

# Inferring Students’ Tracing Behaviors from Interaction Logs of a Learning Environment for Software Design Comprehension



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## Motivation: Helping students comprehend designs

Modeling software designs is an essential skill required of computing students.

Students have difficulties in dealing with models having multiple views, such as the structural view (e.g. class diagrams), and the behavioral view (e.g. sequence diagrams)

Goal: Develop pedagogy to help students understand different design diagrams

## VeriSIM Learning Environment

We propose the design tracing pedagogy. In design tracing, students trace the control flow and data flow across different diagrams for a given scenario of system execution.

Students construct a model similar to a state diagram.

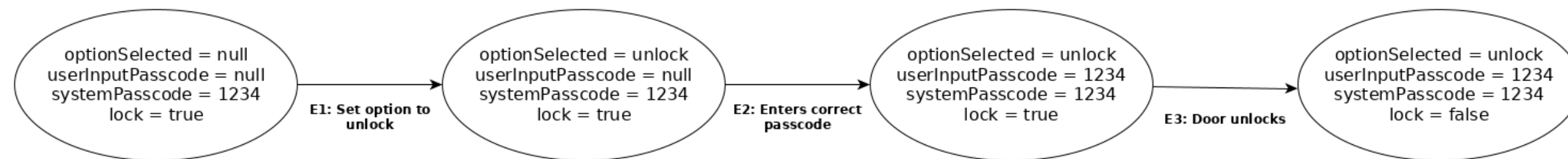


Figure 1: A state diagram which corresponds to the execution of a scenario

## Learning Activities in VeriSIM:

Students go through four challenges in which they progressively construct a state diagram

1. Challenge 1: Explore the model
2. Challenge 2: Correct the model
3. Challenge 3: Complete the model
4. Challenge 4: Construct the model

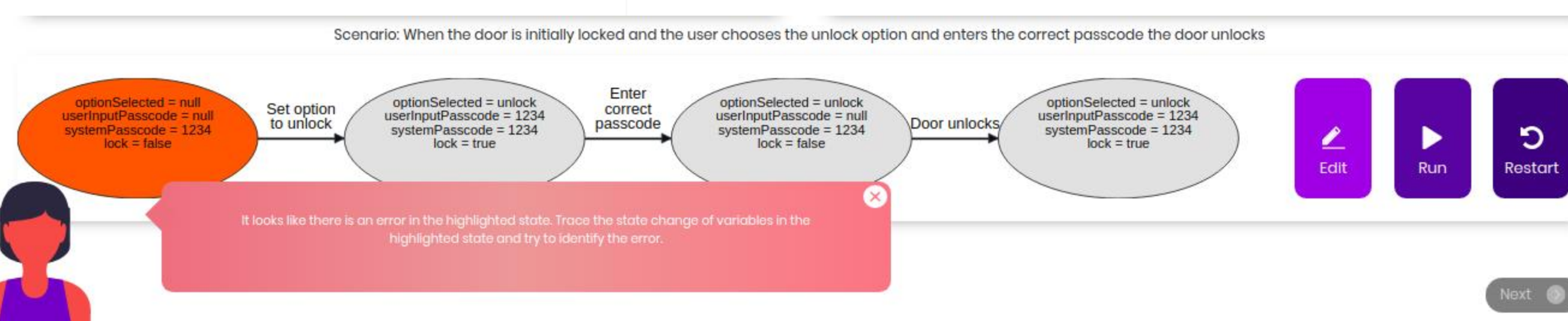


Figure 2. An incorrect model provided in Challenge 2 of VeriSIM

## Logging of User Actions in VeriSIM

As learners construct the state diagram, various actions are logged.

These include actions such as adding, editing, deleting data variables and states, and clicking on “Run”

All these interactions are logged in the system, and available for analysis. Log files contains fields such as timestamp, activity, duration, display name, user id, action and score

## Study to Infer Behavior Patterns

Research Question: “What are different strategies which students use to trace scenarios in a given design?”

Study Procedure:

We conducted a study with 12 second year computing undergraduates (m=9, f=3). From the data logs, we extracted actions performed by each user in Challenge 2,3,4. We then manually analyzed patterns to identify different strategies

## Findings: Strategies Students used to Construct the Model



Figure 3. Graphs depicting different categories of strategies

1. Single Run Strategy: All modifications followed by single run at the end
2. Few Runs Strategy: Between one to three cycles of modification and run
3. Multiple Runs Strategy: Multiple cycles of modification and run

## Findings: Strategies Students Use Across Challenges

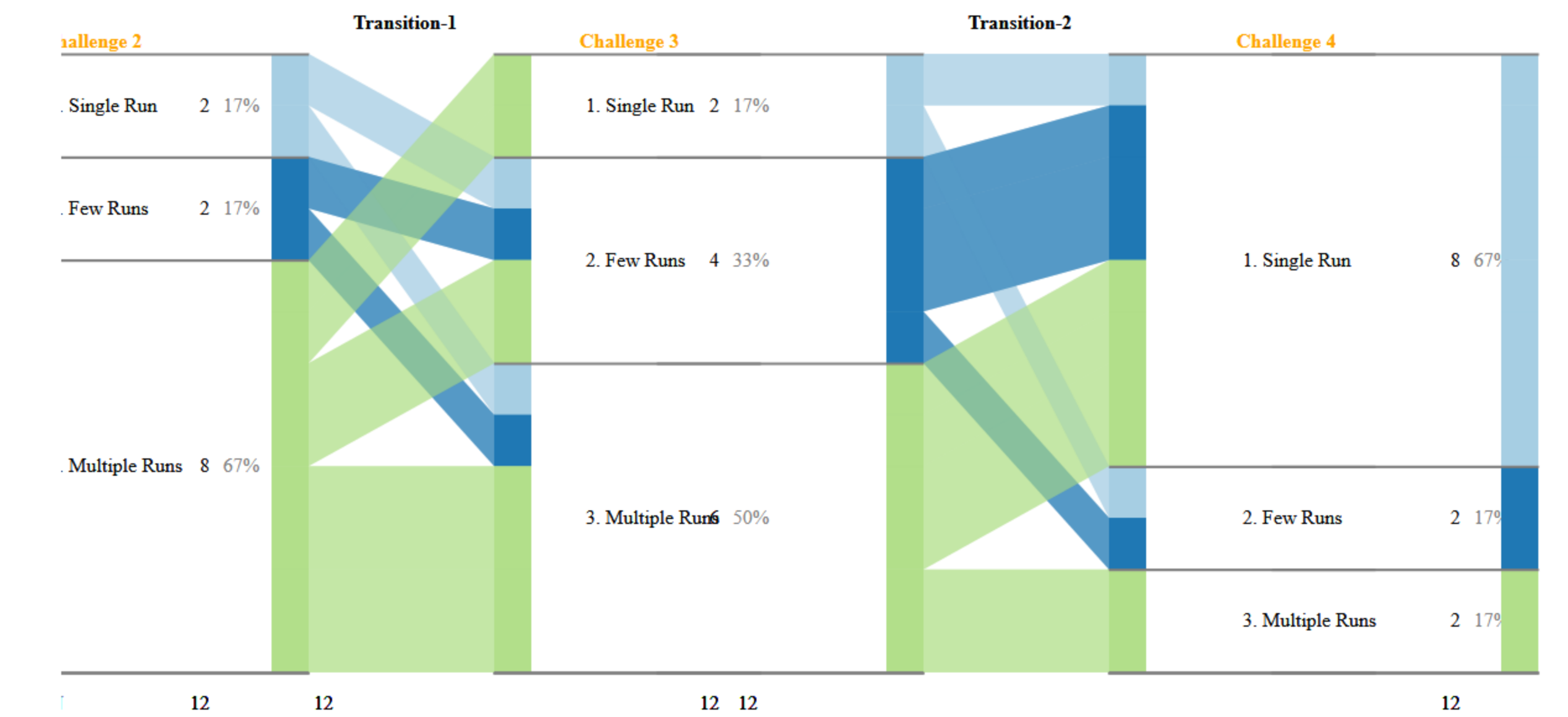


Figure 4: Transition patterns of students using strategies across Challenges

In Challenge 2, most students use “Multiple Runs Strategy”  
In Challenge 4, most students use “Single Run Strategy”

These findings give indicators that previous challenges helped students internalise the execution of the control flow and data flow of the given scenario.

## Future Work

We intend to conduct further studies with students in order to validate the inferred strategies

We also intend to apply machine learning techniques (pattern mining) to automate the process of inferring strategies

We believe that the design tracing pedagogy can be adapted for program comprehension. Thus future work can examine patterns of behaviors students use to trace programs.



# VeriSIM Learning Environment

## Design Tracing Pedagogy:

Students trace the control flow and data flow across different diagrams for a given scenario of system execution. The model which they create is similar to a state diagram

Scenario: When the door is initially locked and the user selects the unlock option and enters the correct passcode, the door unlocks”

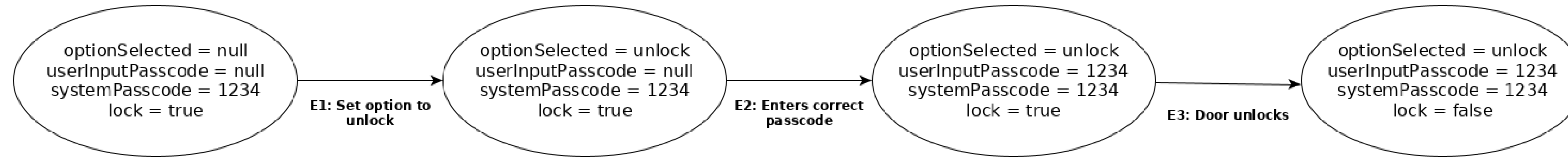


Figure 1.1: A state diagram which corresponds to the execution of a scenario

## Challenges in the VeriSIM Learning Environment:

Challenge 1: Explore the model

Challenge 2 : Correct the model

Challenge 3: Complete the model

Challenge 4: Construct the model

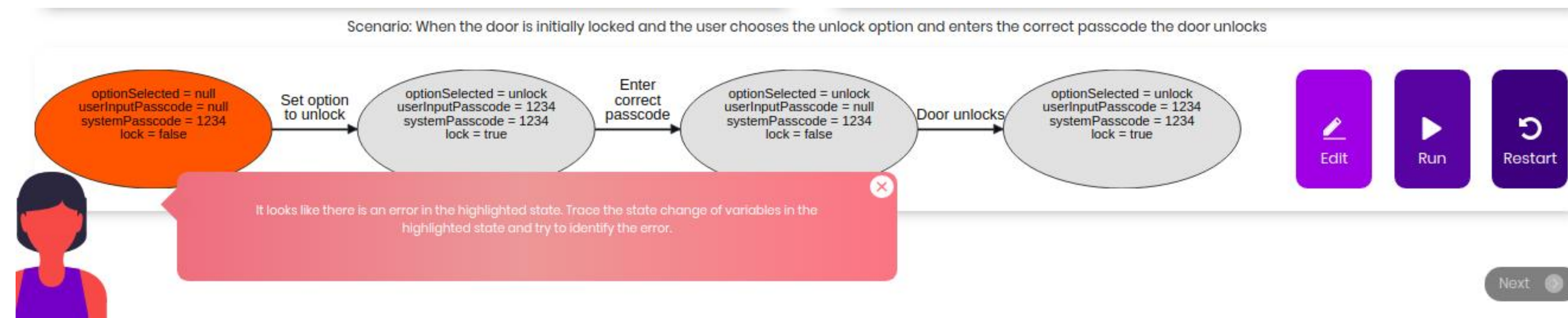


Figure 1.2: In Challenge 2, learners correct an incorrect model

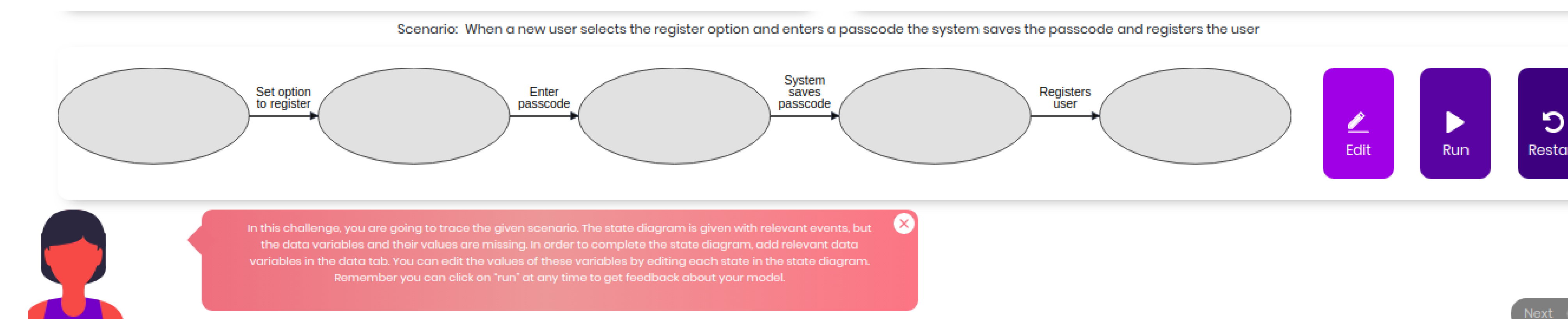


Figure 1.3: In Challenge 3, learners add data variables and its corresponding values to the state diagram

## Different Spaces in VeriSIM:

VeriSIM provides learners affordances to construct, modify, and visualize the execution of a state diagram

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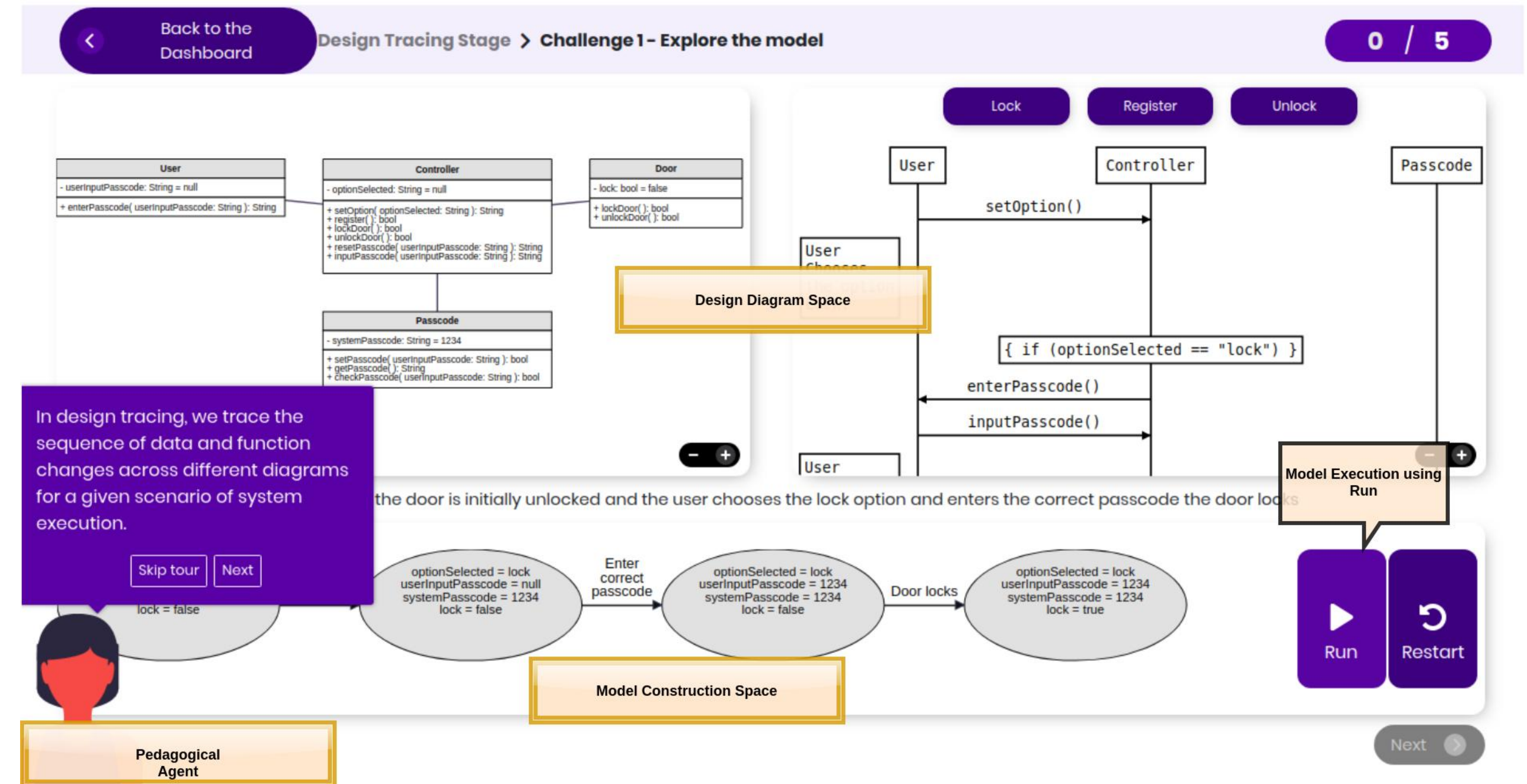


Figure 1.4: Different spaces in VeriSIM

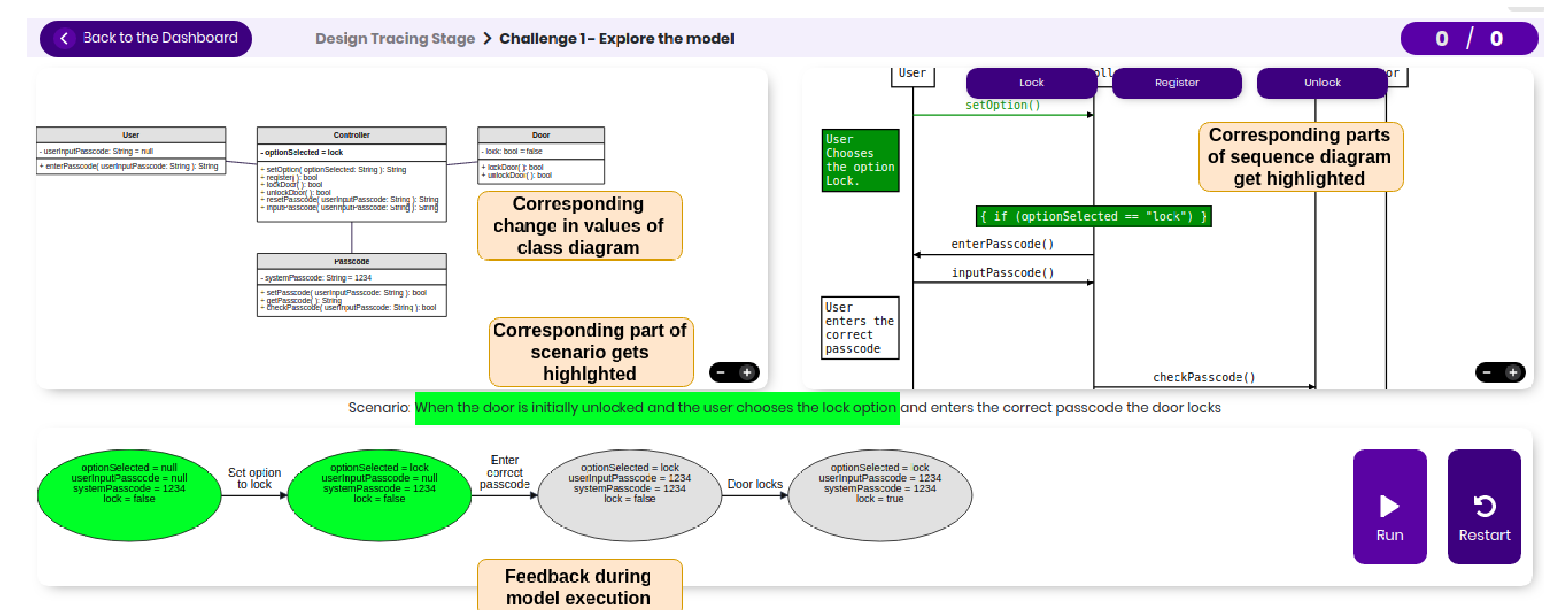


Figure 1.5: Execution of a state diagram in VeriSIM



Logging of User Actions in VeriSIM

As learners construct the state diagram, various actions are logged. These include actions such as adding, editing, deleting data variables and states, and clicking on “Run”. All these interactions are logged in the system, and available for analysis. Log files contains fields such as timestamp, activity, duration, display name, user id, action and score

id	timestamp	duration	screen	user_id	display_name	action_name	data_score	event_score	state_score
5d8844ea18919072731c05d5	2019-09-23 04:39:27.385000+00:00	22	Challenge 1	5d88493618919072731c014f	XXX	system_action	0	0	0
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5d884e4e18919072731c06de	2019-09-23 04:41:05.266000+00:00	0	Challenge 1	5d88493618919072731c014f	XXX	system_action	4	3	19
5d884e5d18919072731c0716	2019-09-23 04:41:18.361000+00:00	13	Challenge 1	5d88493618919072731c014f	XXX	run	4	3	19
5d884e5d18919072731c0717	2019-09-23 04:41:18.363000+00:00	0	Challenge 1	5d88493618919072731c014f	XXX	system_action	4	3	19
5d884e5d18919072731c0718	2019-09-23 04:41:20.335000+00:00	1	Challenge 1	5d88493618919072731c014f	XXX	run	4	3	19
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5d885132cabef674ecdbec51	2019-09-23 04:53:27.196000+00:00	176	Q - Challenge 1	5d88493618919072731c014f	XXX	question	0	0	0
5d885132cabef674ecdbec52	2019-09-23 04:53:27.196000+00:00	0	Q - Challenge 1	5d88493618919072731c014f	XXX	question	0	0	0
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Figure 2.1: A snapshot of the pre-processed interaction log

Study to Infer Behavior Patterns

Research Question: “What are different strategies which students use to trace scenarios in a given design?”

Study Procedure:

We conducted a study with 12 second year computing undergraduates (m=9, f=3). From the data logs, we extracted actions performed by each user in Challenge 2,3 and 4. We then manually analyzed patterns to identify different strategies.

Findings: Strategies Students used to Construct the Model

- 1. Single Run Strategy: All modifications followed by single run at the end
- 2. Few Runs Strategy: Between one to three cycles of modification and run
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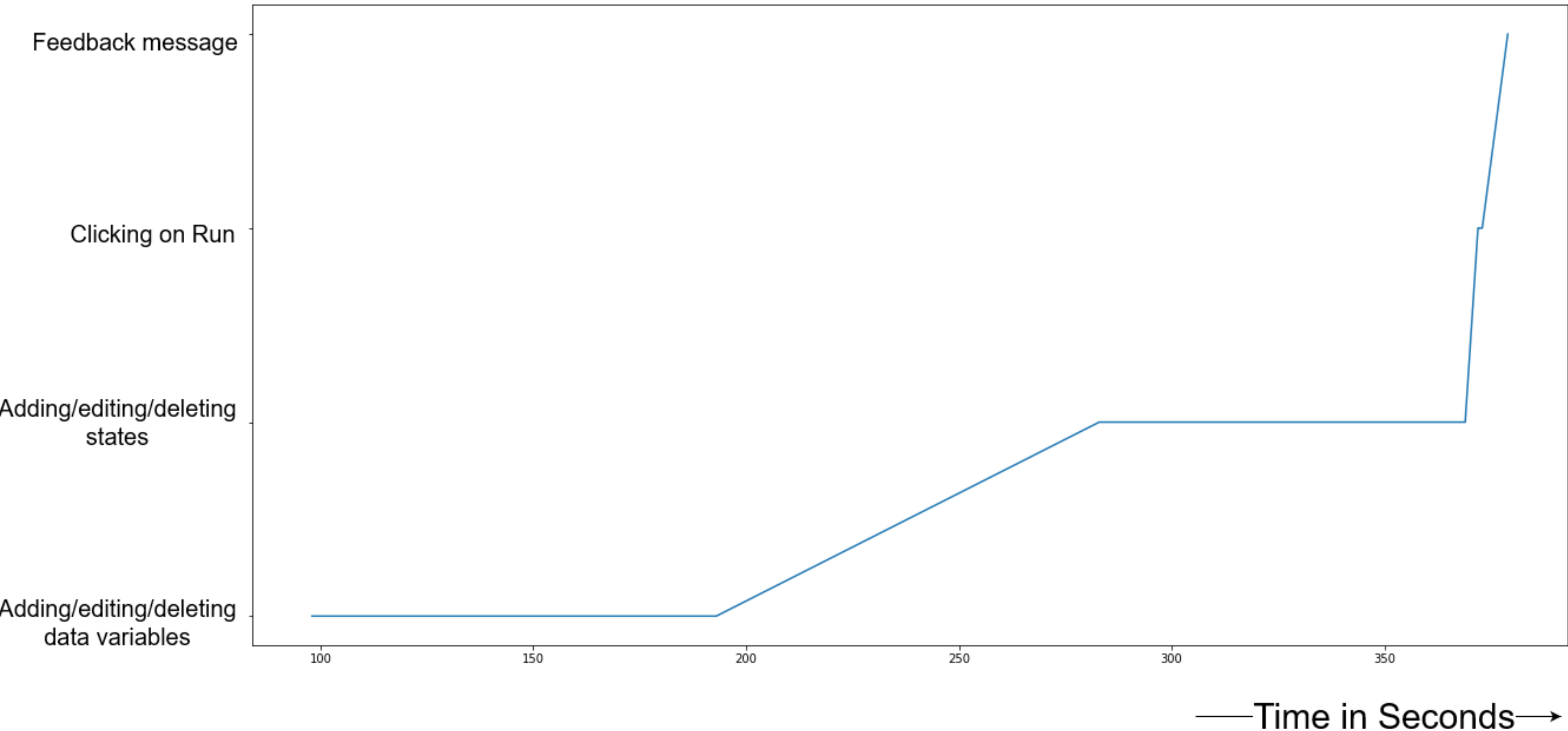


Figure 2.2: Example graph of the Single Run Strategy

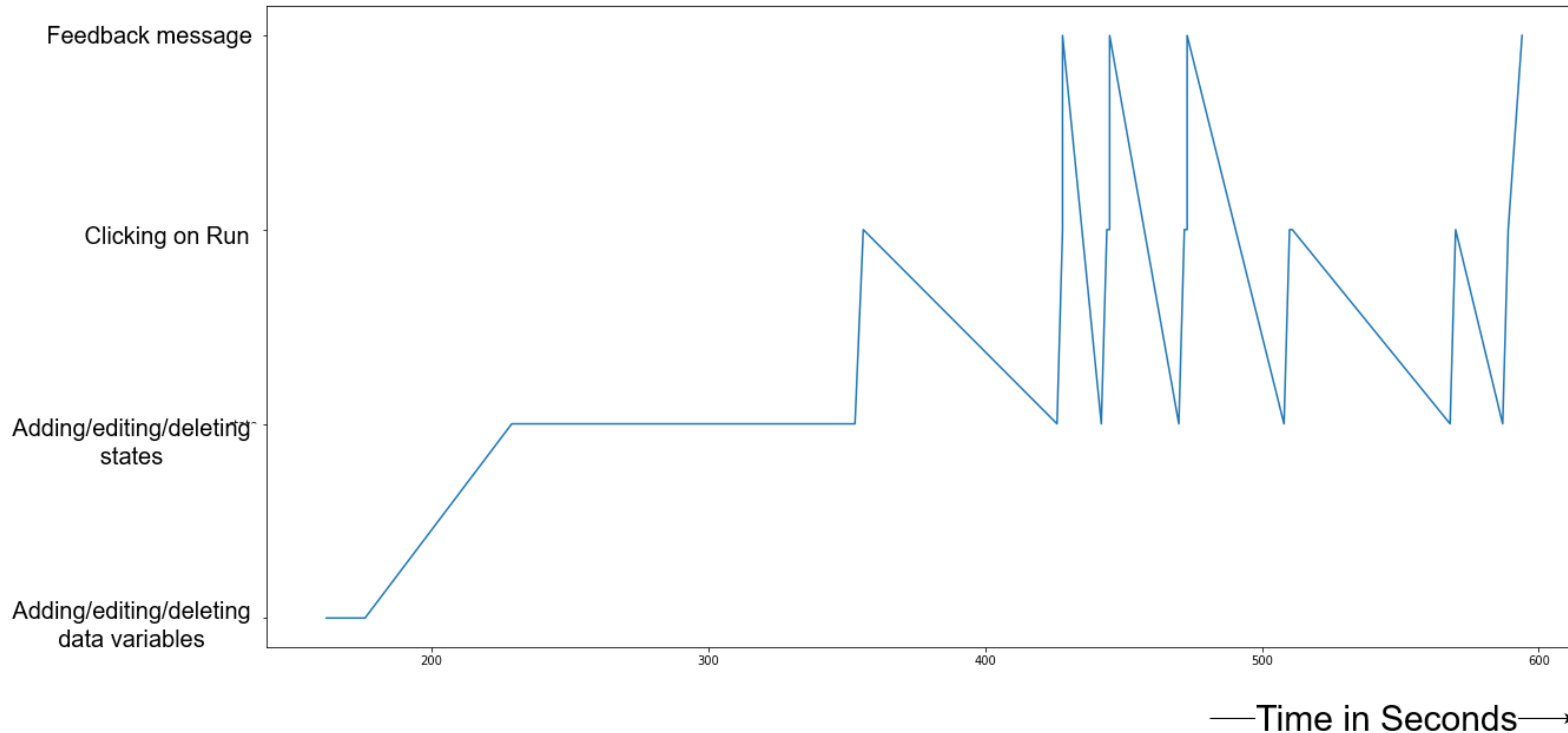


Figure 2.3: Example graph of the Multiple Run Strategy

## Strategies Students Used Across Challenges

In Challenge 2, most students use “Multiple Runs Strategy”

By the time students reached Challenge 4, most students use “Single Run Strategy”

	Challenge 2	Challenge 3	Challenge 4
Single Run Strategy	2	2	8
Few Runs Strategy	2	4	2
Multiple Runs Strategy	8	6	2

Table 3.1: Number of students using a strategy in each challenge

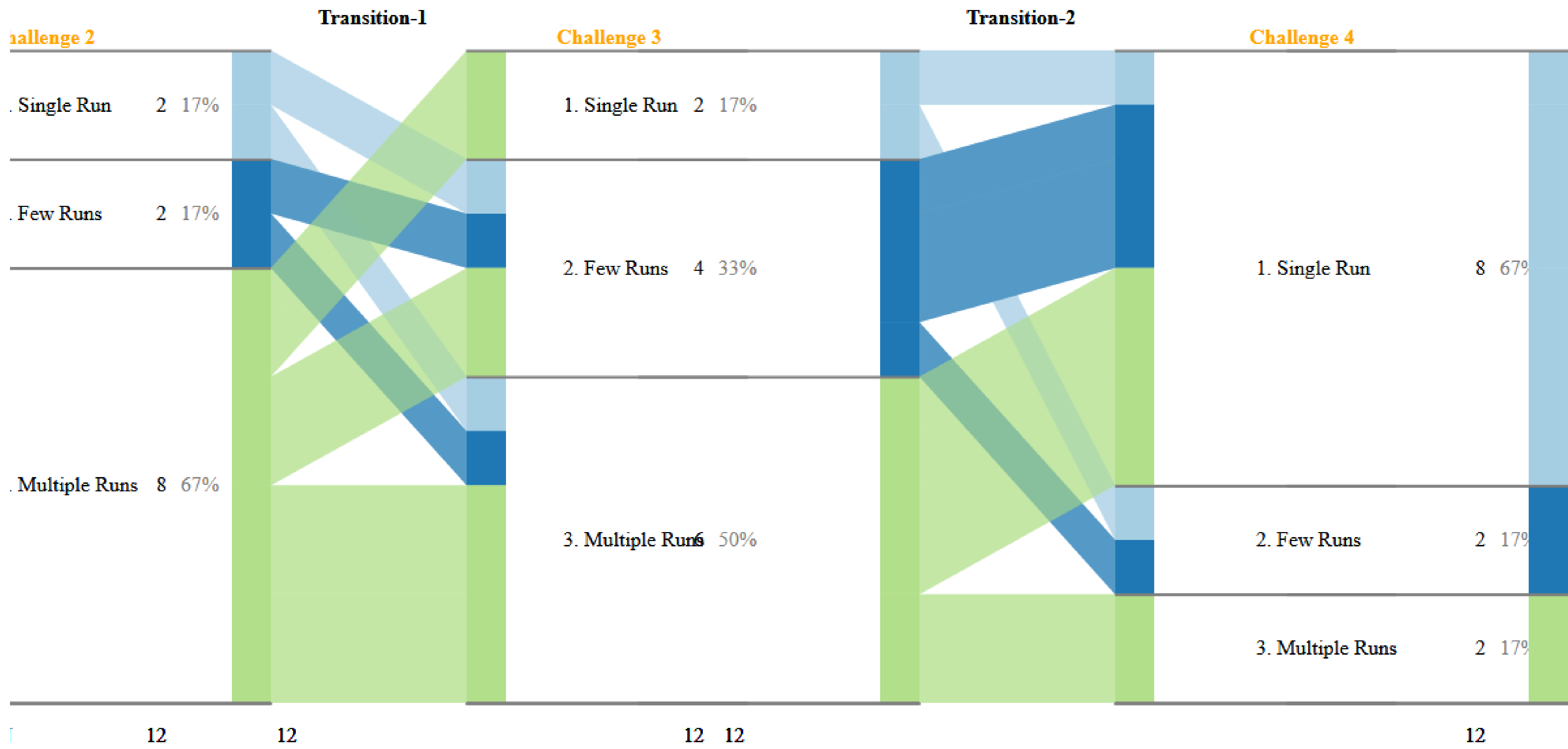


Figure 3.2: Transition patterns of students using strategies across Challenges

## Preliminary Inferences

Students did not frequently use the ‘run’ scaffold to periodically validate their model in latter challenges.

These results also give us indicators that previous challenges helped students internalise the execution of the control flow and data flow of the given scenario.

## Future Work

We intend to conduct further studies with students in order to validate the inferred strategies

We also intend to apply machine learning techniques (pattern mining) to automate the process of inferring strategies

## Points for Discussion

1. Applicability of using the VeriSIM learning environment for helping students trace programs
2. Applicability of activities in VeriSIM (Explore, correct, complete, construct the model) as a progression for helping students trace code
3. Applicability of the analysis framework for evaluating how students trace code



**Thank you for listening!!**

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**VeriSIM is available online: <https://verisim.tech>**