

## Introduction

In programming learning, the impact of programming language is essential to enrich the programming skill. Our aim is to analyze the impact of programming language skills in programming learning by collecting real-world data such as submission logs of a programming course as data-set from an Online Judge (OJ) system. We have considered single and multiple languages used for acceptance for specific problems. Finally, we have presented the analysis of the overall acceptance rate, single and multiple languages used acceptance rate.

## Data Source

This research has conducted by using the data from the AOJ. The AOJ system [1], [2] is a very popular OJ system in Japan as well as worldwide. It contains around 3000 problems, about 100000 registered users, 6 million source codes, many programming languages and submission logs. In addition, the source code of the AOJ system has been used in IBM's research project "Project CodeNet" [3].

## Research Objectives

The key points of this research are as follows:

- The statistical analysis of the used programming languages for solving problems are presented.
- Single and multiple languages used for problem-solving and acceptance rate for both cases are considered.
- The average acceptance rate of users' based on AOJ systems, single and multiple languages used for solutions acceptance rate are presented. As example,

## Proposed Approach

The overview of the proposed approach is shown in Figure 2.

- In stage 1, for the experiment, the data are collected from the Aizu Online Judge (AOJ).
- Five problems of the ALDS1 course as has selected and 10 users are picked up randomly.
- In stage 3, total attempts, total unique languages used for the problem-solving, verdict, and languages used for the acceptance are considered. where,  $U$  = User,  $P$  = Problem,  $L$  = Language used for Problem-Solving,  $A$  = Acceptance,  $W$  = Wrong Verdict,  $TA$  = Total Attempt.

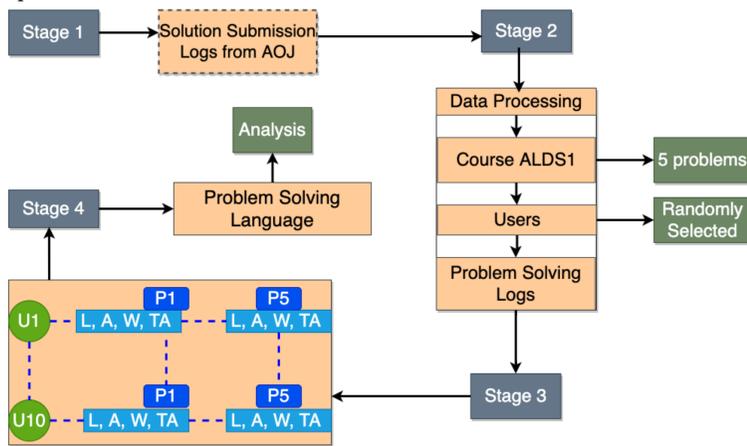


Figure 2: Overview of the proposed approach.

- In stage 4, a general equation for the acceptance rate calculation of all users according to AOJ can be described as follows:

$$U_n = \sum_{i=1}^n \frac{AC_i}{TA_i} \quad (1)$$

Where,  $AC$  = Acceptance rate,  $TA$  = Total Attempts. After that, the acceptance rate based on the languages used for the problem-solving is calculated as follows:

$$U_n = \sum_{i=1}^n \frac{AC_i + LU_i}{TA_i + TUL_i} \quad (2)$$

Where,  $LU$  = Language Used,  $TUL$  = Total Unique Language Used.

The term  $TUL$  used in Equations 2 refers to unique languages that are frequently used to solve the problem by all 10 users which is including C, C++, Python, and Java.

## Experimental Results

The acceptance rate is calculated according to Equation 1. The overall average acceptance rate of all 10 users is 39.84%. Next, we have considered the single and multiple languages used for problem-solving. In Table 1 the acceptance rate based on AOJ and based on the languages used for solutions are calculated by using Equations 1 and 2.

Table 1: Single and multiple languages used for problem-solving

Single Language Used			Multi Language Used		
User	Acceptance Rate Based on AOJ	Acceptance Rate Based on Language	User	Acceptance Rate Based on AOJ	Acceptance Rate Based on Language
$U_2$	33.3%	29.16%	$U_1$	35.29%	42.64%
$U_6$	21.73%	23.36%	$U_3$	25.80%	50.40%
$U_8$	54.16%	39.58%	$U_4$	68.75%	71.87%
$U_9$	40.54%	32.77%	$U_5$	63.63%	56.81%
			$U_7$	20.83%	36.41%
			$U_{10}$	34.37%	42.74%
<b>Average</b>	<b>37.43%</b>	<b>31.21%</b>	<b>Average</b>	<b>41.44%</b>	<b>50.14%</b>

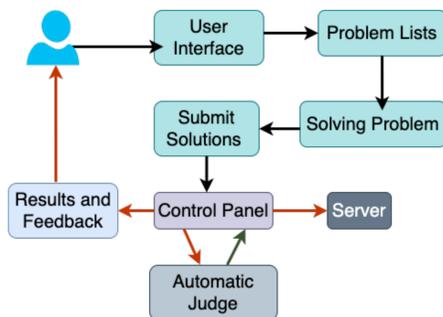


Figure 1: Online Judge

Based on the experimental results according to single and multiple languages used for problem-solving, the comparison of acceptance rate is shown in Figure 3.

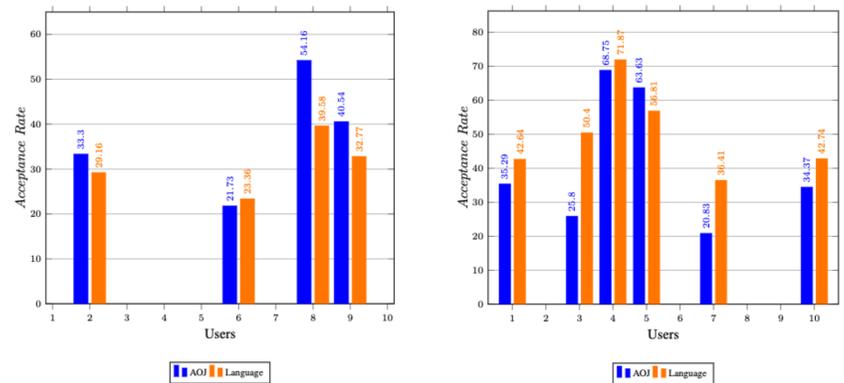


Figure 3: Comparisons of acceptance rate between AOJ and Language. For single language used case (Left) and multiple languages used case (Right) for problem-solving

Finally, the result comparison of the acceptance rate is shown in Table 2. The acceptance rate is higher of the users who have used multiple languages than the users who have used single language in both AOJ-based and language-based cases.

The illustration of overall acceptance rate comparison is shown in Figure 4.

Table 2: Comparison of Single and Multiple Used Language based on Acceptance Rate

Used Language	Acceptance rate based on AOJ	Acceptance Rate based on Language
Single	37.43%	31.21%
Multiple	41.44%	50.14%

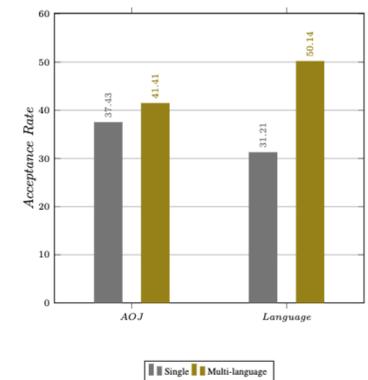


Figure 4: Overall comparisons of acceptance rate between AOJ and Language

## Conclusion

In this research, a statistical analysis has been presented for exploring the effects of programming language skills in programming learning. The analysis has been conducted based on single and multiple languages used for problem-solving including the acceptance rate for both cases. Based on the results, we have realized that multiple languages used for the solution have a higher impact on the acceptance rate than the single language used. These analyses can effectively contribute to the improvement of students, novice programmers as well as overall programming learning.

## Forthcoming Research

- In future work, more data (e.g., users and problems) will be considered for exploring additional features and co-relation using the machine learning model.
- Programming language learning orders such as C to Python, C to C++, and other orders can be explored by comprehensive data analysis.
- Language can be recommended for specific problems as shown in Figure 5. A certain amount of problems, users, and their submission logs can be taken into account. In that case, users' used programming languages for accepted solutions can be considered. After that problems and language pairing can be done. Collaborative, Content-based, and Hybrid Filtering methods can be used finally for the programming languages recommendation.

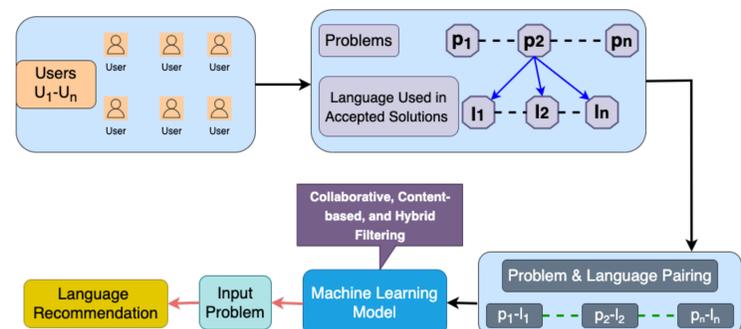


Figure 5: Future work

The preliminary results and analysis of this study can be a good basis for the future research scope to determine the language learning order and language recommendations for the specific problems.

## References

- [1] Aizu Online Judge: Developers Site (API), Dec. 2019, [online] Available: <http://developers.u-aizu.ac.jp/index>
- [2] Y. Watanobe, Aizu Online Judge, May 2020, [online] Available: <https://onlinejudge.u-aizu.ac.jp>
- [3] Machines (IBM): Project CodeNet, 2021, [online] Available: <https://github.com/IBM/Project-CodeNet>