RANDOMIZATION FRAMEWORK

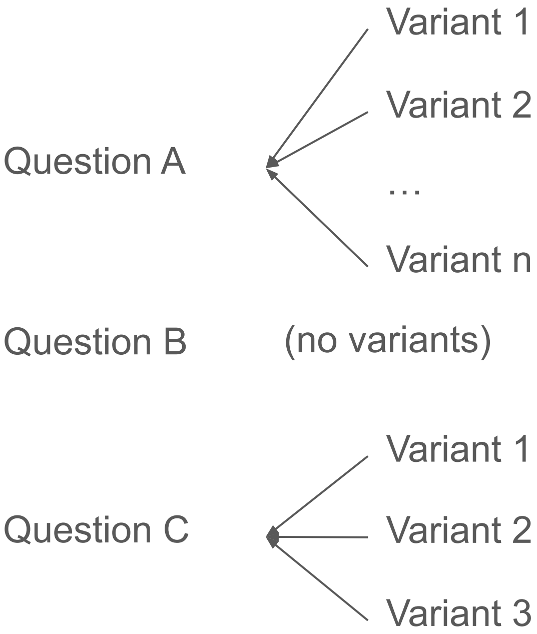
Using the 6-level Framework to Describe Question Randomization

A Walkthrough Guide

https://github.com/open-resources/randomization_framework

What might randomization look like?

on a question level



Question A

Variant 1

Variant 2

…

Variant n

Question B

(no variants)

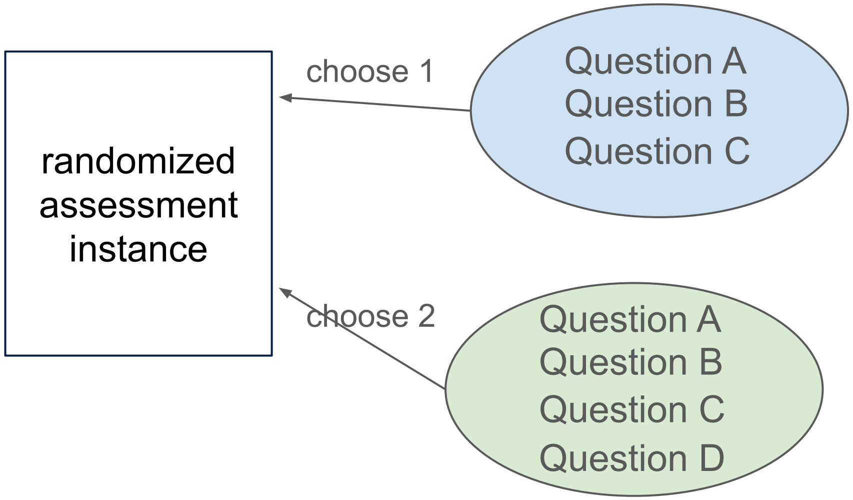
Question C

Variant 1

Variant 2

Variant 3

on an assessment level



randomized assessment instance

choose 1

Question A
Question B
Question C

choose 2

Question A
Question B
Question C
Question D

Framework + Examples

Question Evaluation

Question Design

Unrandomized

Level 0

Every student receives precisely the same question.

Abdallah uses a perfect binary tree to implement a small database system with 63 nodes. How many leaves will this tree have?

Surface Features

Level 1

Surface level features (e.g., names, colours, phrases) change for each variant.

[“Abdallah”, “Bob”, “Cat”]

{{Abdallah}} uses a perfect binary tree with 63 nodes to implement a {{small database system}}. How many leaves will this tree have?

[“small database system”, “decision tree in a game”, “network routing table”]

Conditions

Level 2

Within a single problem scenario, conditions and values change for each variant.

Abdallah uses a perfect binary tree with {{63}} nodes to implement a small database system. How many leaves will this tree have?

$2^h - 1$ for some random positive integer *h*

Scenarios

Level 3

Problem scenarios change for each variant, assessing a single concept.

[“complete”, “perfect”, “full”]

Abdallah uses a {{complete}} binary tree with 63 nodes to implement a small database system. What {{max height}} will this tree have?

[“max height”, “min height”]

Concepts

Level 4

Randomized variations lead to an assessment of different concepts.

Abdallah uses an {{m-ary tree with m=4}} with 63 nodes to implement a small database system. How many leaves will this tree have?

[“m-ary tree with m=4”,
“full b-tree with order 4”]

Different Questions

Level 5

Each question variant is entirely independent.

{{Abdallah uses a perfect binary tree to implement a small database system with 63 nodes. How many leaves will this tree have?}}

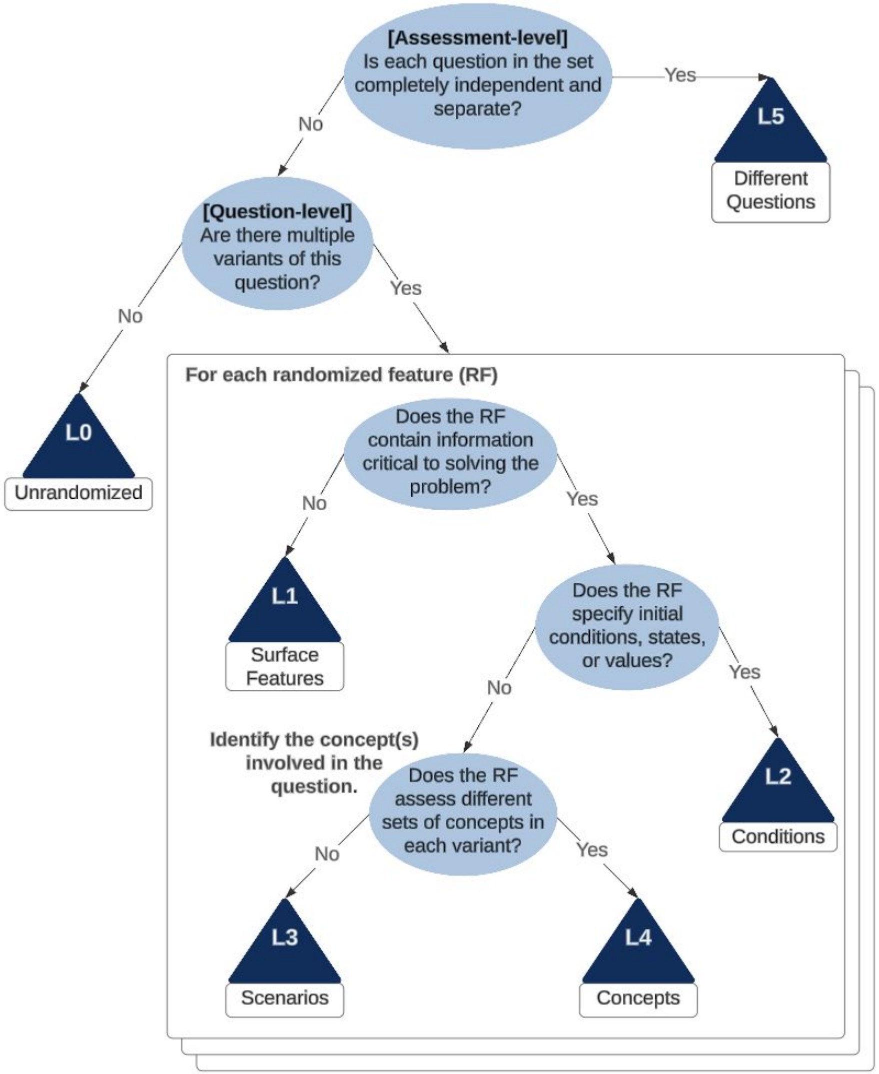
Framework + Examples

Question Evaluation

Question Design

Understanding the randomization in a question

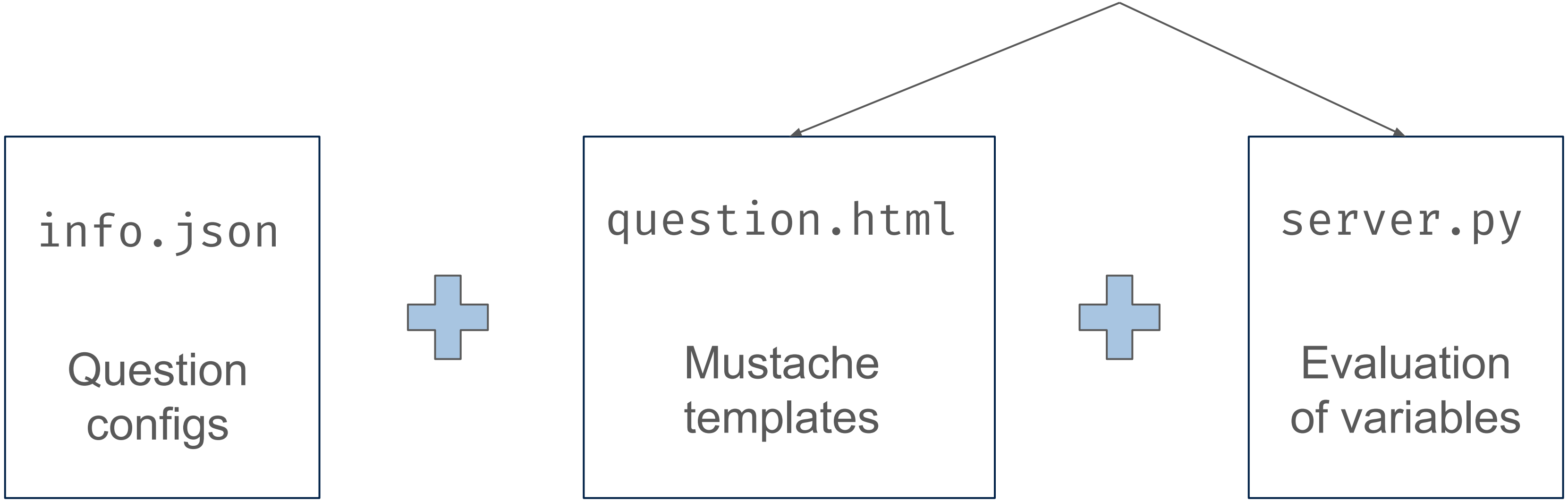
- Key questions to identify the quantity and quality of randomization present
- **Iterative process** evaluating each randomized feature
- Only L0 and L5 are mutually exclusive from the rest



[Assessment-level]
Is each question in the set completely independent and separate?
Yes
L5
Different Questions
No
[Question-level]
Are there multiple variants of this question?
No
L0
Unrandomized
Yes
For each randomized feature (RF)
Does the RF contain information critical to solving the problem?
No
L1
Surface Features
Yes
Does the RF specify initial conditions, states, or values?
Yes
L2
Conditions
No
Identify the concept(s) involved in the question.
Does the RF assess different sets of concepts in each variant?
No
L3
Scenarios
Yes
L4
Concepts

PrairieLearn

Raters can take advantage of source code to easily identify randomized features in more complex questions.



`info.json`

Question configs

`question.html`

Mustache templates

`server.py`

Evaluation of variables

PrairieLearn

question.html

```
<p>
A <strong>perfect</strong> binary tree
with height {{params.h}}, has
<pl-integer-input
answers-name="c_1 "></pl-integer-input>
leaves.
</p>
```

A randomized feature (RF)

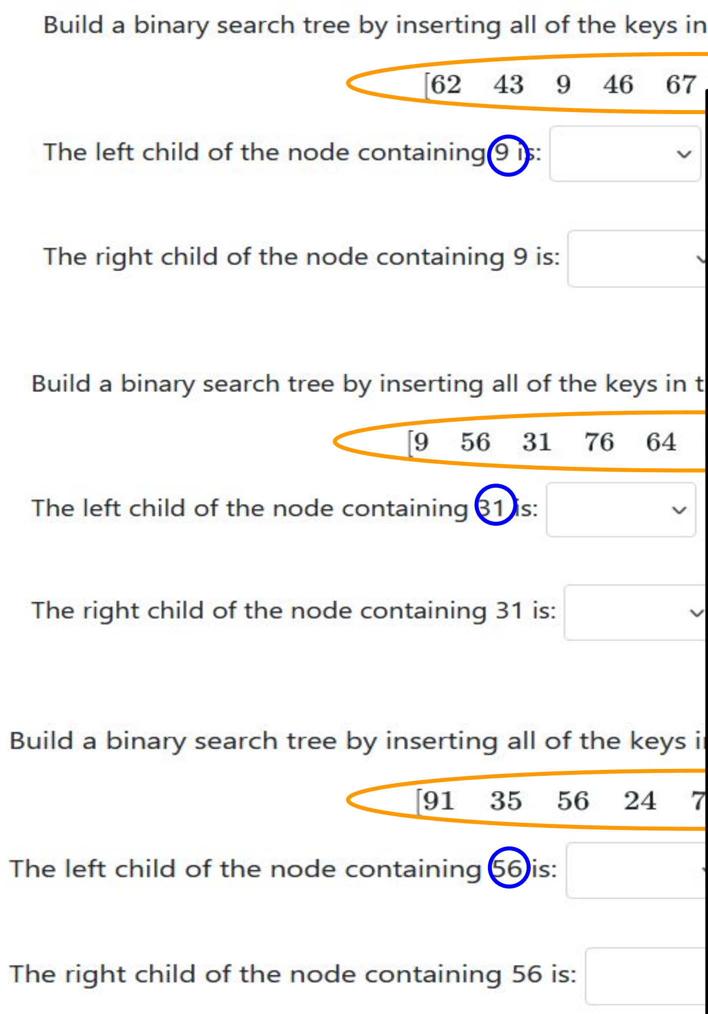
server.py

```
def generate(data):

    upper_power = 9
    h = random.randint(4,upper_power)
    c_1 = 2**h

    # Release parameters
    data["params"]["h"] = h

    # Release correct answer
    data["correct_answers"]["c_1"] =
c_1
```



1

Build a binary search tree by inserting all of the keys in the array below, in the order given.

[62 43 9 46 67 51 78 18 57 10]

The left child of the node containing 9 is:

The right child of the node containing 9 is:

2

Build a binary search tree by inserting all of the keys in t

[9 56 31 76 64

The left child of the node containing 31 is:

The right child of the node containing 31 is:

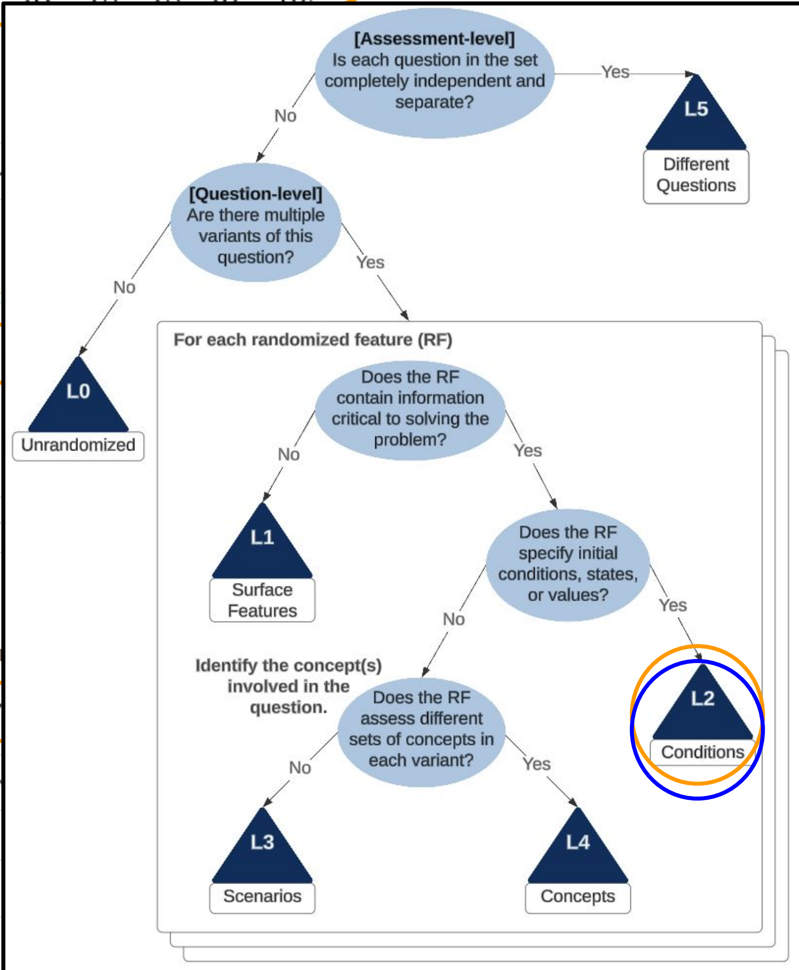
3

Build a binary search tree by inserting all of the keys i

[91 35 56 24 7

The left child of the node containing 56 is:

The right child of the node containing 56 is:



[Assessment-level] Is each question in the set completely independent and separate?

Yes → L5 Different Questions

No → **[Question-level]** Are there multiple variants of this question?

No → L0 Unrandomized

Yes → **For each randomized feature (RF)**

Does the RF contain information critical to solving the problem?

No → L1 Surface Features

Yes → Does the RF specify initial conditions, states, or values?

Yes → L2 Conditions

No → **Identify the concept(s) involved in the question.** Does the RF assess different sets of concepts in each variant?

No → L3 Scenarios

Yes → L4 Concepts

Framework + Examples

Question Evaluation

Question Design

Level	Example Feature	Effect on Approach	Pedagogical Considerations	Logistical Considerations
0 Unrandomized	N/A	N/A	- Students may memorize answers.	- Offers weakest exam security.
1 Surface Features	Changing order of MC options, variable names	Students do not need to account for the feature in their approach.	- Students pra e question understanding xtracting important informa - Tests a specific type o n of question.	- Discourages answer sharing within exam room.
2 Conditions	Changing initial values and states	Students can reuse the exact same approach across question variants.	- Students practice executing algorith - Tests a specific ty question.	swer sharing n room.
3 Scenarios	Giving different cases of the same algorithm	Students can use a similar approach with slight adjustments across question variants.	- Students build cr skills. - Tests the underst multiple scenarios w concept.	t meaningful k. in difficulty.
4 Concepts	Asking about implementation of different data structures	Students have to use different approaches across question variants.	- Students build critical thinking skills. - Tests the understanding of multiple concepts.	- Protects against meaningful information leak. - Moderate variance in difficulty.
5 Different Questions	N/A	N/A	- Enables learning through multiple attempts on assessments.	- Offers strongest exam security. - Wide variance in difficulty.

Consider from a student's perspective: how would you adapt the problem solving approach to tackle differences across question variants?

Level	Example Feature	Effect on Approach	Pedagogical Considerations	Logistical Considerations
0 Unrandomized	N/A	N/A	- Students may memorize answers.	- Offers weakest exam security.
1 Surface Features	Changing order of MC options, variable names	Student[illegible] [illegible]ot need to acc[illegible] the feature in [illegible]proach.	- Students practice question understanding and extracting important information. - Tests a specific type or pattern of question.	- Discourages answer sharing within exam room.
2 Conditions	Cha[illegible] and[illegible]	[illegible] reuse the exact [illegible]ch across [illegible]ants.	- Students practice calculations and executing algorithms. - Tests a specific type or pattern of question.	- Discourages answer sharing within the exam room.
3 Scenarios	Giv[illegible] the [illegible]	[illegible] use a similar [illegible]th slight adjustments across question variants.	- Students build critical thinking skills. - Tests the understanding of multiple scenarios within a concept.	- Protects against meaningful information leak. - Slight variance in difficulty.
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Different levels of randomization may be more appropriate for different stages of mastery learning.

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Using different levels of randomization in an exam setting presents different benefits and challenges such as the balance between security and fairness.

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The interpretation of what constitutes a condition, scenario, or concept can vary significantly between beginner and advanced level courses, leading to differences in how these features are perceived depending on the context.

A big thank you to the UBC CPSC 313 and CPSC 221 teaching teams for contributing questions from their respective courses for this research.