TaskTracker-tool: A Toolkit for Tracking of Code Snapshots and Activity Data During Solution of Programming Tasks

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Introduction

Students’ coding behavior

Find gaps in understanding

Discover typical errors

Facilitate the process of teaching

Reveal code patterns

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data with interactions between a student and IDE

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data gathering tool

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Existing Tools

Tool	Target IDE	Tracking data	Description
ClockIt	BlueJ 	IDE actions	A visualization tool to compare behavior of users with different programming experience
Marmoset plugin	Eclipse 	**coarse-grained** seq. snapshots of code	A testing system to grade submissions of problems with VCS synchronisation
DevEvent Tracker	Eclipse 	**fine-grained** seq. snapshots of code	A part of the Web-CAT system to analyze solution process with many features available
Blackbox	BlueJ 	**fine-grained** seq. snapshots of code + IDE actions	A data collection project, including large open dataset with actions and code from various users

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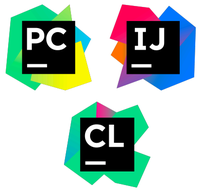
TaskTracker	IntelliJ 	**fine-grained** seq. snapshots of code + IDE actions	A flexible tool to collect and analyze task-specific data with every code change tracked

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Table 1: Existing Tools

Our Contributions

Plugin to track code changes, working in conjunction with *ActivityTracker* plugin

Server to facilitate data gathering process

Data post-processing tool to analyze collected data

TaskTracker-tool

Public **dataset** of problem solving activity data of 148 students

TaskTracker-tool: plugin

- **User interface:**
  - filling a survey
  - choosing task to solve
  - viewing task description

- **Data collection:**
  - using *ActivityTracker*[1] plugin to track actions
  - tracking **only** task-related files
  - taking snapshots of **every** code change
  - saving data in `.csv` format

[1]**ActivityTracker**: https://github.com/dkandalov/activity-tracker

TaskTracker-tool: server

Information common for all languages is filled once

Otherwise, it should be filled for each language

```
{
    'key': 'pies',
    'examples':
        [
            { 'input': '10\n15\n2', 'output': '20 30'},
            { 'input': '2\n50\n4', 'output': '10 0'},
            { 'input': '2\n50\n0', 'output': '0 0' }
        ],
    'descriptions':
        [
            {
                'language': 'en',
                'info': {
                    'name': 'Pies',
                    'description': 'A single pie costs A dollars and B cents in the cafe. ' +
                        'Calculate how many dollars and cents you would need to buy N pies.',
                    'input': 'The program receives three numbers as an input:\n' +
                        'A - how many dollars a pie costs;\n' +
                        'B - how many cents a pie costs;\n' +
                        'N - how many pies do you need to buy.',
                    'output': 'Print out two numbers: the cost of N pies in dollars and cents.'
                }
            }
        ]
},
```

Figure 1: The tasks config file

TaskTracker-tool: server

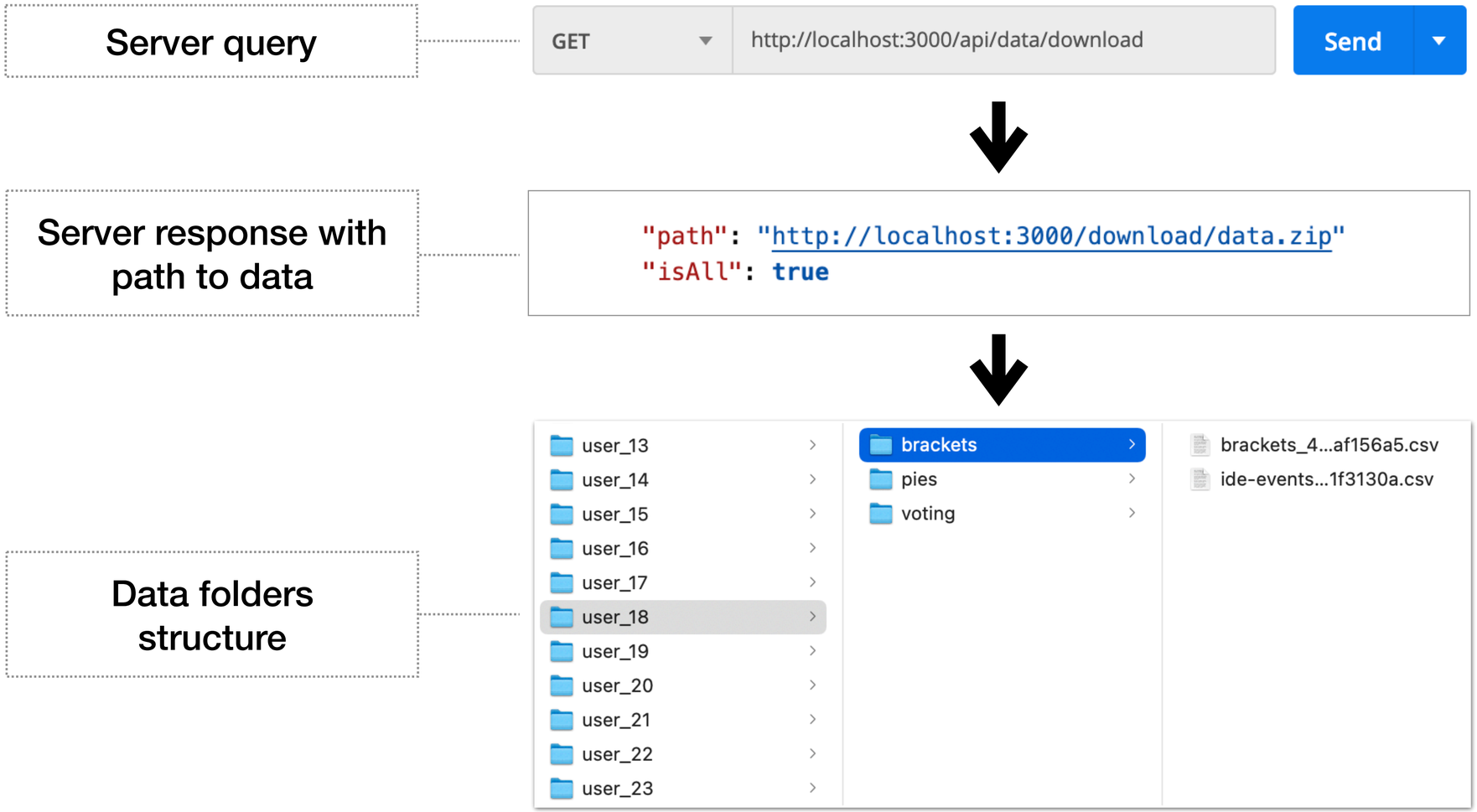


Figure 2: Data downloading pipeline

TaskTracker-tool: data post-processing

	date	fileName	fragment	age
1	2019-12-20T13:45:07.784+03:00	pies.py	a	17.0
2	2019-12-20T13:45:07.869+03:00	pies.py	a =	17.0
3	2019-12-20T13:45:08.085+03:00	pies.py	a =	17.0
4	2019-12-20T13:45:08.126+03:00	pies.py	a = i	17.0
5	2019-12-20T13:45:08.500+03:00	pies.py	a = in	17.0
6	2019-12-20T13:45:08.502+03:00	pies.py	a = in(	17.0
7	2019-12-20T13:45:08.778+03:00	pies.py	a = in()	17.0
8	2019-12-20T13:45:08.779+03:00	pies.py	a = in)	17.0
9	2019-12-20T13:45:08.924+03:00	pies.py	a = in	17.0
10	2019-12-20T13:45:09.049+03:00	pies.py	a = int	17.0
11	2019-12-20T13:45:09.051+03:00	pies.py	a = int(	17.0
12	2019-12-20T13:45:09.529+03:00	pies.py	a = int()	17.0
13	2019-12-20T13:45:09.571+03:00	pies.py	a = int(i)	17.0
14	2019-12-20T13:45:09.795+03:00	pies.py	a = int(in)	17.0
15	2019-12-20T13:45:09.870+03:00	pies.py	a = int(inp)	17.0
16	2019-12-20T13:45:09.946+03:00	pies.py	a = int(inpu)	17.0
17	2019-12-20T13:45:10.130+03:00	pies.py	a = int(input)	17.0
18	2019-12-20T13:45:10.132+03:00	pies.py	a = int(input()	17.0

Figure 3: TaskTracker data format

TaskTracker-tool: data post-processing

- Merging *ActivityTracker* and *TaskTracker* data:

	at_date	action
1	13:45:10.131	EditorRight
2	13:45:10.920	EditorEnter

+

	date	fragment
1	13:45:09.946	a = int(inpu)
2	13:45:10.130	a = int(input)
3	13:45:10.132	a = int(input()
4	13:45:10.917	a = int(input())
5	13:45:10.923	a = int(input())⏎
6	13:45:11.366	a = int(input())⏎b

a) ActivityTracker and TaskTracker files for a task

→

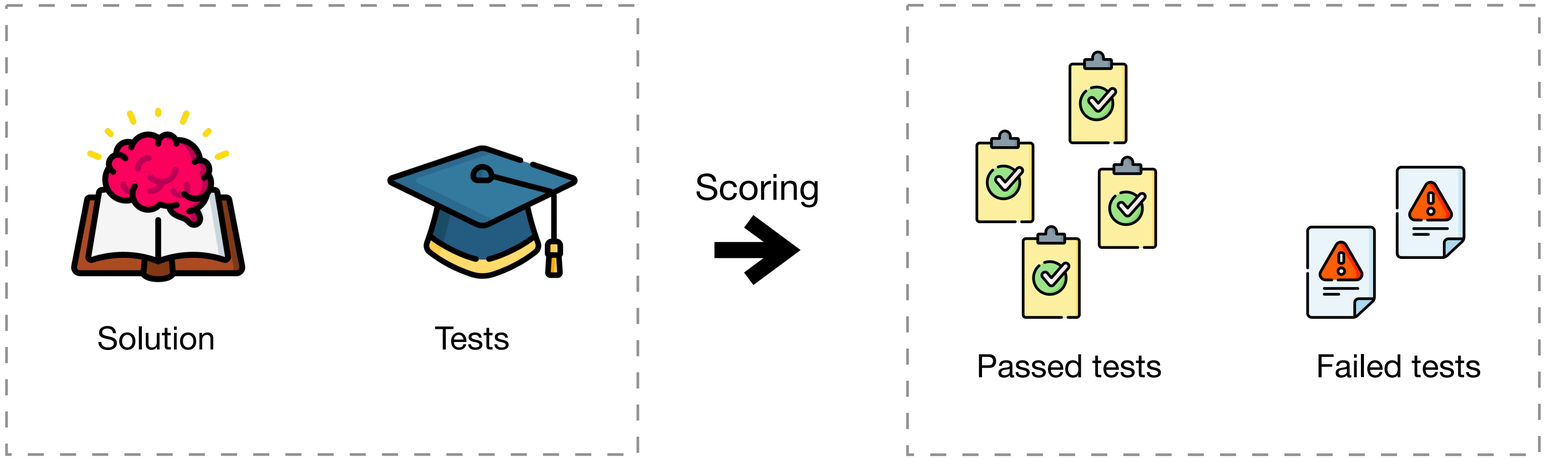
	date	fragment	at_date	action
1	13:45:09.946	a = int(inpu)	*<null>*	*<null>*
2	13:45:10.130	a = int(input)	13:45:10.131	EditorRi…
3	13:45:10.132	a = int(input()	*<null>*	*<null>*
4	13:45:10.917	a = int(input())	13:45:10.920	EditorEn…
5	13:45:10.923	a = int(input())⏎	*<null>*	*<null>*
6	13:45:11.366	a = int(input())⏎b	*<null>*	*<null>*

b) Merged ActivityTracker and TaskTracker files

Figure 4: Merging *ActivityTracker* and *TaskTracker* data pipeline

TaskTracker-tool: data post-processing

- Merging *ActivityTracker* and *TaskTracker* data;
- Scoring solutions:



$$score = \frac{passed\ \ tests}{all\ \ tests}$$

Figure 5: Scoring solutions pipeline

TaskTracker-tool: data post-processing

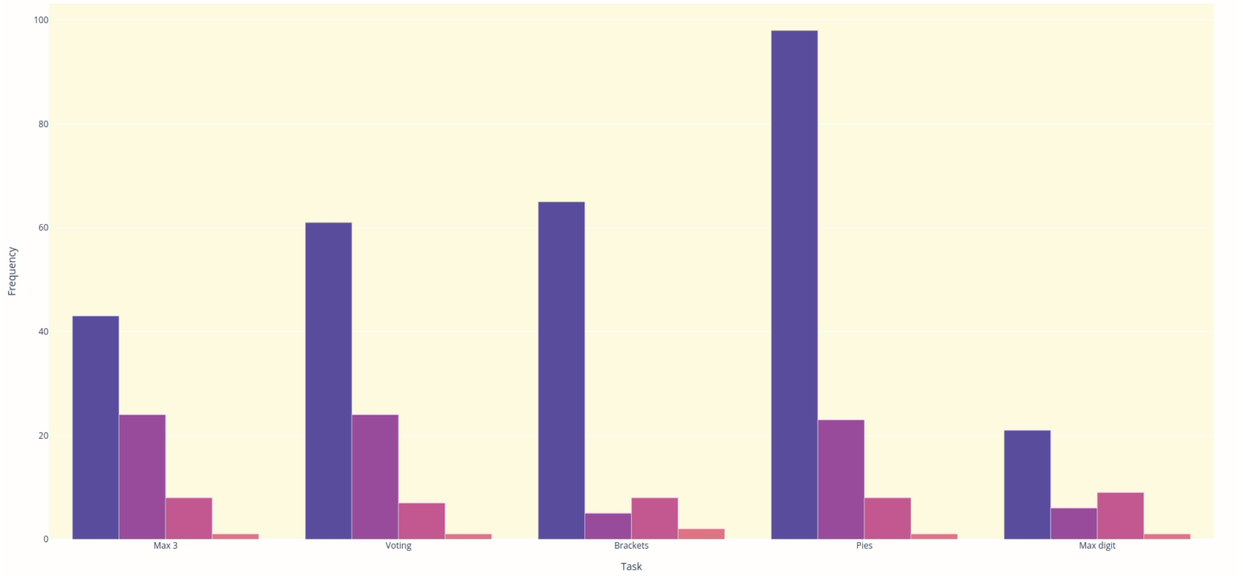
- Merging *ActivityTracker* and *TaskTracker* data;
- Scoring solutions;
- Removing intermediate code changes:

	fragment
1	a = input
2	a = input(
3	a = input()
4	a = input()⏎
5	a = input()⏎b
6	a = input()⏎b =
7	a = input()⏎b =
8	a = input()⏎b = 5
9	a = input()⏎b = 5⏎

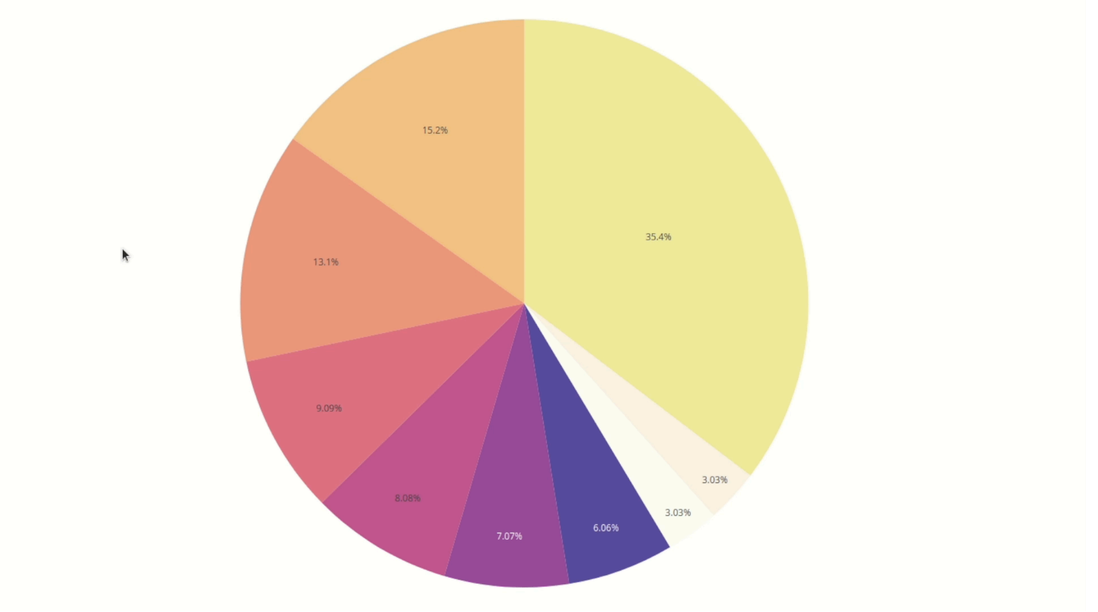
	fragment
1	a = input
2	a = input()⏎
3	a = input()⏎b = 5⏎

Figure 6: Removing intermediate code changes pipeline

TaskTracker-tool: data post-processing



a) Tasks and Languages distribution: bar chart



b) Participants' age distribution: pie chart

Figure 7: Statistics charts

TaskTracker-tool: use cases

- **Programming courses:**

Observed problem-solving in class

Course improvement

Personalized help

Cheating detection

- **Data gathering:**

Suitable for remote gathering

Works with any UI language

Easy to configure, install and use

With care for users' privacy

Dataset: description

Task	Description
Pies	A single pie costs A dollars and B cents in the cafe. Calculate how many dollars and cents one needs to pay for N pies
Max of 3	Print the largest of three numbers in the input
Zero	Check if there are zeros among numbers in the input
Voting	Given three numbers, each of them being 1 or 0, determine which one occurs more often: 1 or 0. Print the number that occurs more often
Max digit	Given a string containing only digits, find and print the largest digit
Brackets	Place opening and closing brackets into the input string like this: for odd length: `example` →`e(x(a(m)p)l)e`; for even length: `card` → `c(ar)d`, but not `c(a()r)d`.

Table 2: Task descriptions

Dataset: statistics

- **148** participants;
- **11** to **40** years old (mean age is **19**);
- **4** languages: Python, Java, Kotlin, or C++;
- collected:
  - **326** correct solutions,
  - **148** incorrect solutions;
- anonymized and open.

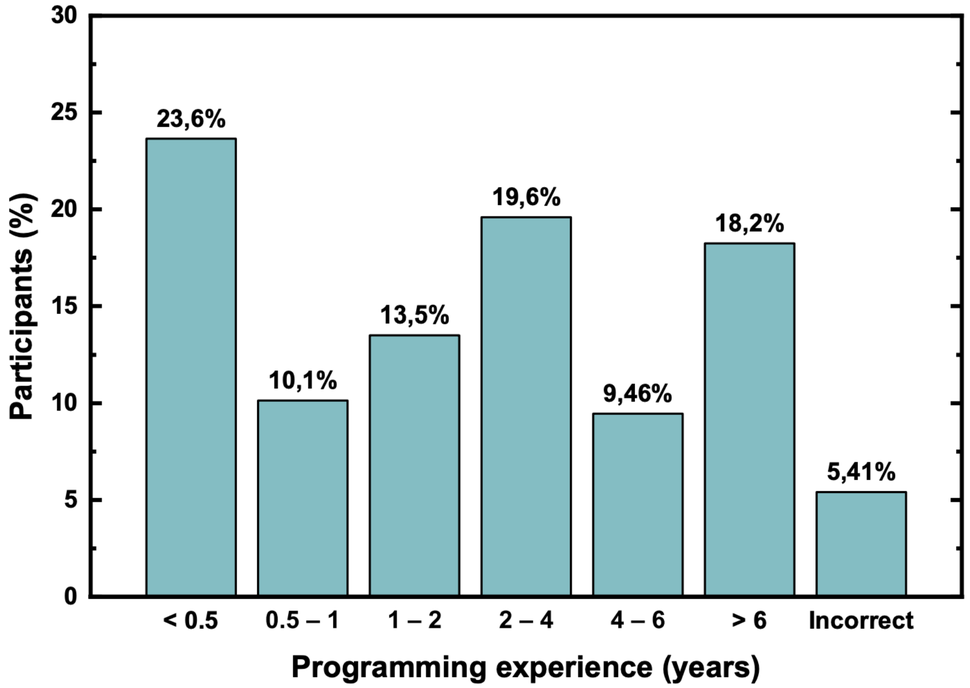


Figure 8: Distribution of participants' experience

Dataset: analysis

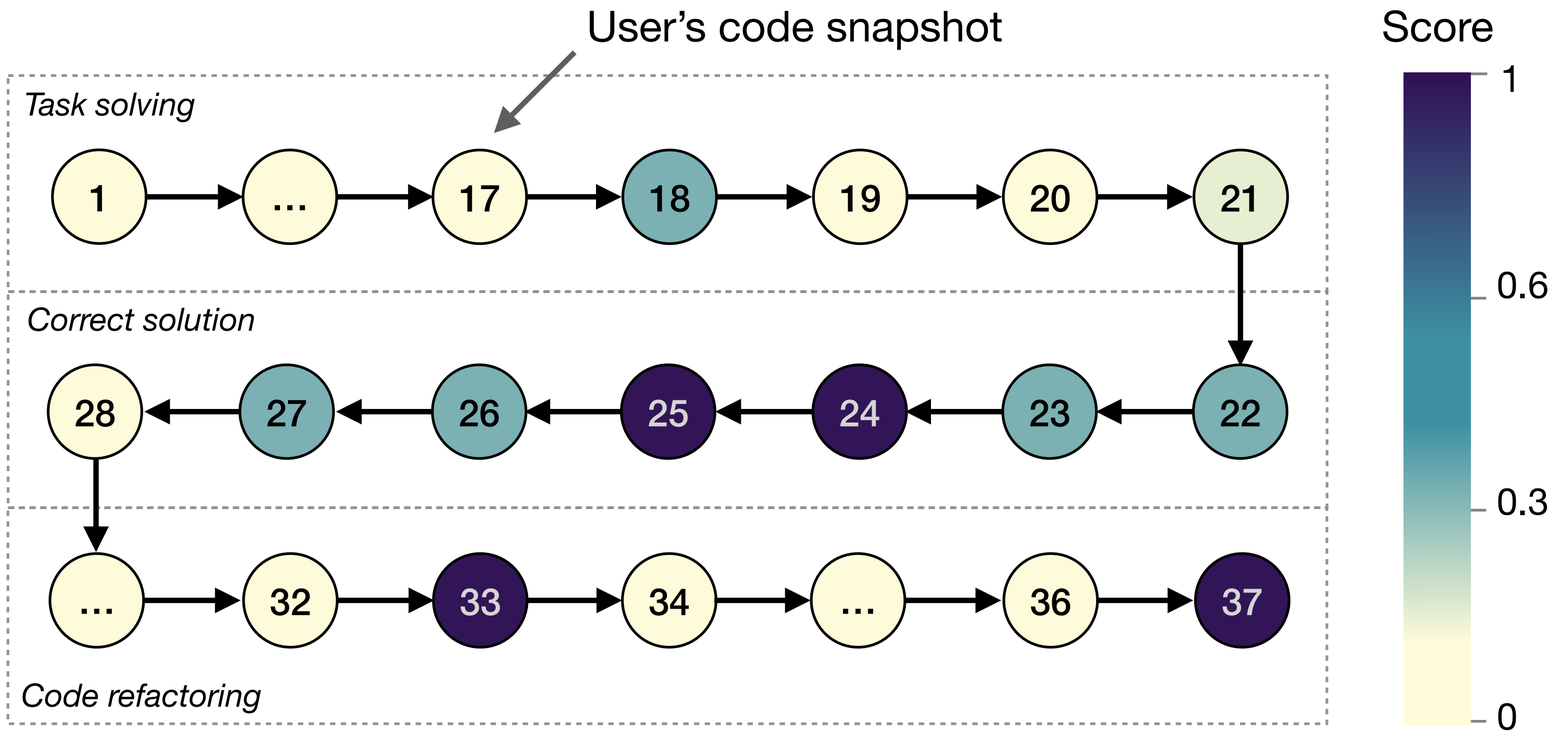


Figure 9: Changes of task score during a sample solution

Dataset: analysis

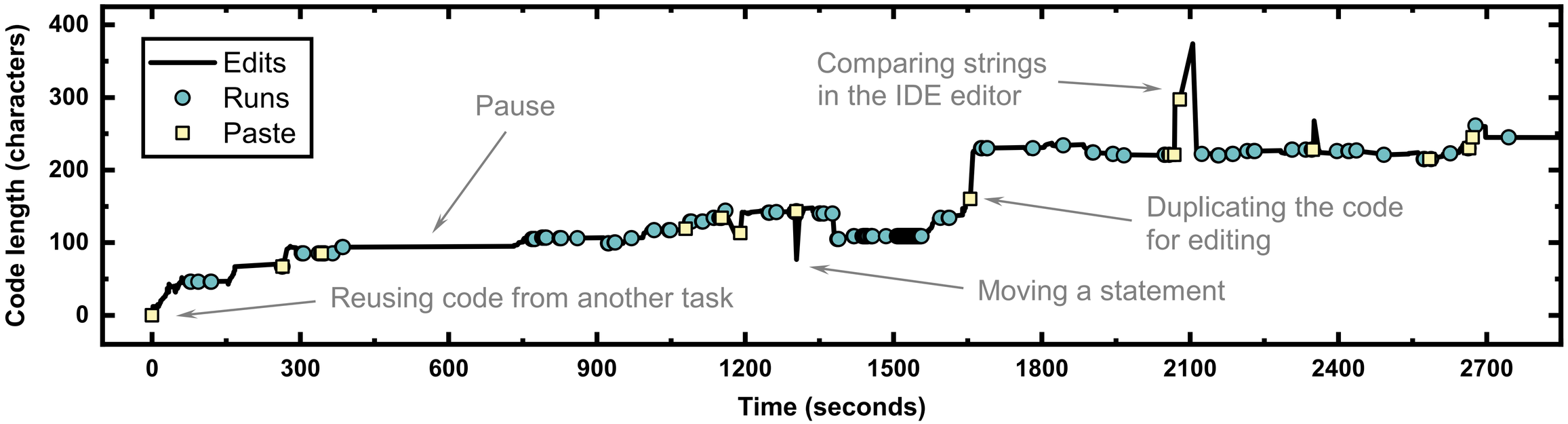


Figure 10: Actions performed in IDE during solution of a task

Dataset: use cases

Experience and feature use

Influence of age on feature use

Actions after solution

Common errors

Advanced solution metrics

Generating personalized hints

Conclusion

- **TaskTracker-tool**
  - gather task-specific data of solution activity
  - collect data on server
  - perform basic analysis
- Public **dataset** of 148 students

Thank you!

- **Elena Lyulina** - elena.lyulina@jetbrains.com

- **Links**:

Plugin

Server

Dataset

Post-processing tool

Dataset anonymizer