- Smart Classrooms
- Smart STEAM Lab
- Smart Cafeteria/Minimart
- Student Activity Tracking
- Student IoT Project Management

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

IoT Use Case – Foreign Language Instruction

41


- One of the most powerful mechanisms for learning foreign languages is **immersion**, whose secret weapon is **real-time feedback**.
- Using **connected devices** to determine whether students have made the correct statements or selections in **foreign language simulation environments**, teachers are able to provide **real-time feedback** to students and **automatically monitor** student progress.

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

IoT Use Case – Connected/Smart Classrooms

42

- IoT applications will be the foundation on **smart classrooms**.
- Students will be **automatically counted** when the bell rings.
- **Wearable devices** will determine when the class is **too tired** or disengaged and may need a break.
- **Smart whiteboards** will record all notes taken in a class.
- **Smart-microphones** may even recognize when a teacher mentions there is a homework assignment due and update students' planners accordingly.



Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

IoT Use Case – Smart IDs

43

- ▶ A school in Richmond, California, embeds **RFID chips** in **ID cards** to track the presence of students.
- ▶ Even if students are not present for check-in, the system will track and **log** their presence on campus.



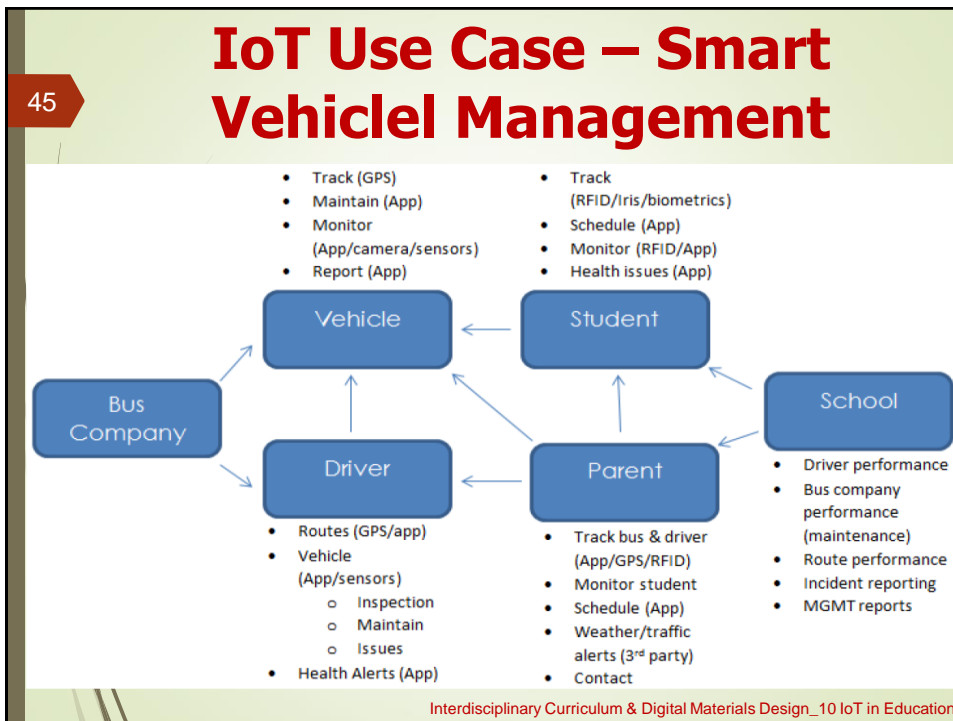
Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

IoT Use Case – Task-Based Learning

44

- ▶ IoT **facilitates** the move from a knowledge transfer model to a **collaborative, information-sharing model**.
- ▶ In task-based instruction, students learn-by-doing and teachers assist when needed.
- ▶ IoT systems provide **feedback, assistance**, and classroom-level **monitoring** automatically.
- ▶ By signaling teachers for help and by increasing difficulty when necessary, no student falls too far behind nor gets too far ahead.

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education



46

IoT Use Case – Disability Accommodation

- IoT devices and systems is a constructive way to provide **educational assistance** to **disabled learners**.
- Hearing-impaired** students may utilize a **connected gloves** and a **tablet** to translate from sign language to verbal speech, converting sound into written language.

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education

Other IoT Applications in Education

47

- Special education
- Physical education
- School security
- Classroom monitoring using Video-as-a-Sensor technology
- Attendance monitoring automation
- Student physical and mental health
- Learning from home
- Personalized learning
- . . .

Interdisciplinary Curriculum & Digital Materials Design_10 IoT in Education