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MANAGING ONLINE PROGRAMMING LAB USING CODEZINGER

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Abstract

Introductory programming is a basic course compulsory for students majoring in computer studies. This course is considered a difficult course to learn since time immemorial. Starting from 2020, measures taken by the Malaysian government in dealing with the COVID-19 pandemic has resulted in the educational institutions to be closed to students and face-to-face lessons replaced with online classes. Therefore, the process of learning programming becomes increasingly difficult since the instructors are unable to have face-to-face interaction with neither their local nor their international students during online classes. This paper aims to implement CodeZinger, used as an initiative to replace physical laboratory classes, and is used in monitoring the students' achievement. In this study, the application of CodeZinger was made on two programming courses involving 266 students of Year 1, namely students taking the Computer Programming course (semester 1), and Data Structure course (semester 2). The diverse test data provided by the instructors made the students more skilful and critical in doing programming, and easier for students due to the automatic assessment function provided in CodeZinger. This study's findings greatly influence students' motivation in learning programming, considering that CodeZinger allows prompt feedback and automatic assessment. Moreover, for the instructors' view of point, CodeZinger allows instructors to manage and identify students who need extra assistance in programming. In conclusion, CodeZinger assisted the students in optimizing the management of learning programming where CodeZinger provides the solution for problems and obstacles in face-to-face learning, facilitated the students in learning at their own pace, and facilitated the instructors in monitoring the students' tasks.

Keywords: Automatic assessment; CodeZinger; COVID-19 Pandemic; online programming lab; programming learning

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Abstrak

Pengenalan Pengaturcaraan adalah kursus asas yang mesti diambil oleh pelajar jurusan komputer. Kursus ini dianggap sebagai kursus yang sukar untuk dipelajari sejak dari dulu lagi. Mulai tahun 2020, pandemik COVID-19 menyebabkan Institusi Pendidikan Tinggi (IPT) ditutup kepada pelajar. Proses pembelajaran pengaturcaraan menjadi semakin sukar kerana tenaga pengajar berada jauh dari pelajar yang berada di dalam dan luar negara. Oleh itu, objektif kajian ini adalah implimentasi CodeZinger digunakan sebagai inisiatif untuk menggantikan kelas makmal yang sebelumnya diadakan secara bersemuka dan melihat pencapaian pelajar dengan menggunakan CodeZinger. Kajian ini melibatkan seramai 266 pelajar Tahun Satu yang mengikuti kursus Pengaturcaraan Komputer (semester 1) dan Struktur Data (Semester 2). Input output yang pelbagai yang diberikan oleh pengajar menjadikan mereka lebih mahir dan kritikal dalam melakukan pengaturcaraan kerana terdapatnya semakan automatik dalam CodeZinger. Kajian ini mendapati CodeZinger mempengaruhi motivasi pelajar dalam pembelajaran Pengaturcaraan, memandangkan perisian tersebut memberi maklum balas segera dan penilaian automatik kepada pelajar. Manakala, dari sudut pandangan pengajar, CodeZinger membenarkan pengajar mengurus dan mengenal pasti pelajar yang memerlukan bantuan tambahan dalam pengaturcaraan. Kesimpulannya, CodeZinger membantu pelajar dalam mengoptimumkan pengurusan pembelajaran pengaturcaraan di mana CodeZinger dapat menyelesaikan masalah pembelajaran secara bersemuka, memudahkan pelajar belajar mengikut rentak mereka, dan juga memudahkan pengajar memantau pelajar.

Kata kunci: Penilaian automatic; CodeZinger; Pandemik COVID-19; makmal pengaturcaraan dalam talian; pembelajaran pengaturcaraan

1.0 INTRODUCTION

Introductory programming is a basic course that is compulsory for students majoring in computer studies. This course is considered a difficult course to learn since time immemorial (Rahmat et al. 2012; Cheah 2020). The global COVID-19 pandemic has caused face-to-face teaching activities in many countries to be halted. The process of learning programming becomes increasingly difficult since the instructors are not able to have face-to-face interaction with both their local and international students. This has resulted in a high failure rate in Introductory Programming courses conducted by various universities (Dhayanithi et al. 2021). Prior to the COVID-19 pandemic, the students' learning outcome in programming courses was measured through quizzes, tutorial assignments, laboratory assignments, projects, laboratory

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tests and MCQ examinations. However, several restrictions due to the COVID-19 pandemic has resulted in the assessment of students' performance to be more focused on continuous assessment that consist of laboratory assignments, projects, and laboratory tests. This type of assessment is quite burdensome for the instructors because of the need to respond immediately to students' assignments. Teaching programming is a difficult and challenging task, requiring close follow-up and continuous and meaningful feedback (Cardoso et al. 2021). Without support tools, it is not easy to perform this task because there are hundreds of students, and each topic has many practicals and assignments questions which are done individually. It is the nature of programming skills that require a lot of exercises. However, the use of support tools that are available online, such as Virtual Programming Labs (VPLs), CodeZinger, CourseMaster and others can help to ease in the evaluating their students' assessments, apart from helping the students in their learning process.

This paper is divided into five sections. The following section overview some related tools. The third part is about the results of using CodeZinger from students and instructors' viewpoints, and the advantages of using CodeZinger. Finally, the last section discusses future research.

2.0 RELATED WORK

2.1 Virtual Programming Lab (VPL)

One of the latest teaching and learning methods is VPL. VPL is one of Information and Communication Technologies (ICT) that has become an important teaching and learning tool. The greatest impact of technology nowadays is to allow for instantaneous communication. Previous research has also predicted that new applications will be adopted in most universities in the future, especially when communicating digitally in online learning (Hannay & Fretwell 2011; Abd Rahman et al. 2016). Since the start of the COVID-19 pandemic, most higher education institutions have shifted to online learning. Although the concept of distance learning is not new since the television has been used for decades for educational purposes, yet computers, smart phones and the internet have completely changed the paradigm; they have enabled for distance classes to be conducted alongside the interaction between the teachers and students, communicating in a synchronous or asynchronous way (Cardoso et al. 2017). VPL is an open-source software product, which a Moodle plugin that allows students to submit their coding answers and get prompt feedback without the teacher's intervention (Cardoso et al. 2021). VPL allows programs to be edited and executed in a wide range of languages, and enables for automatic assessment and prompt feedback to be made. VPL stores historic results regarding the compilation and implementation of the proposed problems and keep

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track of the students' submissions (Cardoso et al. 2018). According to Ramos et al. (2021), lecturers consider VPL as an interesting tool for teaching programming, however the VPL interface is not easy to use.

2.2 PC^2

PC^2 is a Programming Contest Control System developed by the California State University, Sacramento (CSUS) in support of the Computer Programming Contest activities, and in particular the International Collegiate Programming Contest (ICPC) and its Local and Regional Contests around the world (California State University 2021). The objective of PC^2 is for the purpose of contests, therefore some features are not suitable to be used for non-face-to-face programming class. Students are not able to see the errors they have made when submitting their laboratory assignment answers to PC^2. They are also unable to fix the program errors that have been submitted. The use of PC^2 is appropriate if the learning environment involves face-to-face interaction.

2.3 CourseMaster

CourseMaster is a flexible, secure and user-friendly system developed at the University of Nottingham (Foxley et al. 2001). CourseMaster is a courseware system that supports the automatic assessment of students' work. CourseMaster consists of a group of materials from which students can learn, and a delivery mechanism to prepare these materials and administer the implementation of the course. CourseMaster can mark several types of coursework in a non-trivial way. That is, the criteria can be set for work that is assessed as a whole. In particular, this system is perfect for marking computer programs in several languages, including Java and C++. It can also mark diagrams and help mark essays. Multiple choice question markings are also supported. In addition to marking, the system also supports the preparation of lecture notes, and websites and links. It can be used to gather any online work and enforce deadlines. Finally, it provides a suite of web-based tools that allow easy course management.

2.4 CodeRoom

CodeRoom was developed to create and integrate a competitive programming learning environment (Mohamad Zulkufli & Abu Bakar 2018). The CodeRoom system is a web-based learning system to facilitate the teaching and learning process of programming in a classroom developed by final year students of UKM. CodeRoom has an automated assessment that runs the source code submitted by the students, and assigns marks automatically. The system allows students primarily to answer and solve programming problems continuously without

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requiring them to be together or ask the instructors to get marks or find out whether the written answer is correct or incorrect. The instructors are also not required to download and run the program of each student and assign marks manually. However, CodeRoom is not used since no maintenance is made for its use in UKM.

2.5 CodeZinger

CodeZinger is a cloud-based coding laboratory for computer science programming course with ready problem library, auto grading, and online editor, which gets rolling in minutes. CodeZinger provides a platform for the delivery of practical engagement in foundational programming classes to the students. The instructors can leverage the CodeZinger library of ready-to-use coding problems in their classrooms, or assign homework (CodeZinger, 2017). Equipped with an editor, the students can answer the laboratory assignments at their own convenience. Once they have answered the laboratory assignment, the students can run their programs and the auto grading will take place. If their programs contain any errors, they can identify the errors and continue fixing them. They can then submit the assignment once their programs contain no more errors. The automatic assessment in CodeZinger makes it as a must-use by students to overcome the problems caused by the COVID-19 pandemic.

The automatic assessment provided in CodeZinger does not only benefit the students, but also the instructors. Monitoring and evaluating students' programming assignments are difficult. Furthermore, the closure of the university campus makes it difficult for the instructors to monitor the programming that the students have made. However, by using CodeZinger, students' assignment answers are auto graded by CodeZinger, and the assignments can additionally be checked for plagiarism. The instructors can quickly identify students who require additional attention, as well as concepts that may not be well understood by their class based on their students' performance in the coding exercises (CodeZinger, 2017). A common teaching method practised prior to the COVID-19 pandemic was to have the students and instructors in the same laboratory where the students would create a program in the eclipse software and later submit it using the PC^2 software. However, by using CodeZinger, the students can directly create a program in it, run the program, identify the errors, fix the errors and re-submit their coding answers.

The current features in CodeZinger provide a solution to the problems faced by students undertaking programming courses, especially in the current state of COVID-19 pandemic. CodeZinger also has a great maintenance team that is suitable for flexibility in a variety of conditions and requirements. Therefore, the objective of this study is to demonstrate the implementation of CodeZinger to the students in optimizing the management of

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programming classes, and in looking at students' achievement through the use of CodeZinger. These programming tools available have been compared as illustrated in Table 1.

Table 1. Comparison of Programming Tools

Characteristics	VPL	PC^2	CourseMaster	CodeRoom	CodeZinger
Various programming languages	Yes	Limited	Yes	Limited	Yes
Auto assessment	Yes	No	Yes	Yes	Yes
Suitable for online learning?	Yes	No	Yes	Yes	Yes
Suitable for offline learning?	Yes	No	Yes	Yes	Yes
Error detection?	No	No	No	No	Yes
Plagiarism checker	Yes	No	No	No	Yes
Questions Bank	No	Yes	Yes	No	Yes

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3.0 MATERIALS AND METHODS

There are two types of CodeZinger users, which are the students, and the instructors. When logging in as a student, it provides functions such as laboratory practice, laboratory assignments, online examination, and student information. However, when logging in as an instructor, it provides functions such as question release, test data setting, question setting, student progress, similarity detection result, and student's achievement. Figure 1 shows the diagram of the core business among the different roles.

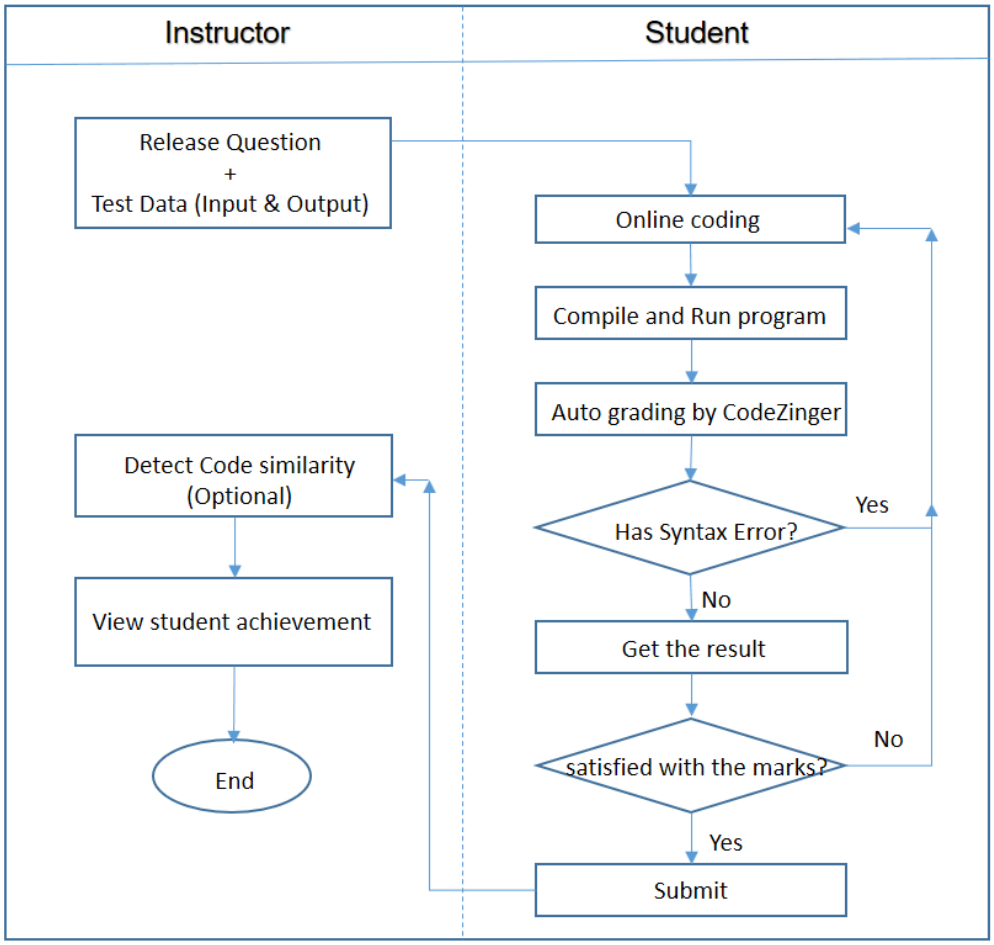

Figure 1. The activities by type of role in CodeZinger

Each question is arranged according to the topic or week. There are 12 topics constructed, including two topics related to the intermediate and final exams. This is to make it easier for the students to access the questions. Figure 2 shows the topics that have been created for the Computer Programming course (semester 1).

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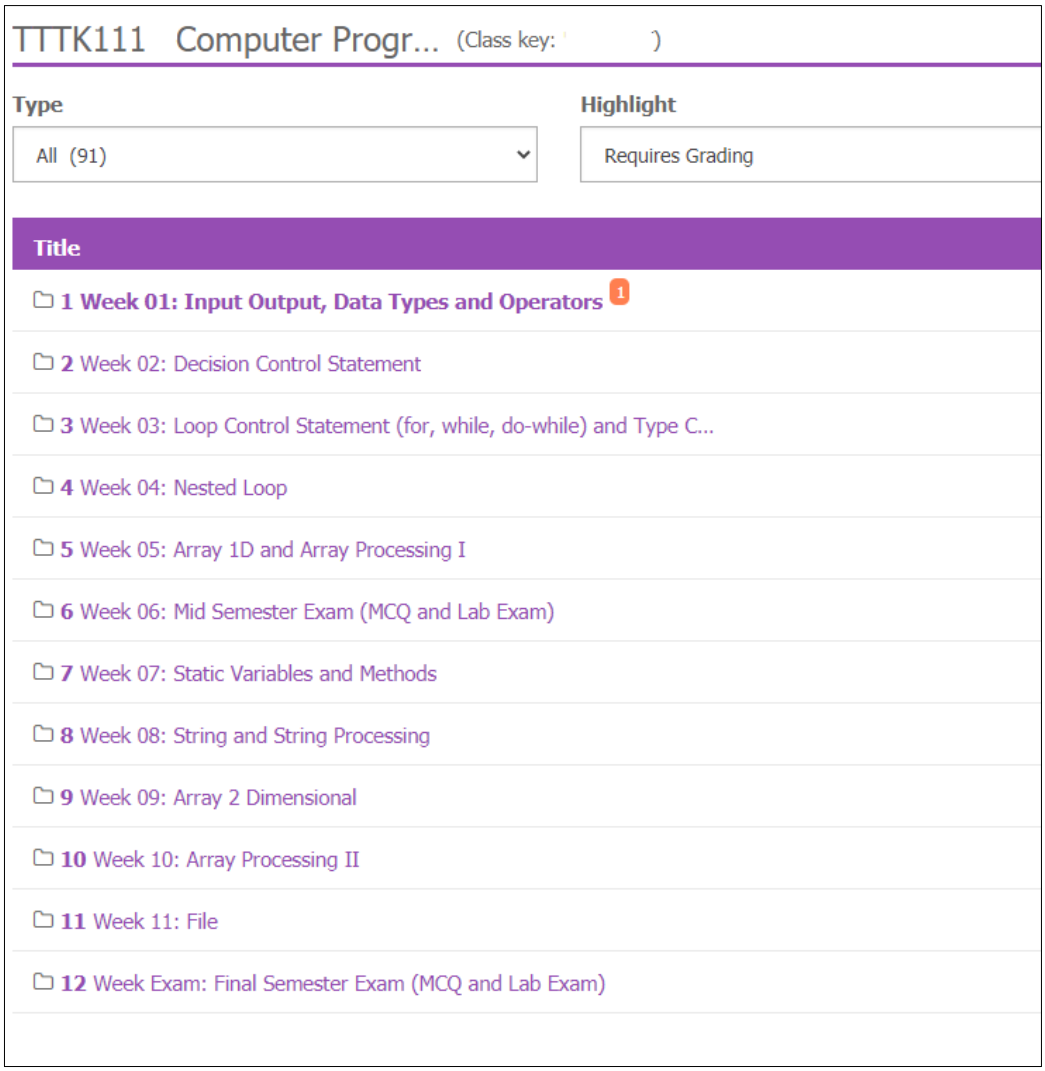

Figure 2. The course topics for Computer Programming course

For both of these courses, namely the Computer Programming (semester 1), and Data Structure (semester 2), the instructors have set two categories of questions; practical and assignment. Two assignment questions were constructed for each topic as opposed to practical questions depending on the sample questions. Practical questions are the questions that students have the option to either answer or not answer. However, assignment questions are mandatory to be answered within the allotted time. Practical questions are given to help students answer assignment questions that are more problem solving in nature compared to practical questions that are direct. Besides that, a skeleton is given in the practical questions to help the students answer the questions. Therefore, even without an instructor, the students are assisted in a self-directed approach. Figure 3 shows the categories and characteristics for each question. Figure 4 shows the icons displayed on each question, either 'P' or 'A' that indicates whether it is practical or assignment.

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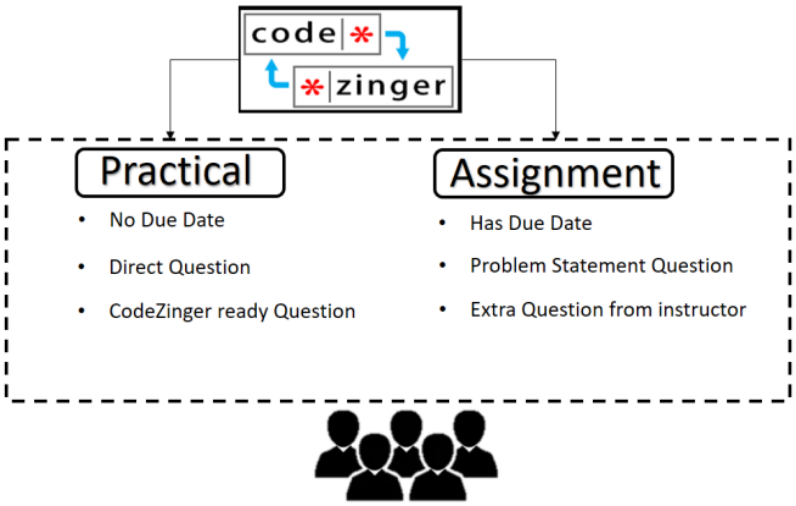

Figure 3. The categories of question in CodeZinger

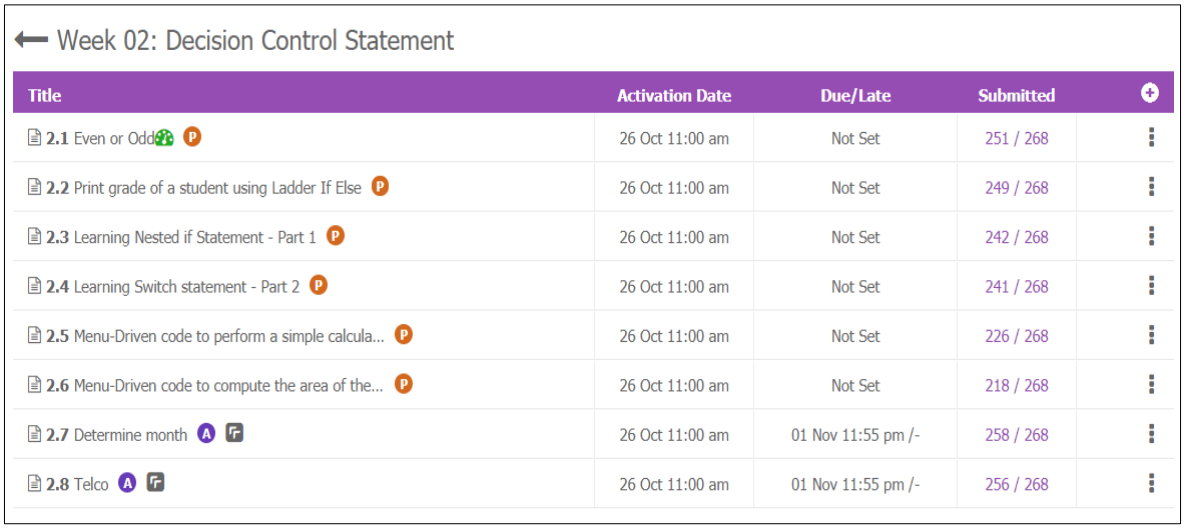

Figure 4. Questions in topic Week 2 for Computer Programming course

3.1 CodeZinger Student's View

When the students log into CodeZinger, they will be able to see the questions that need to be answered. They are required to click the start button to answer the questions. An editor such as shown in Figure 5 will be displayed. The students can continue typing in the editor space. Once completed, they need to click on the "Run All" button to see whether the program entered earlier contains a syntax error. As shown in Figure 6, if no syntax errors are found in the programs, auto-grading will take place. The students can view the marks that have been earned. If all the test data provided are correct, they can then continue to submit the assignment.

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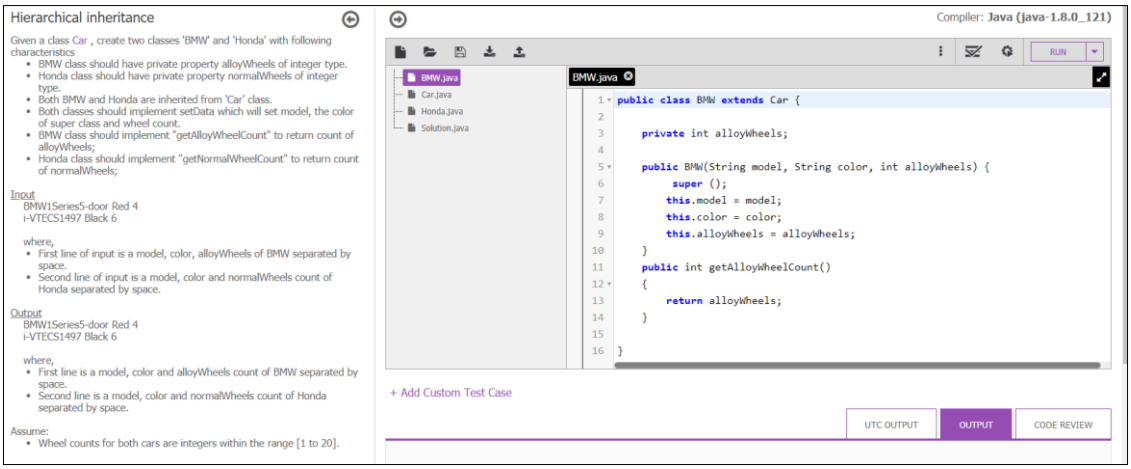

Figure 5. An editor in CodeZinger

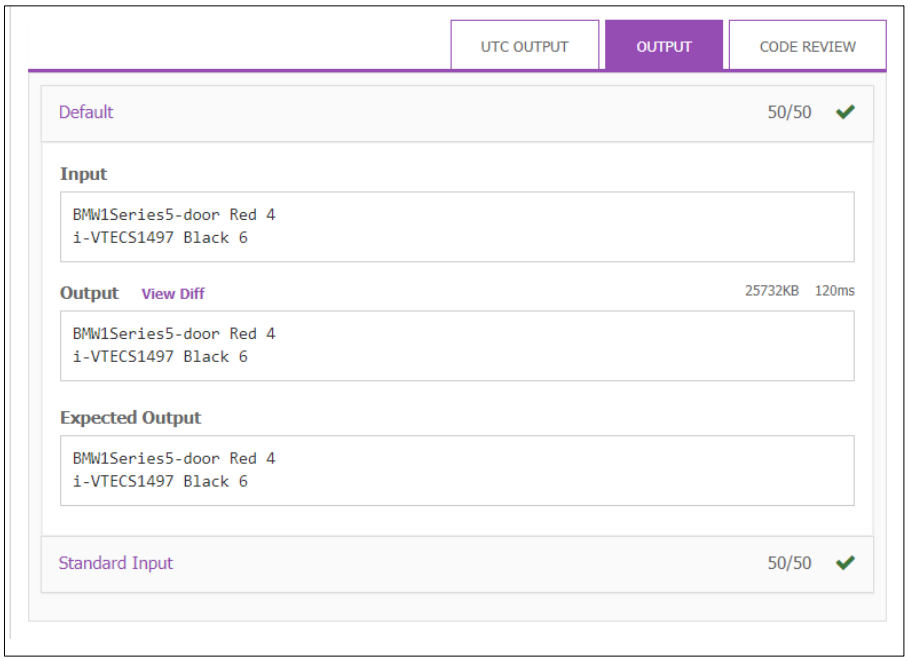

Figure 6. Auto grading takes place

3.2 CodeZinger Instructor's View

When the instructors log into CodeZinger, they will be able to create questions. Figure 7 shows that there are many questions already provided in CodeZinger for the instructors to choose from. However, in preparing the questions for the Computer Programming (semester 1), and the Data Structure (semester 2) courses, the questions provided in CodeZinger were only used as practical questions. Meanwhile, for the assignment questions, the instructors created their own questions in the form of a problem statement. Then, some test data were entered to ensure that the programs created by the students were correct, especially the equations from which will consider all the factors shown in Figure 8 and Figure 9.

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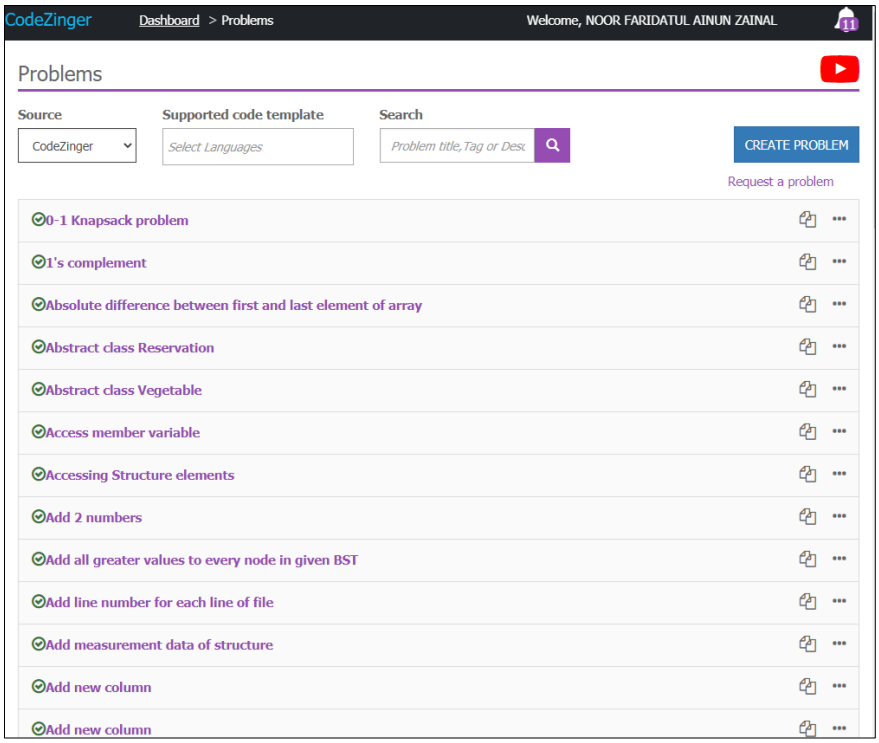

Figure 7. Questions provided in CodeZinger

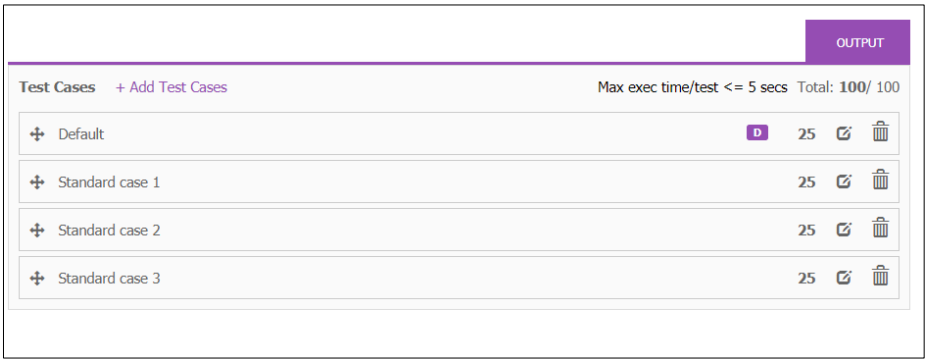

Figure 8. Several test data for each question

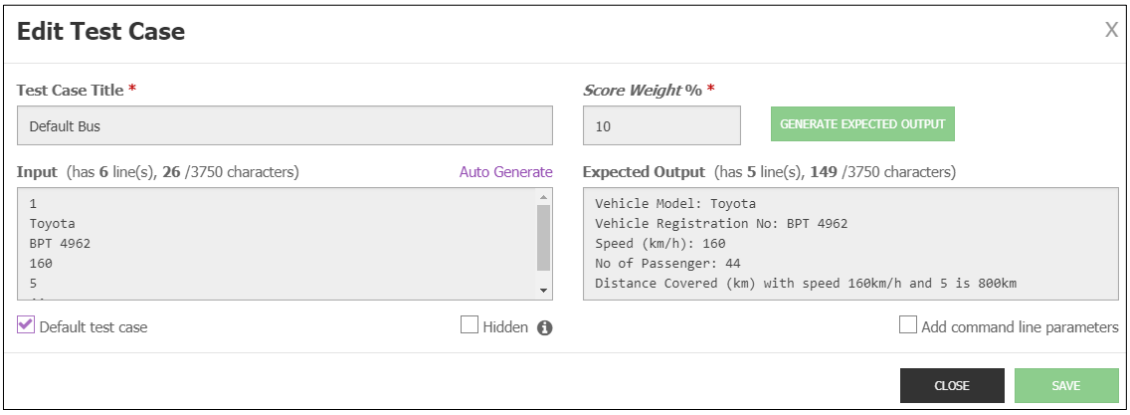

Figure 9. Input Output for each test data

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4.0 RESULTS AND DISCUSSION

The use of CodeZinger assists the students in managing their programming lessons in an orderly and systematic manner as shown in Figure 10. Each student can view all the assignments that they have submitted. The practical questions provided help students to understand the topics, and indirectly serve as a guide for them in answering the assignment questions. The log activity of all assignments can also be viewed by the students, except for the laboratory test questions, where they are not able to view the marks obtained as shown in Figure 11. CodeZinger does not only assist the students in creating programs, but also assists them in managing the tasks to be performed.

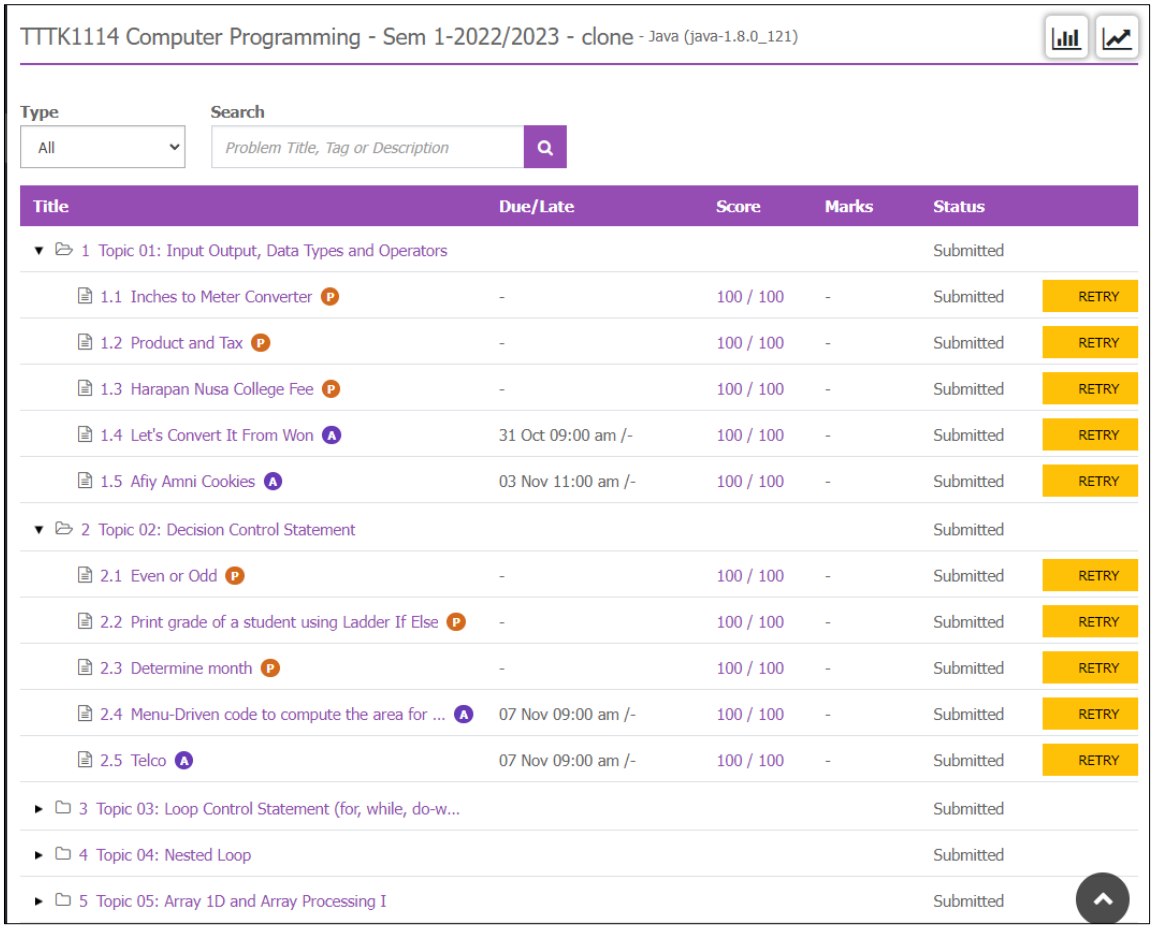

Figure 10. The student's view - submitted assignments

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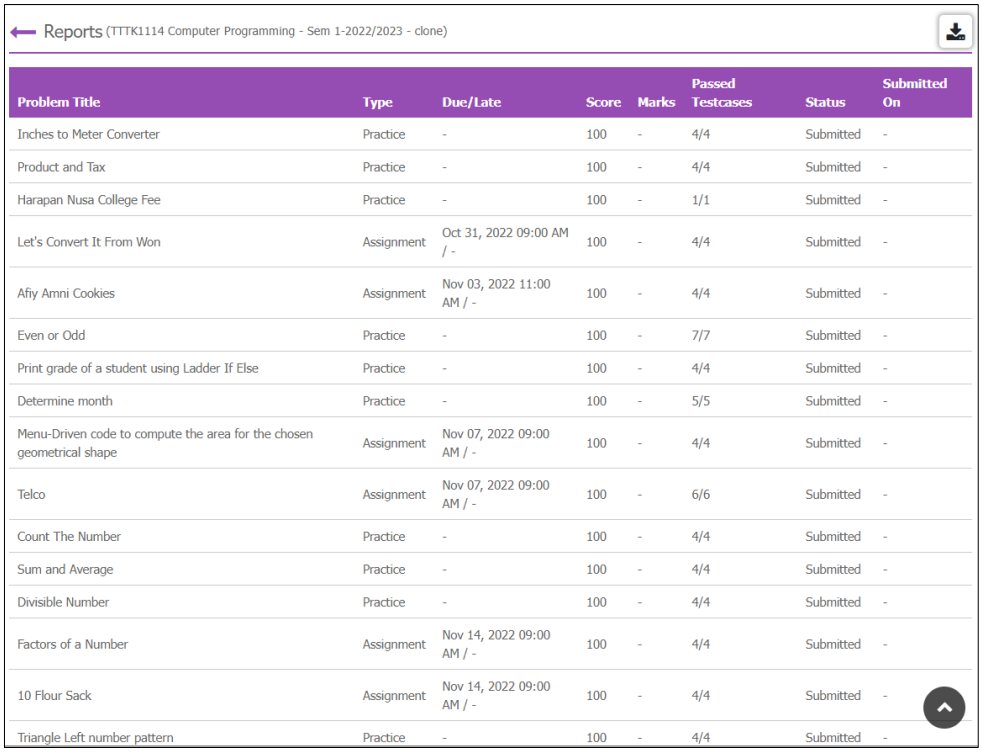
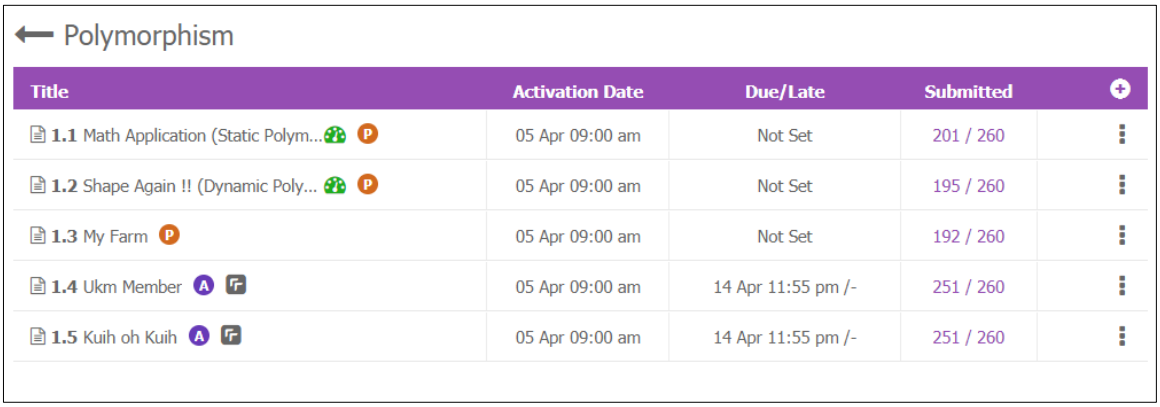


Reports (TTTK1114 Computer Programming - Sem 1-2022/2023 - clone)

Problem Title	Type	Due/Late	Score	Marks	Passed Testcases	Status	Submitted On
Inches to Meter Converter	Practice	-	100	-	4/4	Submitted	-
Product and Tax	Practice	-	100	-	4/4	Submitted	-
Harapan Nusa College Fee	Practice	-	100	-	1/1	Submitted	-
Let's Convert It From Won	Assignment	Oct 31, 2022 09:00 AM / -	100	-	4/4	Submitted	-
Afiy Amni Cookies	Assignment	Nov 03, 2022 11:00 AM / -	100	-	4/4	Submitted	-
Even or Odd	Practice	-	100	-	7/7	Submitted	-
Print grade of a student using Ladder If Else	Practice	-	100	-	4/4	Submitted	-
Determine month	Practice	-	100	-	5/5	Submitted	-
Menu-Driven code to compute the area for the chosen geometrical shape	Assignment	Nov 07, 2022 09:00 AM / -	100	-	4/4	Submitted	-
Telco	Assignment	Nov 07, 2022 09:00 AM / -	100	-	6/6	Submitted	-
Count The Number	Practice	-	100	-	4/4	Submitted	-
Sum and Average	Practice	-	100	-	4/4	Submitted	-
Divisible Number	Practice	-	100	-	4/4	Submitted	-
Factors of a Number	Assignment	Nov 14, 2022 09:00 AM / -	100	-	4/4	Submitted	-
10 Flour Sack	Assignment	Nov 14, 2022 09:00 AM / -	100	-	4/4	Submitted	-
Triangle Left number pattern	Practice	-	100	-	4/4	Submitted	-

Figure 11. Student's log activities

Figure 12 shows that an instructor is able to identify the number of students who have answered each question in CodeZinger. This demonstrates that CodeZinger assists the instructors in monitoring problematic students, who have not answered the assignments given. The instructors can also access the students' achievement report for each assignment as shown in Figure 13. The red cell indicates the student who has answered but could not obtain any score. This indicates whether the student's program was incorrect, or the submitted program did not meet all the required test data. Compared to the yellow cell, it shows that the student's program has only met some test data.



Polymorphism

Title	Activation Date	Due/Late	Submitted
1.1 Math Application (Static Polym...	05 Apr 09:00 am	Not Set	201 / 260
1.2 Shape Again !! (Dynamic Poly...	05 Apr 09:00 am	Not Set	195 / 260
1.3 My Farm	05 Apr 09:00 am	Not Set	192 / 260
1.4 Ukm Member	05 Apr 09:00 am	14 Apr 11:55 pm /-	251 / 260
1.5 Kuih oh Kuih	05 Apr 09:00 am	14 Apr 11:55 pm /-	251 / 260

Figure 12. The number of submitted solutions

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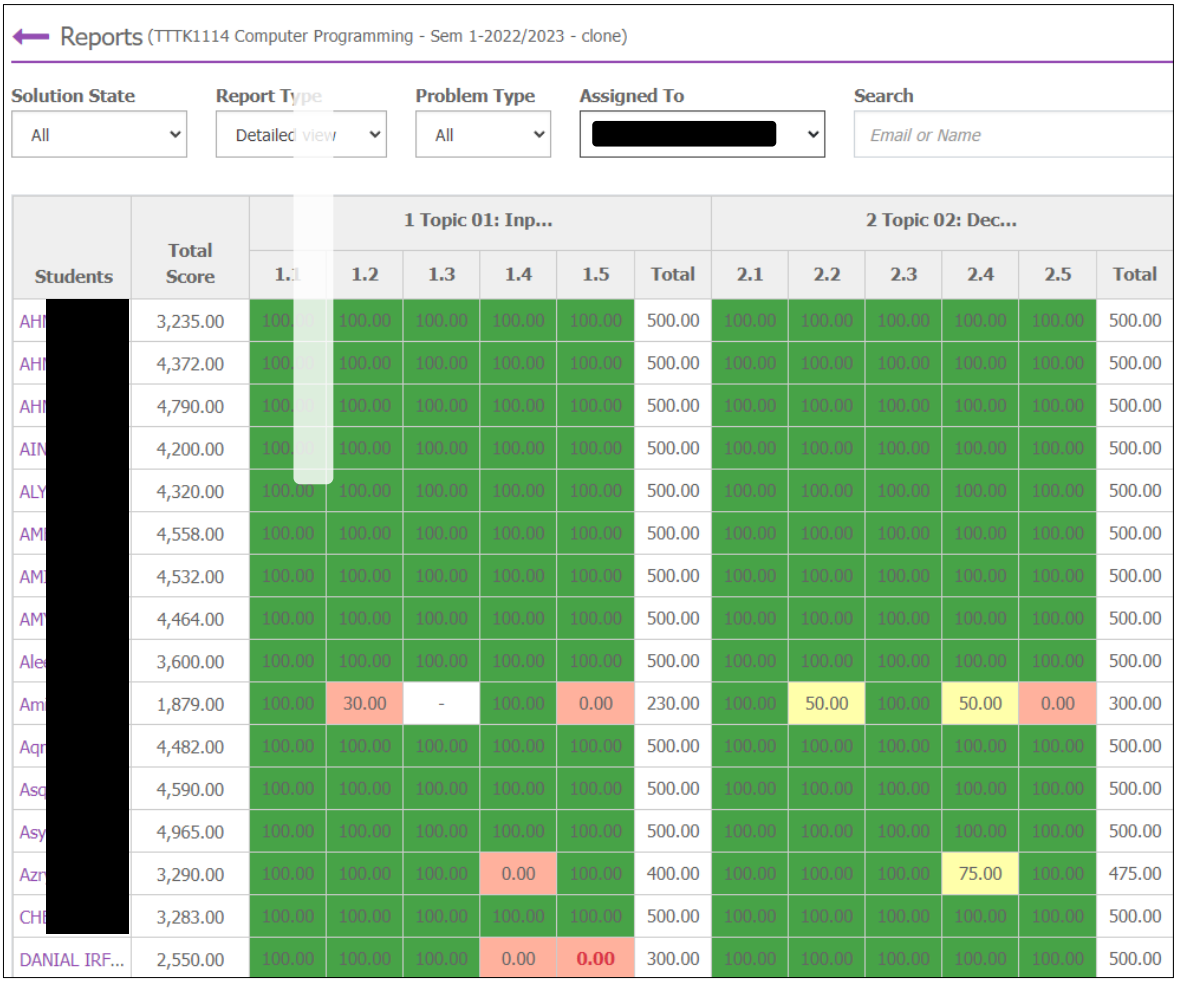

Reports (TTTK1114 Computer Programming - Sem 1-2022/2023 - clone)

Solution State: All | Report Type: Detailed view | Problem Type: All | Assigned To: [redacted] | Search: Email or Name

Students	Total Score	1 Topic 01: Inp...						2 Topic 02: Dec...					
		1.1	1.2	1.3	1.4	1.5	Total	2.1	2.2	2.3	2.4	2.5	Total
AHI[redacted]	3,235.00	100.00	100.00	100.00	100.00	100.00	500.00	100.00	100.00	100.00	100.00	100.00	500.00
AHI[redacted]	4,372.00	100.00	100.00	100.00	100.00	100.00	500.00	100.00	100.00	100.00	100.00	100.00	500.00
AHI[redacted]	4,790.00	100.00	100.00	100.00	100.00	100.00	500.00	100.00	100.00	100.00	100.00	100.00	500.00
AIN[redacted]	4,200.00	100.00	100.00	100.00	100.00	100.00	500.00	100.00	100.00	100.00	100.00	100.00	500.00
ALY[redacted]	4,320.00	100.00	100.00	100.00	100.00	100.00	500.00	100.00	100.00	100.00	100.00	100.00	500.00
AMI[redacted]	4,558.00	100.00	100.00	100.00	100.00	100.00	500.00	100.00	100.00	100.00	100.00	100.00	500.00
AMI[redacted]	4,532.00	100.00	100.00	100.00	100.00	100.00	500.00	100.00	100.00	100.00	100.00	100.00	500.00
AMY[redacted]	4,464.00	100.00	100.00	100.00	100.00	100.00	500.00	100.00	100.00	100.00	100.00	100.00	500.00
Ale[redacted]	3,600.00	100.00	100.00	100.00	100.00	100.00	500.00	100.00	100.00	100.00	100.00	100.00	500.00
Ami[redacted]	1,879.00	100.00	30.00	-	100.00	0.00	230.00	100.00	50.00	100.00	50.00	0.00	300.00
Aqr[redacted]	4,482.00	100.00	100.00	100.00	100.00	100.00	500.00	100.00	100.00	100.00	100.00	100.00	500.00
Asq[redacted]	4,590.00	100.00	100.00	100.00	100.00	100.00	500.00	100.00	100.00	100.00	100.00	100.00	500.00
Asy[redacted]	4,965.00	100.00	100.00	100.00	100.00	100.00	500.00	100.00	100.00	100.00	100.00	100.00	500.00
Azr[redacted]	3,290.00	100.00	100.00	100.00	0.00	100.00	400.00	100.00	100.00	100.00	75.00	100.00	475.00
CHI[redacted]	3,283.00	100.00	100.00	100.00	100.00	100.00	500.00	100.00	100.00	100.00	100.00	100.00	500.00
DANIAL IRF...	2,550.00	100.00	100.00	100.00	0.00	0.00	300.00	100.00	100.00	100.00	100.00	100.00	500.00

Figure 13. Students' achievement for each question

CodeZinger is helpful to both students and instructors in terms of managing their programming lesson. Non-face-to-face programming learning using CodeZinger is not interrupted even due to the COVID-19 pandemic. CodeZinger enables both students and instructors to manage their respective roles well. However, CodeZinger developers need to enhance some elements in the software, among them are to overcome the problems of the students' submission of their solutions, and auto grading when there is a simultaneous submission involving 266 students that results in a time delay in the automatic assessment process. Since this is the first time the application of CodeZinger was made, the instructors maintained their communication with the person in charge of CodeZinger for better performance.

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5.0 CONCLUSION

The implementation of CodeZinger in the teaching and learning process of computer programming course can solve problems such as the lack of face-to-face interaction and minimal supervision from the instructors due to COVID-19 restrictions. It also provides advantages such as easy monitoring of students' assignments, easy monitoring of problematic students, and the provision of automatic assessments. Although the initial objective for the implementation of CodeZinger was as an alternative in solving teaching and learning problems due to COVID-19 pandemic restrictions, yet it is also very suitable to be used in face-to-face classes. Therefore, studies on CodeZinger's acceptance need to be conducted in the future to further improve these online learning activities.

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