Unpacking Digital Technologies

James Curran (james@groklearning.com)
Associate Professor, School of IT, University of Sydney
Director, National Computer Science School
CEO and Co-founder, Grok Learning
Technologies structure

- in two subjects:
  - Digital Technologies
  - Design and Technology

- and in two strands:
  - knowledge and understanding
  - processes and production skills
    - investigating and defining
    - generating and designing
    - producing and implementing
    - evaluating
    - collaborating and managing
Key concepts

- abstraction
- data: collection, representation, interpretation
- specification, algorithms, implementation
- digital systems
- interaction
- impact
Key concepts split by strand

- **knowledge and understanding:**
  - digital systems
  - data representation

- **process and production skills**
  - collecting, managing and analysing data (interpreting)
  - investigating and defining: specification
  - generating and designing: algorithms
  - producing and implementing: implementation
  - evaluating/collaborating and managing: interaction and impact
### Digital Technologies: Sequence of content F-10  
**Strand: Knowledge and understanding**

<table>
<thead>
<tr>
<th></th>
<th>F-2</th>
<th>3-4</th>
<th>5-6</th>
<th>7-8</th>
<th>9-10 (Elective subject)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Digital systems</strong></td>
<td>Recognise and explore digital systems (hardware and software components) for a purpose (ACTDIK001)</td>
<td>Identify and explore a range of digital systems with peripheral devices for different purposes, and transmit different types of data (ACTDIK007)</td>
<td>Examine the main components of common digital systems and how they may connect together to form networks to transmit data (ACTDIK014)</td>
<td>Investigate how data is transmitted and secured in wired, wireless and mobile networks, and how the specifications affect performance (ACTDIK023)</td>
<td>Investigate the role of hardware and software in managing, controlling and securing the movement of and access to data in networked digital systems (ACTDIK034)</td>
</tr>
<tr>
<td><strong>Representation of data</strong></td>
<td>Recognise and explore patterns in data and represent data as pictures, symbols and diagrams (ACTDIK002)</td>
<td>Recognise different types of data and explore how the same data can be represented in different ways (ACTDIK008)</td>
<td>Examine how whole numbers are used to represent all data in digital systems (ACTDIK015)</td>
<td>Investigate how digital systems represent text, image and audio data in binary (ACTDIK024)</td>
<td>Analyse simple compression of data and how content data are separated from presentation (ACTDIK035)</td>
</tr>
</tbody>
</table>

### Digital Technologies: Sequence of content F-10  
**Strand: Processes and production skills**

<table>
<thead>
<tr>
<th></th>
<th>F-2</th>
<th>3-4</th>
<th>5-6</th>
<th>7-8</th>
<th>9-10 (Elective subject)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Collecting, managing and analysing data</strong></td>
<td>Collect, explore and sort data, and use digital systems to present the data creatively (ACTDIP003)</td>
<td>Collect, access and present different types of data using simple software to create information and solve problems (ACTDIP009)</td>
<td>Acquire, store and validate different types of data, and use a range of software to interpret and visualise data to create information (ACTDIP018)</td>
<td>Acquire data from a range of sources and evaluate authenticity, accuracy and timeliness (ACTDIP025)</td>
<td>Develop techniques for acquiring, storing and validating quantitative and qualitative data from a range of sources, considering privacy and security requirements (ACTDIP036)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Analyse and visualise data using a range of software to create information, and use structured data to model objects or events (ACTDIP026)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Analyse and visualise data to create information and address complex problems, and model processes, entities and their relationships using structured data (ACTDIP037)</td>
</tr>
</tbody>
</table>

**Creating digital solutions by:**

<table>
<thead>
<tr>
<th></th>
<th>F-2</th>
<th>3-4</th>
<th>5-6</th>
<th>7-8</th>
<th>9-10 (Elective subject)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Investigating and defining</strong></td>
<td>Follow, describe and represent a sequence of steps and decisions (algorithms) needed to solve simple problems (ACTDIP004)</td>
<td>Define simple problems, and describe and follow a sequence of steps and decisions (algorithms) needed to solve them (ACTDIP010)</td>
<td>Define problems in terms of data and functional requirements drawing on previously solved problems (ACTDIP017)</td>
<td>Define and decompose real-world problems taking into account functional requirements and economic, environmental, social, technical and usability constraints (ACTDIP027)</td>
<td>Define and decompose real-world problems precisely, taking into account functional and non-functional requirements and including interviewing stakeholders to identify needs (ACTDIP038)</td>
</tr>
</tbody>
</table>
Digital Technologies: Sequence of content F-10  
**Strand: Processes and production skills**

<table>
<thead>
<tr>
<th></th>
<th>F-2</th>
<th>3-4</th>
<th>5-6</th>
<th>7-8</th>
<th>9-10 (Elective subject)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Generating and designing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Design the user experience of a digital system by evaluating alternative designs against criteria including functionality, accessibility, usability, and aesthetics (ACTDIP039) Design algorithms represented diagrammatically and in structured English and validate algorithms and programs through tracing and test cases (ACTDIP040)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Design the user experience of a digital system, generating, evaluating and communicating alternative designs (ACTDIP028) Design algorithms represented diagrammatically and in English, and trace algorithms to predict output for a given input and to identify errors (ACTDIP029)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Producing and implementing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Implement and modify programs with user interfaces involving branching, iteration and functions in a general-purpose programming language (ACTDIP030) Implement modular programs, applying selected algorithms and data structures including using an object-oriented programming language (ACTDIP041)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Implement simple digital solutions as visual programs involving branching (decisions) and user input (ACTDIP011)</td>
<td>Implement digital solutions as simple visual programs involving branching, iteration (repetition), and user input (ACTDIP020)</td>
<td>Implement and modify programs with user interfaces involving branching, iteration and functions in a general-purpose programming language (ACTDIP030)</td>
<td>Implement modular programs, applying selected algorithms and data structures including using an object-oriented programming language (ACTDIP041)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Evaluating</strong></td>
<td>Explore how people safely use common information systems to meet information, communication and recreation needs (ACTDIP005)</td>
<td>Explain how student solutions and existing information systems meet common personal, school or community needs (ACTDIP012)</td>
<td>Explain how student solutions and existing information systems are sustainable and meet current and future local community needs (ACTDIP021)</td>
<td>Evaluate critically how student solutions and existing information systems meet needs, are innovative, and take account of future risks and sustainability and provide opportunities for innovation and enterprise (ACTDIP042)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Collaborating and managing</strong></td>
<td>Create and organise ideas and information using information systems independently and with others, and share these with known people in safe online environments (ACTDIP006)</td>
<td>Plan, create and communicate ideas and information independently and with others, applying agreed ethical and social protocols (ACTDIP013)</td>
<td>Plan, create and communicate ideas and information, including collaboratively online, applying agreed ethical, social and technical protocols (ACTDIP022)</td>
<td>Create interactive solutions for sharing ideas and information online, taking into account safety, social contexts and legal responsibilities (ACTDIP043) Plan and manage projects using an iterative and collaborative approach, identifying risks and considering safety and sustainability (ACTDIP044)</td>
<td></td>
</tr>
</tbody>
</table>

Writing a curriculum involves packing everything up
Teaching a curriculum involves unpacking everything.
Digital Systems

2. Recognise and **explore digital systems** (hardware and software components) for a **purpose**

4. Identify and **explore a range of digital systems** with peripheral devices for **different purposes**, and **transmit different types of data**

6. Examine the **main components of common digital systems** and how they may **connect together to form networks** to transmit data
Digital Systems

8. Investigate how data is transmitted and secured in wired, wireless and mobile networks, and how the specifications affect performance.

10. Investigate the role of hardware and software in managing, controlling and securing the movement of data and access to data in networked digital systems.
# Digital Systems

<table>
<thead>
<tr>
<th>Systems</th>
<th>Networks</th>
<th>Security</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explore systems with purpose</td>
<td>Transmit data</td>
<td></td>
</tr>
<tr>
<td>Explore range of systems + peripherals with purposes</td>
<td>How to form networks to transmit data</td>
<td></td>
</tr>
<tr>
<td>Explore components</td>
<td>How data is transmitted</td>
<td>How data is secured</td>
</tr>
<tr>
<td>How specifications affect performance</td>
<td>Movement of data in networks</td>
<td>How data is controlled and secured</td>
</tr>
</tbody>
</table>
Data representation describes how data are represented and structured symbolically for storage and communication, by people and in digital systems...

Purpose of representation

- communication
- thought / creating knowledge
- manipulation and “calculation”
- storage
Say we want to hunt/trade a pig
A representation of a pig is not a pig

- pre-language communication involved pointing at actual pigs
- limited to things you could see directly
- humans discovered they could communicate things indirectly by representing the pig in other ways
  - parts of a pig (e.g. a pig skull)
  - paintings => symbols
  - sounds => language
  - and eventually language => symbols
A pig in 354000 BC, Sulawesi
A pig in 35400 BC, Sulawesi
Abstraction involves **hiding details** of an idea, problem or solution that are **not relevant**, to focus on a **manageable number of aspects**. Abstraction is a **natural part of communication**: people rarely communicate every detail, because many details are not relevant in a given context...

A pig in 2016 AD
A pig in 2016 AD
Representation as sound and language

- humans developed language
- a conventionalised sequence of arbitrary sounds to convey meaning (represent a concept or emotion)

In English we agree to use pɪɡ (IPA)
We imitate pigs in language (onomatopoeia)

But it turns out we don’t agree...

- English: oink oink
- Dutch: knor knor
- German: grunz grunz
- Polish: kwi kwi
  ... and perhaps most worrying for me...
- Indonesian: grok grok

All language is just convention!
Number representations

- what if we want to trade several pigs?
- humans developed an abstraction over countable things: the idea of 5 things, regardless of the thing itself
- one-to-one number representations developed for communicating counts
  - using fingers (leading to base-10)
  - tallies
Number representations

- Tallies are hard to read and error prone when they get big => group tallies
- Introduce more symbols and make their arrangement significant:

$$103 = 1 \times 100 + 0 \times 10 + 3 \times 1$$

$$= 1 \times 10^2 + 0 \times 10^1 + 3 \times 10^0$$

Hindu-Arabic Base-10 is a convention
Two digits is all you need

- numbers can be represented with just two symbols: 0 and 1 (binary)
- circuits can be built to store and manipulate two states (on/off) with low and high voltages
Everything in a computer is binary

- Everything is represented as numbers:
  - text
  - images
  - audio
  - video
  - ...

  which are represented as *many 0’s and 1’s*

- A typical computer might have 64 billion 0’s and 1’s in its working memory.
Example: Text

- each character (letter, digit, punctuation or space) is represented by a number

  this convention is a character set

- **Unicode** is the character set of the world
  - a proposal for Klingon was rejected ...

- \( a = 97, \ b = 98, \ldots \) so

- **pig** is represented as 112, 105, 103
Structured representations

- what attributes and relationships do you need to represent an entity or event in the real world?
- and what type of data is each attribute
- is a phone number really a number?
Representation

2. Recognise and explore patterns in data and represent data as pictures, symbols and diagrams.
4. Recognise different types of data and explore how the same data can be represented in different ways.
6. Examine how whole numbers are used to represent all data in digital systems.
8. Investigate how digital systems represent text, image and audio data in binary.
10. Analyse simple compression of data and how content data are separated from presentation.
## Representation

<table>
<thead>
<tr>
<th>Representation</th>
<th>Types of data</th>
<th>Compression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Represent data as pictures, symbols and diagrams</td>
<td>Different types of data</td>
<td></td>
</tr>
<tr>
<td>The same data can be represented in different ways</td>
<td>All (simple) data: <em>types should be more complex</em></td>
<td></td>
</tr>
<tr>
<td>How whole numbers are used to represent all data</td>
<td>Text, image and audio</td>
<td></td>
</tr>
<tr>
<td>Represent data in binary</td>
<td>All data: <em>structured data</em></td>
<td>Simple compression of data</td>
</tr>
<tr>
<td>Content vs. presentation: <em>documents are represented</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
○ Representation: connections

○ Digital Tech/Geography: Data visualisation
○ Mathematics (number systems, place/value, data interpretation)

Watch out: Data representation in maths is NOT exactly the same thing.

○ Art (visual/media representations)
○ English/languages (pronunciation, vocabulary, spelling, grammar conventions)
Collection and interpretation

2. Collect, explore and sort data, and use digital systems to present the data creatively.

4. Collect, access and present different types of data using simple software to create information and solve problems.

6. Acquire, store and validate different types of data, and use a range of software to interpret and visualise data to create information.
Collection and interpretation

8 Acquire data from a range of sources and evaluate authenticity, accuracy and timeliness

8 Analyse and visualise data using a range of software to create information, and use structured data to model objects or events

10 Develop techniques for acquiring, storing and validating quantitative/qualitative data from a range of sources, considering privacy and security requirements

10 Analyse and visualise data to create information and address complex problems, and model processes, entities and their relationships using structured data
<table>
<thead>
<tr>
<th>Collect</th>
<th>Organise / create</th>
<th>Visualise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collect and explore data</td>
<td>Sort data</td>
<td>Present the data</td>
</tr>
<tr>
<td>Collect and access different types of data</td>
<td>Create information and solve problems</td>
<td></td>
</tr>
<tr>
<td>Acquire, store and validate different types of data</td>
<td>Interpret data to create information</td>
<td>Visualise data to create information</td>
</tr>
<tr>
<td>Evaluate authenticity, accuracy and timeliness</td>
<td>Use structured data to model objects or events</td>
<td>Visualise data using a range of software</td>
</tr>
<tr>
<td>Validating quantitative and qualitative data; considering privacy and security</td>
<td>Model processes, entities and their relationships using structured data</td>
<td>Visualise data to create information and address complex problems</td>
</tr>
</tbody>
</table>
Collection and interpretation: connections

- Digital Tech: Specification, Algorithms and Implementation
- Maths: Statistics and Probability, especially *Data representation and interpretation*
- Geography: Geographical Inquiry and Skills, especially *Collecting, recording, evaluating and representing*
- History: Historical Skills, especially *Analysis and use of sources*
An algorithm is a **precise description of the steps and decisions needed to solve a problem**. Algorithms will need to be tested before the final solution can be implemented. Anyone who has followed or given instructions, or navigated using directions, has used an algorithm.

Making a Vegemite sandwich
Making a Vegemite sandwich

- how do you make a Vegemite sandwich?
- how much detail for each step?
- what order must the steps be done in?
- how does the algorithm generalise?
- what about making lots of sandwiches?
Sorting as a general algorithm
Travelling salesman problem
Specification and Algorithms

2. Follow, describe and represent a sequence of steps and decisions (algorithms) needed to solve simple problems.

4. Define simple problems, and describe and follow a sequence of steps and decisions (algorithms) needed to solve them.

6. Define problems in terms of data and functional requirements drawing on previously solved problems.

6. Design a user interface for a digital system.

6. Design, modify and follow simple algorithms involving sequences of steps, branching, and iteration.
**Specification and Algorithms**

1. Define and **decompose real-world problems** taking into account functional requirements and **economic, environmental, social, technical and usability** constraints.

2. Design the **user experience** of a digital system, generating, **evaluating** and communicating **alternative designs**.

3. Design algorithms represented **diagrammatically and in English**, and **trace algorithms** to predict output for a given input and to identify errors.
Define and decompose real-world problems precisely, taking into account functional and non-functional requirements and including interviewing stakeholders to identify needs.

Design the user experience of a digital system by evaluating alternative designs against criteria including functionality, accessibility, usability, and aesthetics.

Design algorithms represented diagrammatically and in structured English and validate algorithms and programs through tracing and test cases.
## Specification and Algorithms

<table>
<thead>
<tr>
<th>Describe problems</th>
<th>Follow/design algorithms</th>
<th>Design user interfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2</strong> Define simple problems</td>
<td>Follow, describe and represent a sequence of steps and decisions</td>
<td></td>
</tr>
<tr>
<td><strong>4</strong> Define problems using data and functional requirements</td>
<td>Describe/follow a sequence of steps and decisions (algorithms) needed to solve problems</td>
<td></td>
</tr>
<tr>
<td><strong>6</strong> Decompose real-world problems; Consider economic, environmental, social, technical and usability constraints</td>
<td>Design/modify simple algorithms (also) involving iteration</td>
<td>Design a user interface</td>
</tr>
<tr>
<td><strong>8</strong> Interviewing stakeholders to identify needs</td>
<td>Represent algorithms using diagrams and English; trace algorithms</td>
<td>Generate and evaluate alternative designs</td>
</tr>
<tr>
<td></td>
<td>Validate algorithms and programs through tracing and test cases</td>
<td>Evaluate designs against criteria: functionality, accessibility, usability, and aesthetics</td>
</tr>
</tbody>
</table>
Implementation

4. Implement simple digital solutions as visual programs with algorithms involving branching (decisions) and user input.

6. Implement digital solutions as simple visual programs involving branching, iteration (repetition), and user input.
Implementation

8. Implement and modify programs with user interfaces involving branching, iteration and functions in a general-purpose programming language.

10. Implement modular programs, applying selected algorithms and data structures including using an object-oriented programming language.
## Implementation

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Programming</th>
<th>Test and debug</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branching (decisions) and user input</td>
<td>Visual programming</td>
<td></td>
</tr>
<tr>
<td>Iteration (repetition)</td>
<td>Visual programming</td>
<td></td>
</tr>
<tr>
<td>User interfaces and functions</td>
<td>General purpose text programming</td>
<td><em>In algorithms content descriptor</em></td>
</tr>
<tr>
<td>Modularity, algorithms and data structures</td>
<td>Object-oriented programming</td>
<td><em>In algorithms content descriptor</em></td>
</tr>
</tbody>
</table>
Impact (including evaluation)

2. Explore how people safely use common information systems to meet information, communication and recreation needs.

4. Explain how student solutions and existing information systems meet common personal, school or community needs.

6. Explain how student solutions and existing information systems are sustainable and meet current and future local community needs.
Impact (including evaluation)

8 Evaluate how student solutions and existing information systems meet needs, are innovative, and take account of future risks and sustainability.

10 Evaluate critically how student solutions and existing information systems and policies, take account of future risks and sustainability and provide opportunities for innovation and enterprise.
## Impact (including evaluation)

<table>
<thead>
<tr>
<th>Users</th>
<th>Solutions</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>“people”</td>
<td>Common information systems</td>
<td>Information, communication and recreation needs</td>
</tr>
<tr>
<td>Personal, school or community</td>
<td>Student solutions and existing information systems</td>
<td>Sustainability; Current and future needs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Innovation; Future risks and sustainability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Opportunities for innovation and enterprise</td>
</tr>
<tr>
<td>Policies</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Interaction (including creativity)

2 Create/organise ideas and information using information systems independently and *with others*, and share these with known people in safe online environments

4 Plan, create and communicate ideas and information independently and with others, *applying agreed ethical and social protocols*

6 Plan, create and communicate ideas and information, including *collaboratively online*, applying agreed ethical, social and *technical protocols*
Plan and manage projects that create and communicate ideas and information collaboratively online, taking safety and social contexts into account.

Create interactive solutions for sharing ideas and information online, taking into account safety, social contexts and legal responsibilities.

Plan and manage projects using an iterative and collaborative approach, identifying risks and considering safety and sustainability.
## Interaction (including creativity)

<table>
<thead>
<tr>
<th>Collaboration</th>
<th>Environment/Protocols</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create ideas/information with others; share with known people</td>
<td>Safe online environments</td>
<td></td>
</tr>
<tr>
<td>Plan, create and communicate ideas and information</td>
<td>Applying agreed ethical and social protocols</td>
<td></td>
</tr>
<tr>
<td>Plan, create and communicate collaboratively online</td>
<td>Applying technical protocols</td>
<td></td>
</tr>
<tr>
<td>Create interactive solutions for sharing ideas and information online</td>
<td>Taking into account safety and social contexts</td>
<td>Plan and manage projects</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use an iterative and collaborative management approach, identifying risks</td>
</tr>
</tbody>
</table>
Questions?

Find me at:
@drjamescurran / @groklearning
james@groklearning.com