

Coding Strip: A Pedagogical Tool for Teaching and Learning Programming Concepts through Comics

Sangho Suh, Martinet Lee, Gracie Xia, Edith Law



UNIVERSITY OF
WATERLOO

WATERLOO **HCI**
CHERITON SCHOOL OF
COMPUTER SCIENCE

Table of Contents

- **Motivation**
- **Related Work**
- **Methodology & Results**
- **Summary & Future Work**

Motivation

Teaching kids to code is the next frontier in 21st century education

By [Helena Game](#) | 🕒 September 15, 2017 | [@helenagame](#)

Japan Makes Coding Mandatory for All Students Starting in Elementary School

Posted on March 28, 2019 by Ted



China Pushes Coding for Kids in Effort to Tackle Innovation Gap



— A young boy learns to code at the Tarena Learning Center in Beijing. NBC News

EDUCATION

Teaching coding in Canadian schools: How do the provinces measure up?

BY ALYSSA JULIE • NEWS TALK 770
Posted August 24, 2017 2:23 pm
Updated August 28, 2017 12:10 pm



— File photo. AP Photo/Stephan Savoia

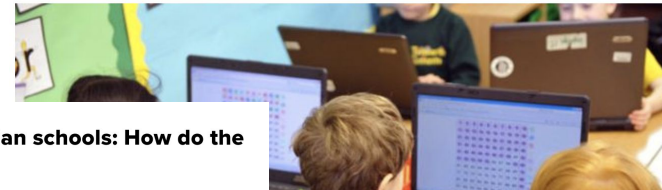
A computing revolution in schools



Rory Cellan-Jones
Technology correspondent
@BBCRoryCJ

🕒 1 September 2014 | 📄

👤 🗨️ 🐦 ✉️ ➦ Share



Coding at school: a parent's guide to England's new computing curriculum

From the start of the new term, children as young as five will be learning programming skills in the classroom



▲ Coding is on the curriculum for primary and secondary school pupils in the UK. Photograph: Alamy

Programming remains difficult to master because
it involves **concepts** and **procedures** that are **abstract**

Learning Concepts in Programming

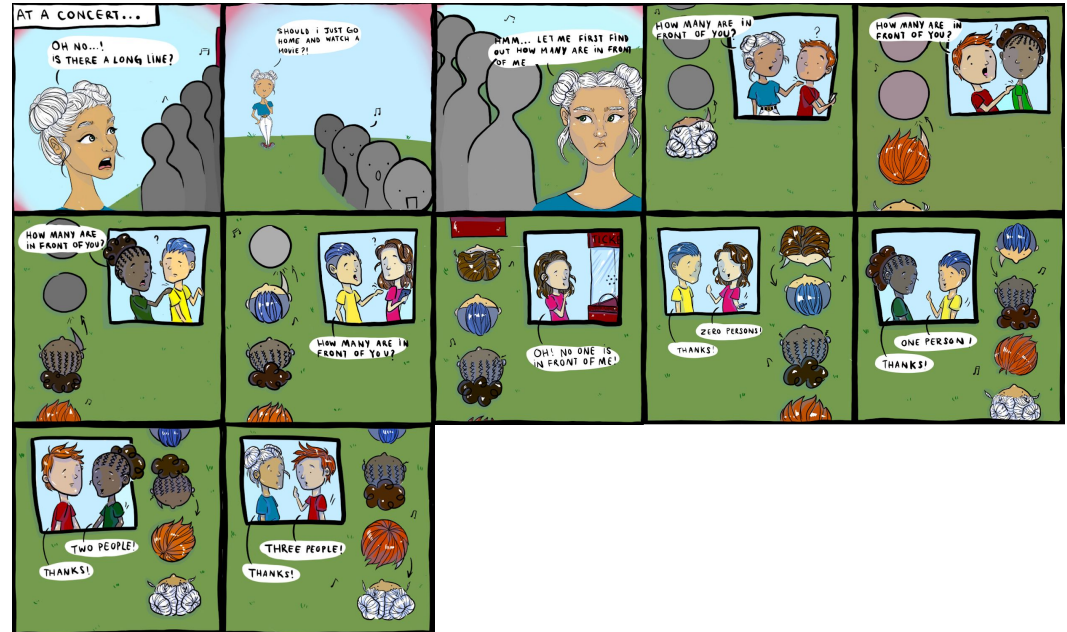
*“in learning programming, [students] need to imagine ... many **abstract terms** that do not have equivalents in **real life**: how does a variable, a data type, or a memory address relate to a real-life object?”*

Learning Procedures in Programming

Procedures in computing are often presented as an abstraction (e.g., loop), i.e., without showing the steps and thereby obscuring and making the procedures **abstract** for novice learners

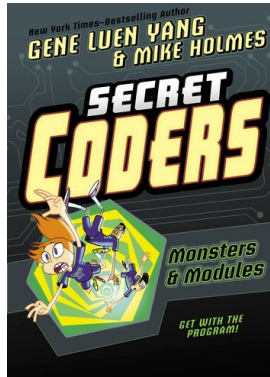
Making Abstract More Concrete with Comics

- The **sequential** nature of the medium and its ability to express complicated concepts and procedures through **visual storytelling** provide reasons to believe that it can be an effective medium

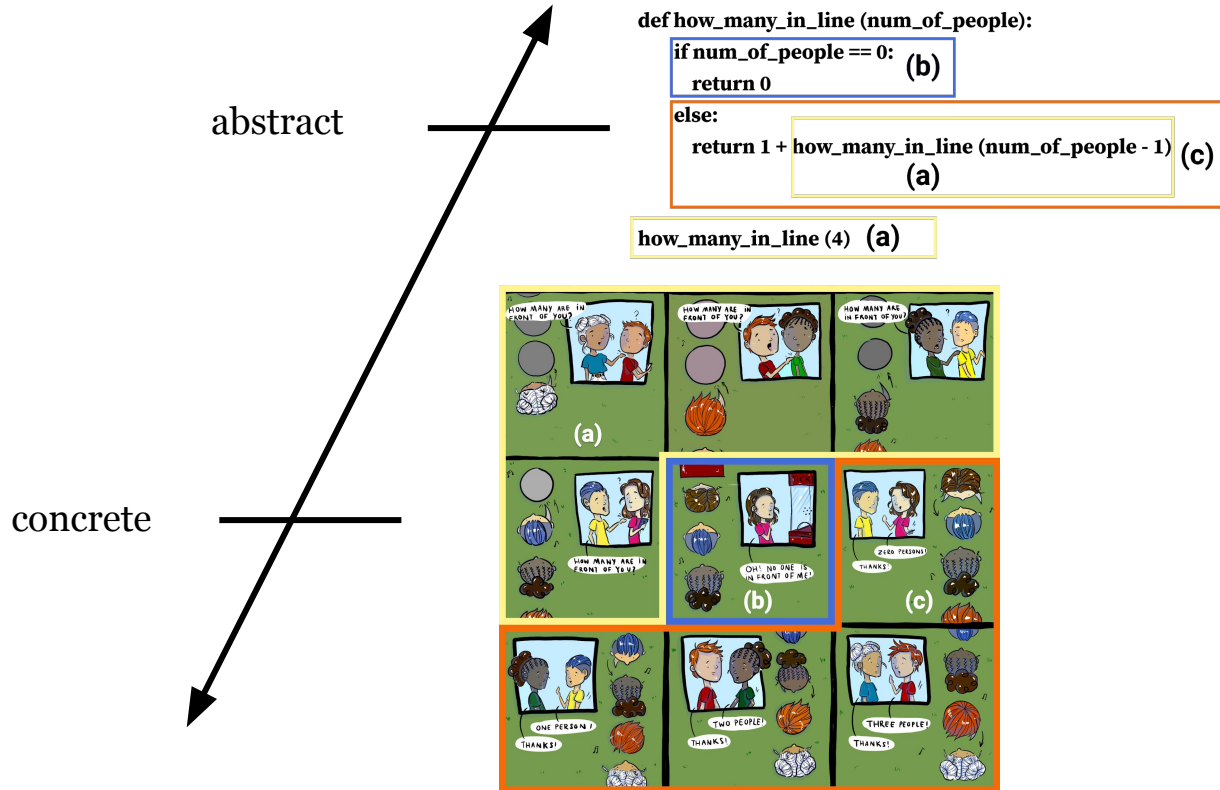


Limitation with Comics for CS Education

- While there have been several comic books for CS education, they are formatted as storybooks without correspondence to code
- This misses out on the opportunity for students to transfer what they learn to traditional text-based programming



Coding Strip



Coding Strip

abstract

```
def func(x):  
    if x == 0:  
        return 0  
    else:  
        return 1 + func(x - 1)
```

How do we design it?

In what ways can it be used to support teaching and learning of programming concepts?

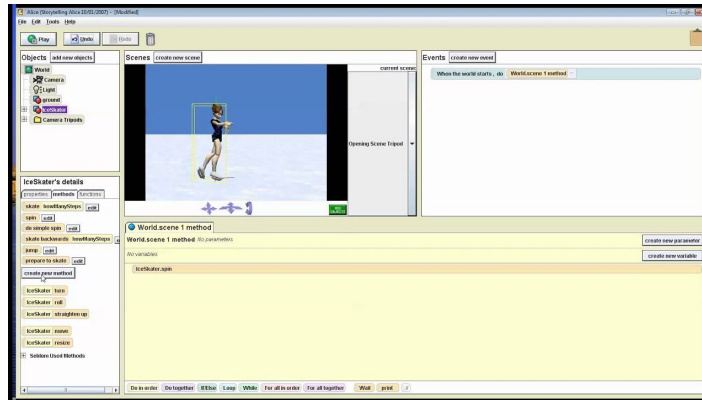
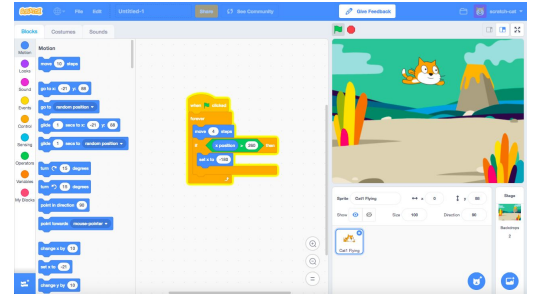
concrete



Related Work

Making Programming More Concrete

- Hands-on activities (e.g., CS Unplugged)
- Block-based / Tangible programming languages
- Storytelling (e.g., Storytelling Alice)



Making Programming More Concrete

- Visualization tools (e.g., Python Tutor)

The image displays a Python Tutor interface for Python 2.7. On the left, a code editor shows the following code:

```
Python 2.7
1 def listSum(numbers):
2     if not numbers:
3         return 0
4     else:
5         (f, rest) = numbers
6         return f + listSum(rest)
7
8 myList = (1, (2, (3, None)))
9 total = listSum(myList)
```

Line 5 is highlighted with a green arrow, and line 6 is highlighted with a red arrow. Below the code is an "Edit code" link and a legend: a green arrow for "line that has just executed" and a red arrow for "next line to execute". A progress bar shows "Step 11 of 22" with "Back" and "Forward" buttons.

On the right, the "Frames" and "Objects" panels are shown. The "Frames" panel includes the "Global frame" and a "listSum" frame. The "listSum" frame contains variables: "numbers" (a tuple), "f" (1), and "rest" (a tuple). The "Objects" panel shows three tuple objects: (0, 1), (0, 1), and (0, 3, None). Arrows indicate that the "numbers" variable in the "listSum" frame points to the first tuple object, and the "rest" variable points to the second tuple object.

Visualized using [Python Tutor](#) by [Philip Guo](#)

Making Abstract More Concrete with Comics

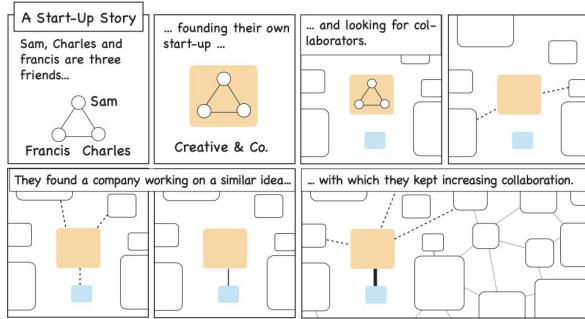
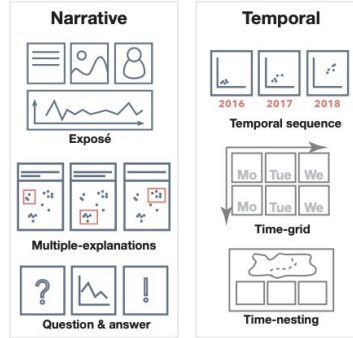
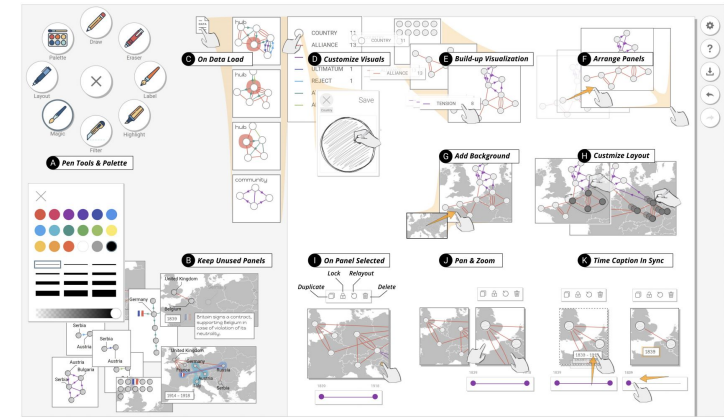


Figure 1. Graph comic: Evolving fictitious business relations.

Data-driven storytelling



Design patterns
for data comics



Authoring tool
for data comics

Design Process & Tools



Mora, Simone, Francesco Gianni, and Monica Divitini. Tiles: a card-based ideation toolkit for the internet of things.

Design Process & Tools

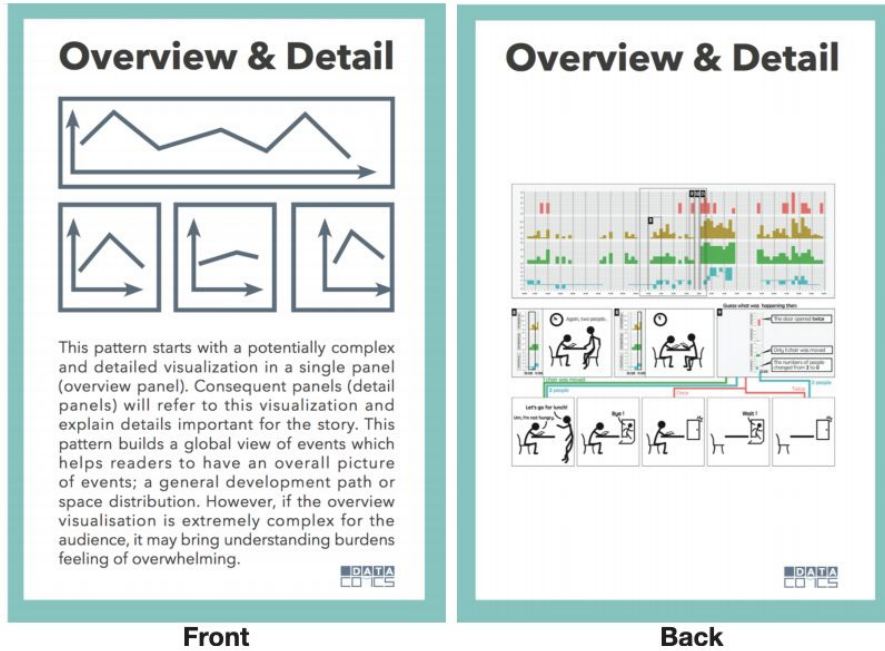


Figure 8. Data-Comics workshop: (left) designing with pattern cards, (right) storyboarding with post-its.

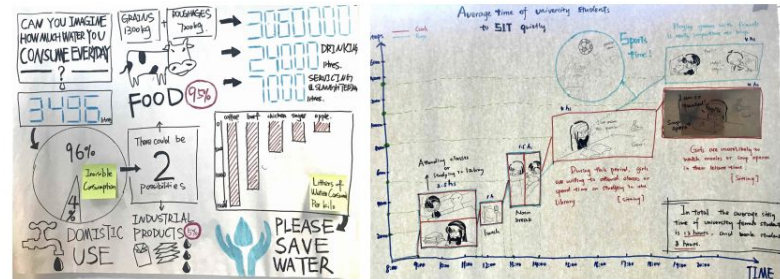


Figure 9. Data-Comic from the workshop: (left) annual water consumption (©Xudong Jiang, Yi He), (right) how long students sit (©Yuchen Ye, Wenqi Cai).

Methodology

Methodology

- **Phase I. Develop Design Process & Tools**
- **Phase II. Evaluate through Design Workshops**

Design Process

- **Step 1. Identify main programming concepts**

TABLE I: Concepts used in our study. Bolded are the concepts that workshop participants chose for their coding strips.

Constructs	Data Structures	Algorithms	Problem Solving Techniques
Variable	Array	Selection Sort	Greedy
Boolean	Linked List	Insertion Sort	Divide & Conquer
Condition	Queue	Merge Sort	Recursion
Counted Loop	Stack	Bubble Sort	
Conditional Loop	Tree	Linear Search	
Function	Graph	Binary Search	
	Dictionary		

Design Process

- Step 2. Design coding strips for concepts

The image displays a collection of hand-drawn design artifacts:

- Comic Strips:** A series of panels showing a piggy bank and a character named Jane. One panel says "JANE STARTED PUTTING IN \$1 EVERY DAY TO HER PIGGY BANK". Another says "ON SOME DAYS, HOWEVER, SHE WANTED TO ENJOY HERSELF AND SHE PUT IN \$25".
- Diagram:** A vertical stack of purple plates with green figures on top, connected by dashed lines, representing a linked list.
- Diagram:** A stack of colorful plates with arrows pointing to the right, labeled "NODE1", "NODE2", "NODE3", "NODE4", "NODE5". Below it, text reads: "LINKED LIST IS A DATA STRUCTURE IN WHICH NODES ARE CONNECTED THROUGH LINKS".
- Diagram:** A stack of colorful plates with a hand holding a plate on top. Text says: "Imagine that you have to wash a pile of dirty dishes." and "But then so someone adds another plate to your pile".
- Diagram:** A stack of colorful plates with a hand holding a plate on top. Text says: "In order to get to the original plate on top, you have to wash the dirty plate".
- Diagram:** A stack of colorful plates with a hand holding a plate on top. Text says: "What if we replaced stack of plates with a stack of data? Then this is the Stack ADT." Below it, text reads: "In the stack ADT, you can only add data to the top of the stack. This creates a pile of information." To the right are two diagrams of a stack with "Top" and "Bottom" labels and arrows indicating push and pop operations.
- Diagram:** A large diagram with numbered steps (1-5) explaining linked list operations: 1. In the original group, a group of 8 in this case, we can divide the set of houses into smaller groups. 2. Now, each house is linked to the next house. 3. We can now have these in memory. 4. Now every each group of 2, from smallest to largest in each group. 5. We can merge the houses in two groups together to get group sorted in 2.
- Diagram:** A diagram showing a linked list structure with nodes and arrows, and a separate diagram showing a stack structure with nodes and arrows.
- Comic Strips:** Two panels showing a character and a piggy bank. One says "HOW MANY ARE IN FRONT OF ME?" and the other says "HOW MANY ARE IN BACK OF ME?".

Design Process

- **Step 3. Identify process & support (tool) required**

Design Process

- **Step 3. Identify process & support (tool) required**

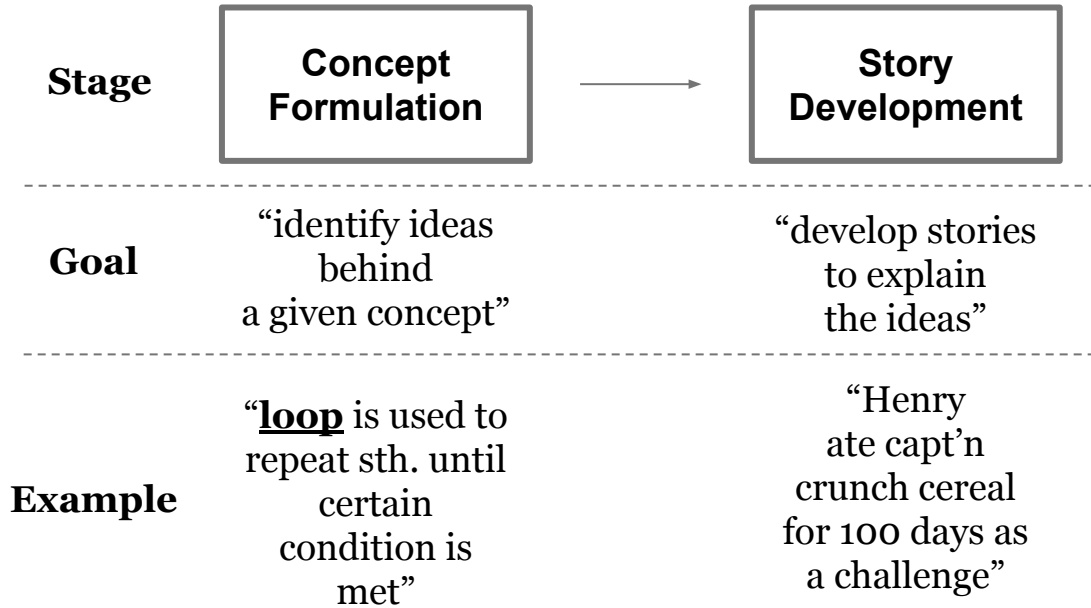
Design Process

- **Step 3. Identify process & support (tool) required**

Stage	Concept Formulation
Goal	“identify ideas behind a given concept”
Example	“ <u>loop</u> is used to repeat sth. until certain condition is met”

Design Process

- **Step 3. Identify process & support (tool) required**



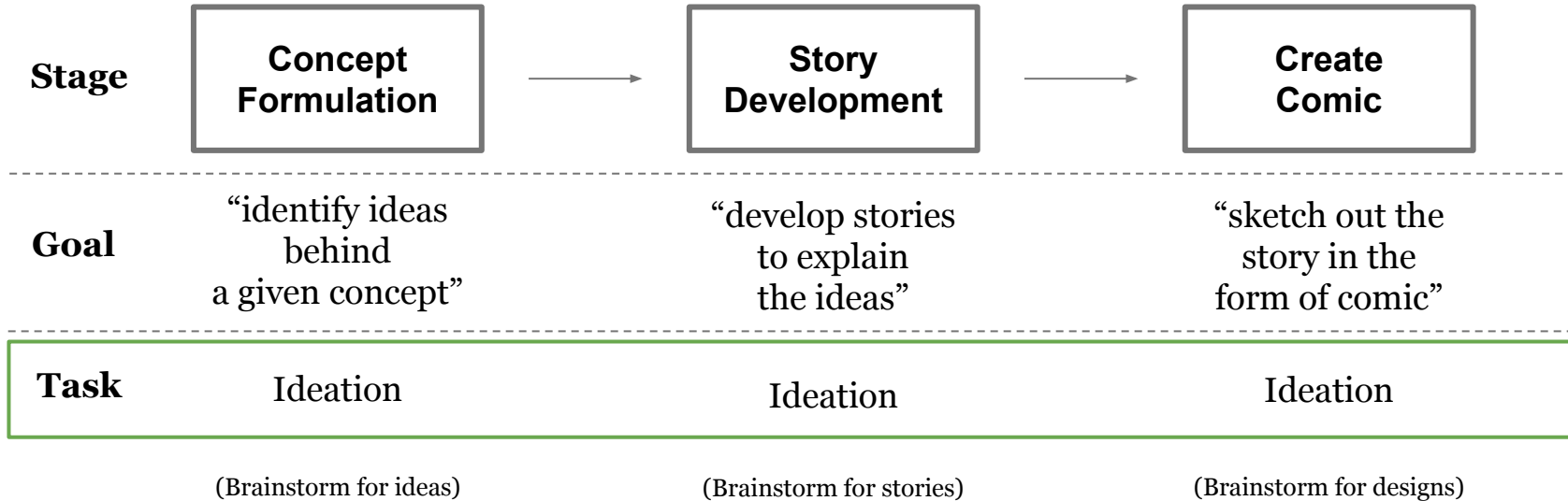
Design Process

- **Step 3. Identify process & support (tool) required**

Stage	Concept Formulation	→	Story Development	→	Create Comic
Goal	“identify ideas behind a given concept”		“develop stories to explain the ideas”		“sketch out the story in the form of comic”
Example	“ loop is used to repeat sth. until certain condition is met”		“Henry ate capt’n crunch cereal for 100 days as a challenge”		

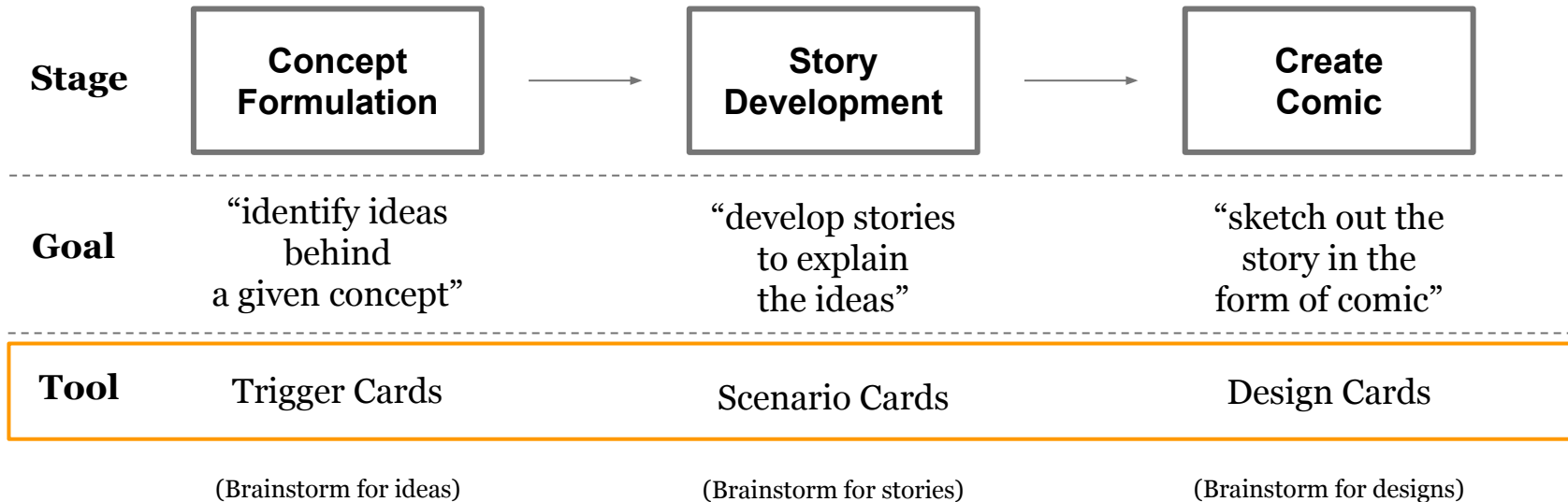
Design Process

- **Step 3. Identify process & support (tool) required**



Design Process

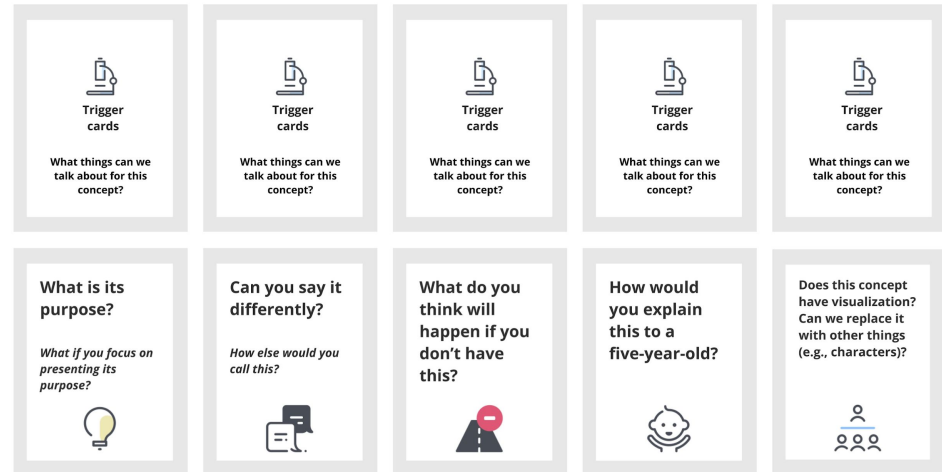
- **Step 3. Identify process & support (tool) required**



Ideation Cards

- Step 4. Create supporting tools

Stage	Concept Formulation
Goal	“identify ideas behind a given concept”
Task	Brainstorming
Tool	16 trigger cards



Ideation Cards

▪ Step 4. Create supporting tools

Stage

Story
Development

Goal

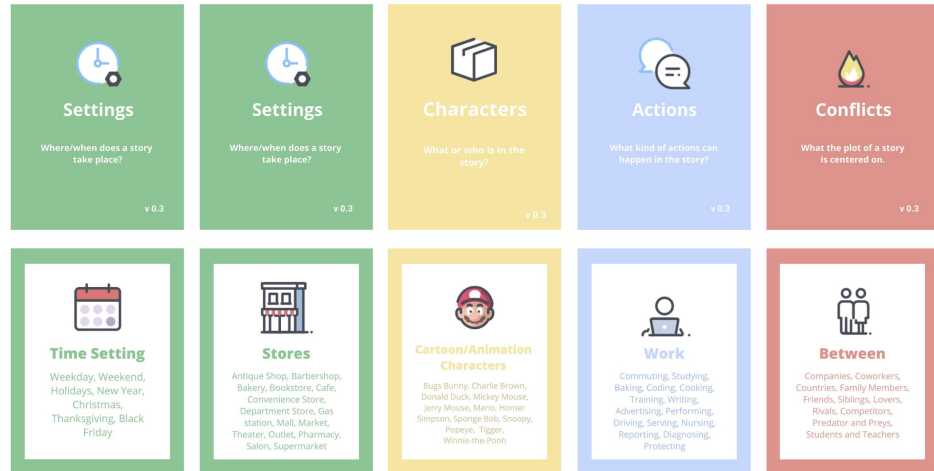
“develop stories
to explain
the ideas”

Task

Brainstorming

Tool

19 scenario cards



Ideation Cards

▪ Step 4. Create supporting tools

Stage

Comic
Illustration

Goal

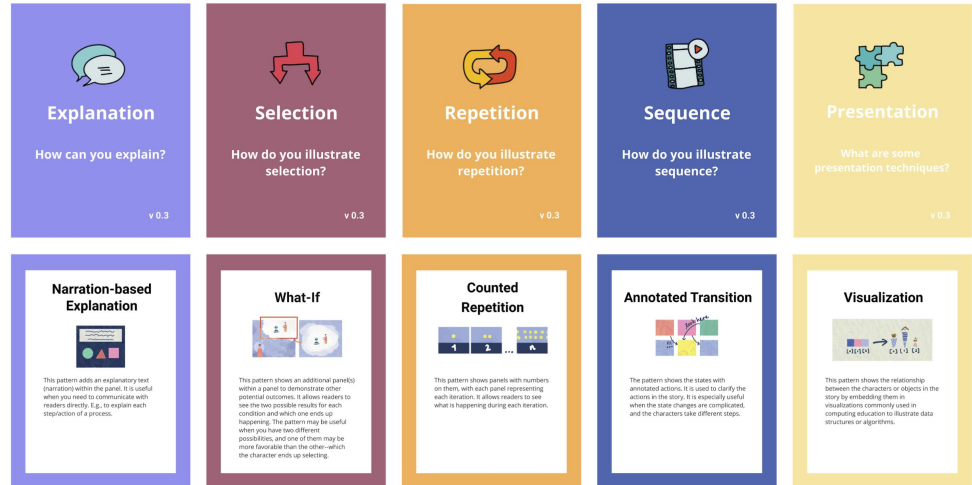
“sketch out
stories in the
form of comic”

Task

Brainstorming

Tool

30 design cards

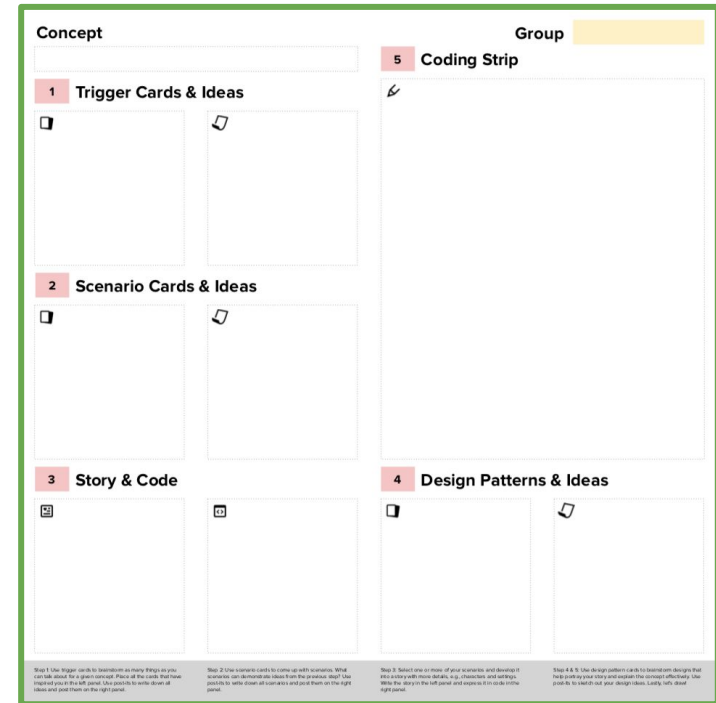


Design Board

- Step 4. Create supporting tools



Tool design board





Design Board



Concept

Group



1 Trigger Cards & Ideas


2 Scenario Cards & Ideas



3 Story & Code

5 Coding Strip



4 Design Patterns & Ideas

Step 1 Use trigger cards to brainstorm as many things as you can think about for a given concept. Place all the cards that have inspired you in the left panel. Use post-its to write down all ideas and post them on the right panel.

Step 2 Use scenario cards to come up with scenarios. What scenarios can be made to deal with the problem? Use post-its to write down all scenarios and post them on the right panel.

Step 3 Select one or more of your scenarios and develop it into a story with more details, e.g., characters and settings. Write the story in the left panel and copy it in code in the right panel.

Step 4 & 5 Use design pattern cards to brainstorm designs that help solve the story and realize the concept effectively. Use post-its to sketch-out your design ideas. Lastly, left-align

Design Board

Concept
Formulation



Concept

1 Trigger Cards & Ideas

--	--

2 Scenario Cards & Ideas

--	--

3 Story & Code

--	--

Step 1 Use trigger cards to brainstorm as many things as you can think about for a given concept. Place all the cards that have inspired you in the left panel. Use post-its to write down all ideas and post them on the right panel.

Step 2 Use scenario cards to come up with scenarios. What scenarios can be formed as ideas with the previous step? Use post-its to write down all scenarios and post them on the right panel.

Group

5 Coding Strip

4 Design Patterns & Ideas

--	--

Step 3 Select one or more of your scenarios and develop it into a story with more details, e.g., characters and settings. Write the story in the left panel and create it in code in the right panel.

Step 4 & 5 Use design pattern cards to brainstorm designs that help solve your story and create the storyboard effectively. Use post-its to sketch-out your design ideas. Lastly, left-down

Design Board

Concept
Formulation



Concept

Group

5 Coding Strip

1 Trigger Cards & Ideas

2 Scenario Cards & Ideas

3 Story & Code

4 Design Patterns & Ideas

Step 1 Use trigger cards to brainstorm as many things as you can think about for a given concept. Place all the cards that come inspired you in the left panel. Use post-its to write down all ideas and post them on the right panel.

Step 2 Use scenario cards to come up with scenarios. What scenarios can be formed as ideas with the previous step? Use post-its to write down all scenarios and post them on the right panel.

Step 3 Select one or more of your scenarios and develop it into a story with more details, e.g., characters and settings. Write the story in the left panel and create it in code in the right panel.

Step 4 & 5 Use design pattern cards to brainstorm designs that help you by the story and realize the concept effectively. Use post-its to sketch-out your design ideas. Lastly, left draw

Design Board

Concept
Formulation



Story
Development



Concept

1 Trigger Cards & Ideas

What is its purpose?
How does this component work?

Can you say it differently?
How can we make it better?

What do you think will happen if your client have this?

2 Scenario Cards & Ideas

Stories

Business

Work

Relationships

3 Story & Code

Step 1 Use trigger cards to brainstorm as many things as you can think about for a given concept. Place all the cards that have inspired you in the left panel. Use post-its to write down all ideas and post them on the right panel.

Step 2 Use scenario cards to come up with scenarios. What scenarios can be formed on these with the previous step? Use post-its to write down all scenarios and post them on the right panel.

Group

5 Coding Strip

4 Design Patterns & Ideas

Step 3 Select one or more of your scenarios and develop it into a story with more details, e.g., characters and settings. Write the story in the left panel and create it in code in the right panel.

Step 4 & 5 Use design pattern cards to brainstorm designs that help justify the story and realize the concept effectively. Use post-its to sketch-out your design ideas. Lastly, left draw

Design Board

Concept
Formulation



Story
Development



Story-to-Code
Mapping



Concept

1 Trigger Cards & Ideas

What is its purpose?
How does this component work?

Can you say it differently?
How can we make it better?

What do you think will happen if your client have this?

2 Scenario Cards & Ideas

Stores

Business

Work

3 Story & Code

If bob lean has slept previous night, he goes to school. If he didn't, he doesn't.

```
If sleep == true:  
  go_to_school()  
else:  
  don't_go()
```

Step 1 Use trigger cards to brainstorm as many things as you can think about for a given concept. Place all the cards that have inspired you in the left panel. Use post-its to write down all ideas and post them on the right panel.

Step 2 Use scenario cards to come up with scenarios. What scenarios can be formed on each of the previous steps? Use post-its to write down all scenarios and post them on the right panel.

Group

5 Coding Strip

4 Design Patterns & Ideas

Step 3 Select one or more of your scenarios and develop it into a story with more details, e.g., characters and settings. Write the story in the left panel and create an UML code in the right panel.

Step 4 & 5 Use design pattern cards to brainstorm designs that help justify your story and realize the scenario effectively. Use post-its to write-out your design ideas. Lastly, left-down

Design Board

Concept
Formulation



Story
Development



Story-to-Code
Mapping



Concept

1 Trigger Cards & Ideas

What is its purpose?
How can users accomplish it?

Can you say it differently?
How can users interact with it?

What do you think will happen if your client have this?
How can users interact with it?

2 Scenario Cards & Ideas

Stores

Business

Work

3 Story & Code

If bob lean has slept previous night, he goes to school. If he didn't, he doesn't.

```
if sleep == true:  
    go_to_school()  
else:  
    don't_go()
```

Step 1 Use trigger cards to brainstorm as many things as you can think about for a given concept. Place all the cards that have inspired you in the left panel. Use post-its to write down all ideas and post them on the right panel.

Step 2 Use scenario cards to come up with scenarios. What scenarios can be formed as tasks with the previous step? Use post-its to write down all scenarios and post them on the right panel.

Group

5 Coding Strip

4 Design Patterns & Ideas

Behavioral Patterns

Structural Patterns

Creational Patterns

Step 3 Select one or more of your scenarios and develop it into a story with more details, e.g., characters and settings. Write the story in the left panel and copy it in code in the right panel.

Step 4 & 5 Use design pattern cards to brainstorm designs that help justify your story and realize the scenario effectively. Use post-its to write-out your design ideas. Lastly, left-align

Design Board

Concept Formulation



Concept

1 Trigger Cards & Ideas

Story Development



2 Scenario Cards & Ideas

Story-to-Code Mapping



3 Story & Code

If bob lean has slept previous night, he goes to school. If he didn't, he doesn't.

```

if sleep == true:
    go_to_school()
else:
    don't_go()
    
```

Step 1 Use trigger cards to brainstorm as many things as you can think about for a given concept. Place all the cards that have inspired you in the left panel. Use post-its to write down all ideas and post them on the right panel.

Step 2 Use scenario cards to come up with scenarios. What activities can be performed in each of the scenarios? Step 3 Use post-its to write down all scenarios and post them on the right panel.

Group

5 Coding Strip

4 Design Patterns & Ideas

Step 4 Select one or more of your scenarios and develop it into a story with three details, e.g., characters and settings. Write the story in the left panel and express it in code in the right panel.

Step 4 & 5 Use design pattern cards to brainstorm designs that help you solve your story and realize the scenario efficiently. Use post-its to write-out your design ideas. Lastly, left, draw



Comic Illustration

Methodology

- **Phase I. Develop Design Process & Tools**
- **Phase II. Evaluate through Design Workshops**

Methodology

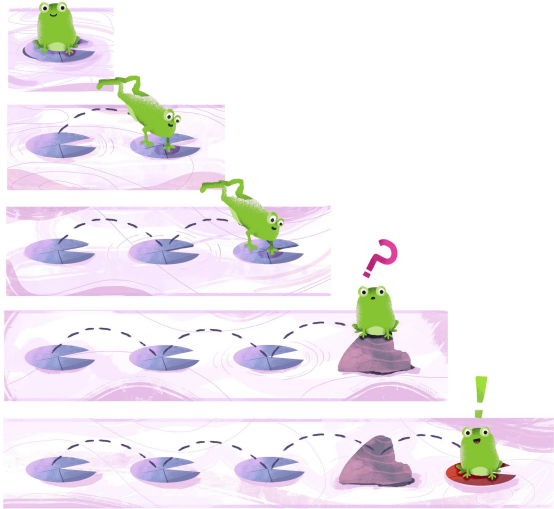
- **Phase I. Develop Design Process & Tools**
- **Phase II. Evaluate through Design Workshops**

Design Workshops (W1 & W2)

- **W1: Undergraduate and graduate students**
 - **13 participants (5M, 8F; age: 17-29, mean 21)**
- **W2: High school computer science teachers**
 - **6 participants (2M, 4F)**
- **2 artists**

	Description	Duration
Session 1 (90 min)	Consent form	5 min
	Pre-study survey	5 min
	Presentation	10 min
	Warm-up: sketch	10 min
	Warm-up: story to code	10 min
	<u>Design session #1</u>	50 min
	Break	15 min
Session 2 (90 min)	<u>Design session #2</u>	50 min
	Discussion	35 min
	Post-study survey	5 min

Design Workshops (W1 & W2)

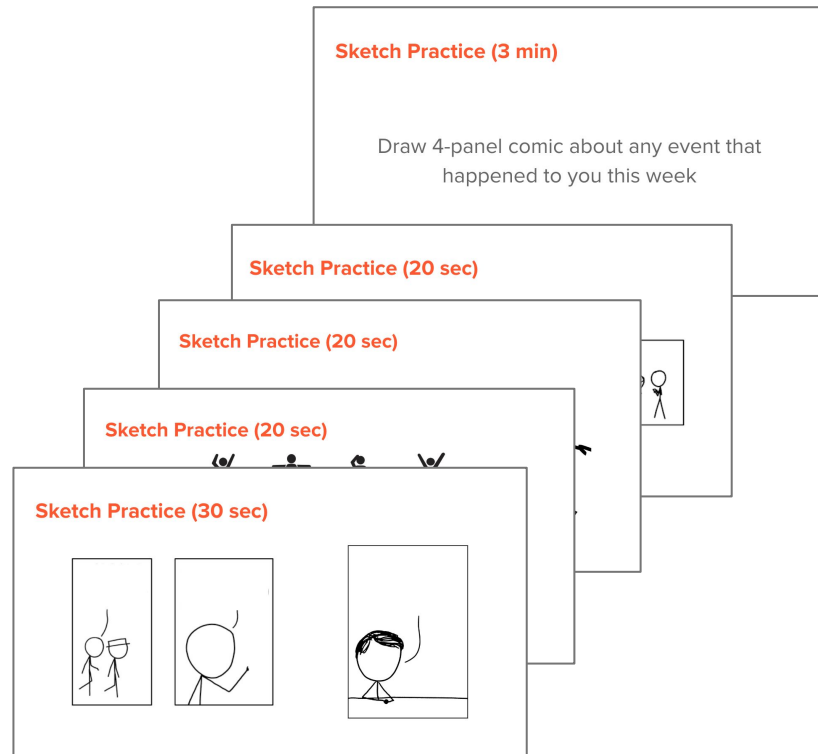


```
String[] lilypad = {"green", "green", "green",  
"rock", "green", "red"};
```

```
While ( lilypad [i] != red) {  
    frog.jump();  
    if ( lilypad[i] == "rock" ) {  
        frog.confused();  
        frog.jump();  
    }  
    i++;  
}
```

	Description	Duration
Session 1 (90 min)	Consent form	5 min
	Pre-study survey	5 min
	Presentation	10 min
	Warm-up: sketch	10 min
	Warm-up: story to code	10 min
	<u>Design session #1</u>	50 min
	Break	15 min
Session 2 (90 min)	<u>Design session #2</u>	50 min
	Discussion	35 min
	Post-study survey	5 min

Design Workshops (W1 & W2)



	Description	Duration
Session 1 (90 min)	Consent form	5 min
	Pre-study survey	5 min
	Presentation	10 min
	Warm-up: sketch	10 min
	Warm-up: story to code	10 min
	<u>Design session #1</u>	50 min
	Break	15 min
Session 2 (90 min)	<u>Design session #2</u>	50 min
	Discussion	35 min
	Post-study survey	5 min

Design Workshops (W1 & W2)

Story to Code: Cinderella

- Prince went around the whole kingdom, checking the feet of every girl until he found Cinderella whose feet fit the

Story to Code: Cinderella

- Before Cinderella went to the ball, Godmother (fairy) changed Cinderella's whole outfit.

Story to Code: Cinderella

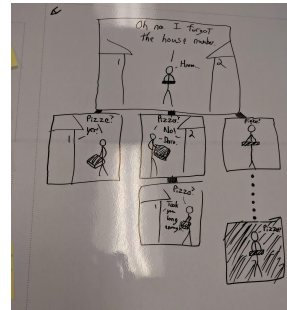
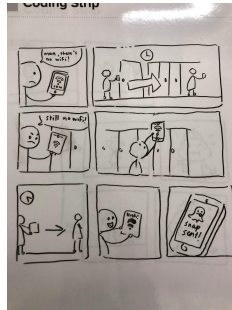
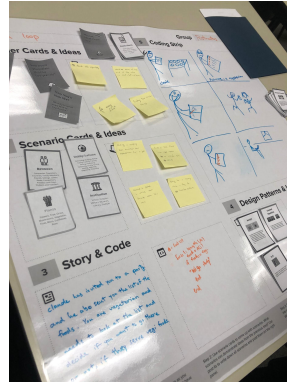
- At the ball, Cinderella had to check the time constantly when dancing with Prince. She had to leave before 12:00 AM.

```
while ( time < 12:00 AM ) {  
    cinderella.dance();  
}  
  
cinderella.leave();
```

Concept: Conditional loop

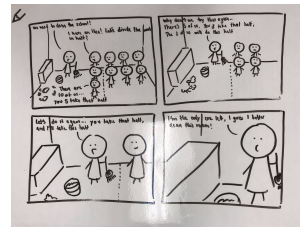
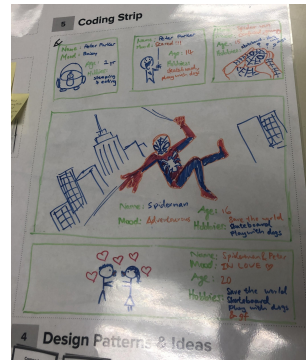
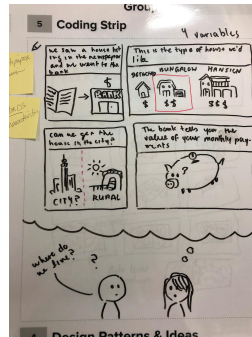
	Description	Duration
Session 1 (90 min)	Consent form	5 min
	Pre-study survey	5 min
	Presentation	10 min
	Warm-up: sketch	10 min
	Warm-up: story to code	10 min
	<u>Design session #1</u>	50 min
	Break	15 min
Session 2 (90 min)	<u>Design session #2</u>	50 min
	Discussion	35 min
	Post-study survey	5 min

Design Workshops (W1 & W2)



	Description	Duration
Session 1 (90 min)	Consent form	5 min
	Pre-study survey	5 min
	Presentation	10 min
	Warm-up: sketch	10 min
	Warm-up: story to code	10 min
	<u>Design session #1</u>	50 min
	Break	15 min
Session 2 (90 min)	<u>Design session #2</u>	50 min
	Discussion	35 min
	Post-study survey	5 min

Design Workshops (W1 & W2)



	Description	Duration
Session 1 (90 min)	Consent form	5 min
	Pre-study survey	5 min
	Presentation	10 min
	Warm-up: sketch	10 min
	Warm-up: story to code	10 min
	<u>Design session #1</u>	50 min
Session 2 (90 min)	Break	15 min
	<u>Design session #2</u>	50 min
	Discussion	35 min
	Post-study survey	5 min

Design Workshops (W1 & W2)

- **Discussion**
 - Use case scenarios for learning & teaching
 - Suggestions for design process & tools
- **Post-study survey**
 - Effectiveness of design process & tools
 - Perceived usefulness of coding strip

	Description	Duration
Session 1 (90 min)	Consent form	5 min
	Pre-study survey	5 min
	Presentation	10 min
	Warm-up: sketch	10 min
	Warm-up: story to code	10 min
	<u>Design session #1</u>	50 min
	Break	15 min
Session 2 (90 min)	<u>Design session #2</u>	50 min
	Discussion	35 min
	Post-study survey	5 min

Results

Effectiveness of Design Process

- Participants found the design process and tools **useful**
(M=4.1, SD=0.8 for W1, and M=4.2, S=0.8 for W2)
- Participants found designing coding strip **engaging**
(M=4.2, SD=1 for W1 | M=4.3, SD=1 for W2)
- Participants did not need much help from the artists

	Description	Duration
Session 1 (90 min)	Consent form	5 min
	Pre-study survey	5 min
	Presentation	10 min
	Warm-up: sketch	10 min
	Warm-up: story to code	10 min
	<u>Design session #1</u>	50 min
	Break	15 min
Session 2 (90 min)	<u>Design session #2</u>	50 min
	Discussion	35 min
	Post-study survey	5 min

Effectiveness of Ideation Cards

- *“How many ideas was each card able to help generate?”*



1.6 ideas per card

1.4 ideas per card

of trigger cards

M=4.2 SD=1.7

of ideas

M=6.7, SD=2.9

of scenario cards

M=3.6 SD=1.7

of ideas

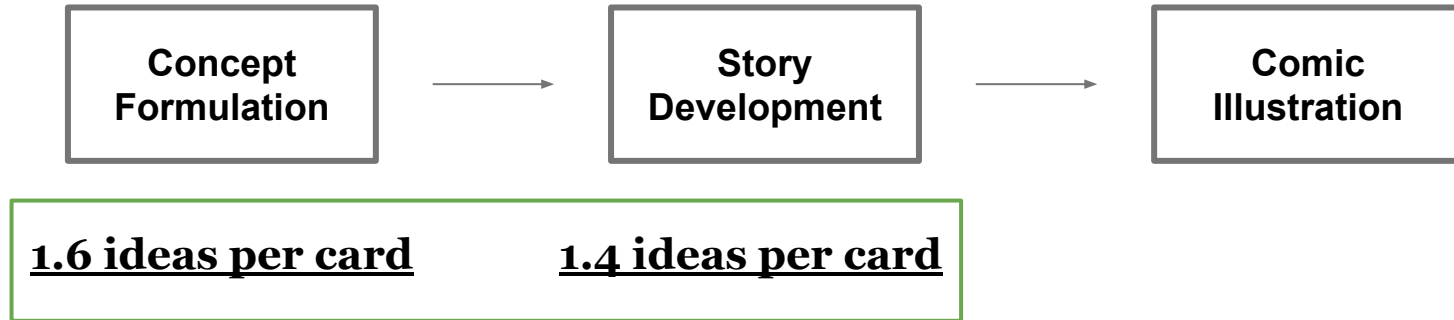
M=5, SD=1.7

of design cards

M=5.2 SD=2.4

Effectiveness of Ideation Cards

- *“How many ideas was each card able to help generate?”*



of trigger cards

M=4.2 SD=1.7

of ideas

M=6.7, SD=2.9

of scenario cards

M=3.6 SD=1.7

of ideas

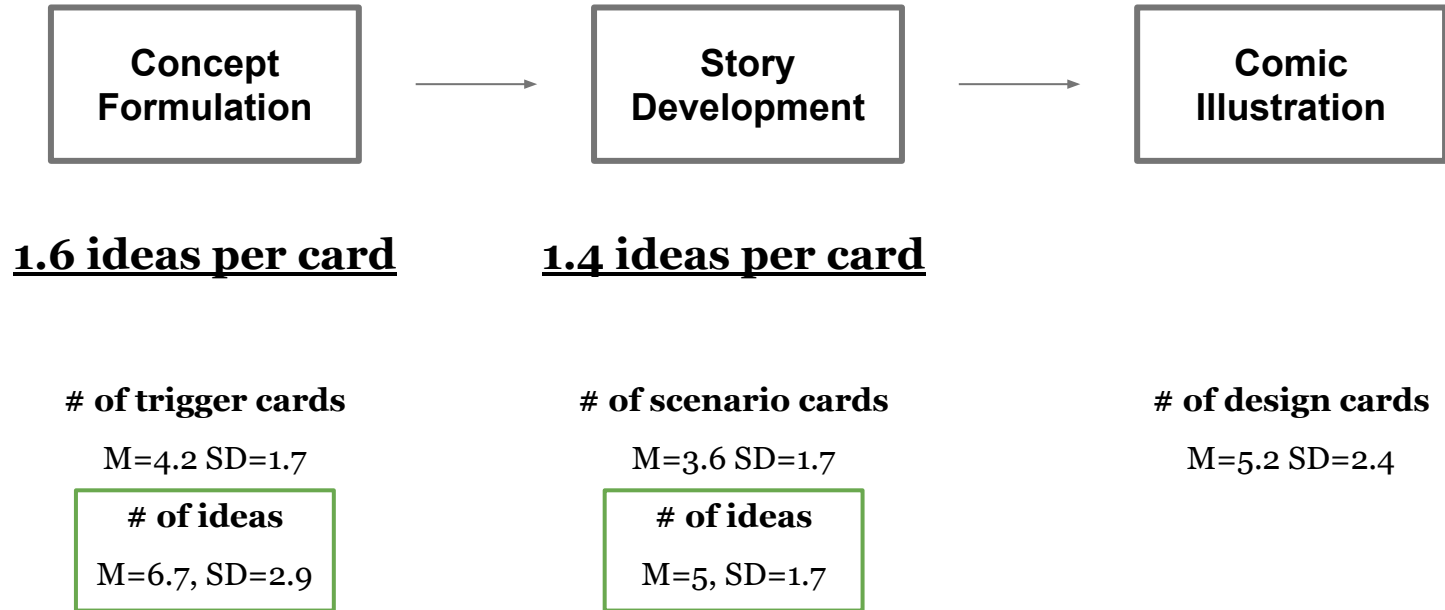
M=5, SD=1.7

of design cards

M=5.2 SD=2.4

Effectiveness of Ideation Cards

- *“How many ideas was each card able to help generate?”*



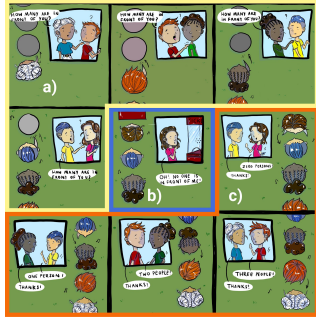
Perceived Utility for Learning & Teaching

- **Both teachers and students want to learn with coding strip**
(5 “yes”, 1 “not sure” for teachers; 10 “yes”, 2 “no” for students)
- **While teachers want to teach with coding strip, students are divided**
(5 “yes”, 1 “not sure” for teachers; 6 “yes”; 7 “not sure” for students)

	Description	Duration
Session 1 (90 min)	Consent form	5 min
	Pre-study survey	5 min
	Presentation	10 min
	Warm-up: sketch	10 min
	Warm-up: story to code	10 min
	<u>Design session #1</u>	50 min
	Break	15 min
Session 2 (90 min)	<u>Design session #2</u>	50 min
	Discussion	35 min
	Post-study survey	5 min

Panel-to-Execution Mapping

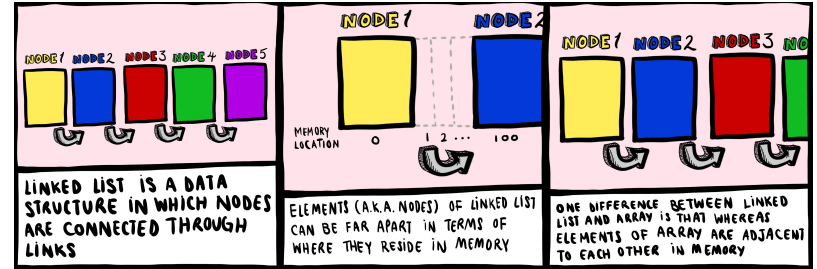
- Analysis of 18 coding strips revealed 3 *panel-to-execution* mapping patterns



1-to-1



1-to-many



many-to-1

Use Case Scenarios

- Design activity
- Instruction
- Complementary resource in textbooks
- Coding exercise
 - write code based on the presented comics

	Description	Duration
Session 1 (90 min)	Consent form	5 min
	Pre-study survey	5 min
	Presentation	10 min
	Warm-up: sketch	10 min
	Warm-up: story to code	10 min
	<u>Design session #1</u>	50 min
	Break	15 min
Session 2 (90 min)	<u>Design session #2</u>	50 min
	Discussion	35 min
	Post-study survey	5 min

Summary

- The proposed design process and tool appear to be effective at supporting the design of coding strip
- Teachers and students are interested in using coding strip for learning and teaching

Future Work

- Develop authoring tool to facilitate the production of coding strips
- Explore how our design process and tools can generalize to work with concepts from other domains (e.g., machine learning, data science, etc.)

Acknowledgements



Edith Law



Martinet Lee



Gracie Xia



Bernadette Cheng



LITE Grant,
Center for
Teaching
Excellence



UNIVERSITY OF
WATERLOO

WATERLOO HCI
CHERITON SCHOOL OF
COMPUTER SCIENCE

Image References

- <https://www.studyinternational.com/news/coding-kids/>
- <https://www.bbc.com/news/technology-29010511>
- <https://www.nbcnews.com/news/china/china-pushes-coding-kids-effort-tackle-innovation-gap-n641966>
- <https://globalnews.ca/news/3693932/teaching-coding-in-canadian-schools-how-do-the-provinces-measure-up/>
- <https://www.strata-gee.com/japan-makes-coding-mandatory-for-all-students-starting-in-elementary-school/>