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ENHANCING THE PROJECT BASED LEARNING IN C++ PROJECT OF PROGRAMMING IN MATHEMATICS COURSE FOR DIPLOMA STUDENTS

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ABSTRACT

A C++ programming project is one of the assessment tools applied in Programming in Mathematics course, offered for Diploma students of Sultan Idris Education University. As the programming coursesare considered to be difficult and less interested among studentsof pre-university and university levels, effective and suitable ways of teaching and learning are implemented to improve students' interest on the course. Project based learning (PjBL) is an instructional model that involves students to participate actively in the project development, and hence increases the students' understanding about the knowledge related to the project. This study focuses on the enhancement of the PjBL in the C++ project of Programming in Mathematics course. Details on the PjBL stages, PjBL assessments and students' achievement of the C++ project are presented in this study. Based on this study, we aim to identify the improvement that can be done to improve the enhancement of the PjBL and therefore to increase students' interest on programming language courses.

INTRODUCTION

Courses related to programming languages are considered as toughest and difficult courses for students of pre-university and university levels [1]. The students who are beginner programmers assumed programming is challenging, due to their incompetence to learn the programming course [3]. They are struggled to understand the programming, which usually lead to frustration and eventually not performed well [12, 13]. Due to this, teaching and learning

methods which are interesting, involving hands-on activities and capable of improved students' interest on this type of courses are usually implemented in teaching and assessment processes [10, 11].

Project based learning (PjBL) is one of the considered methods [2]. The PjBL allows the students to engage actively in the project development, and hence allows the students to learn a deeper level of knowledge related to the project [4, 8]. Nowadays, the PjBL is implemented in schools, pre-university and university courses [7, 9, 14]. The PjBL encourages students' involvement and achievement in the learning process and obtain better knowledge and new skills [10]. Some of the skills that students developed through the PjBL are group work interaction, independent learning, leadership, task distribution and time management.

Programming languages such as C, C++, MATLAB, Maple, Mathematica and FORTRAN are usually related to the Mathematics students and introduced especially for computational and applied mathematics areas [5]. Besides, a course project is an important assessment with high marks allocation for programming language courses [4]. This kind of project allows learning process and is usually connected to the PjBL. In this study, we mainly focus on the enhancement of the PjBL in the C++ project of Programming in Mathematics course for Diploma students in Sultan Idris (UPSI). Based on this study, we want to identify the improvement that can be done to improve the enhancement of the PjBL and therefore to improve students' interest on programming language courses.

The C++ project required students to implement their prior knowledge about mathematics concepts and basics of C++ programming language.The basics of the C++ are introduced to the students during the first 7 weeks of the semester. The C++ includes not only a high level programming features such as object-orientation paradigms and generic programming, but also low-level programming features, such as bit-wise and device I/O control abilities [15].

This paper is organized as follows. Section 2 includes the information about the Programming in Mathematics course offered for Mathematics students of Diploma program in UPSI. Section 3 is dedicated on details of the C++ project,the PjBL stages and assessments implemented in the C++ project. Then, examples of the C++ project and students' achievement on the project are presented in Section 4. The conclusion and suggestion are stated in Section 5.

PROGRAMMING IN MATHEMATICS COURSE

The Programming in Mathematics course is part of the core courses for Diploma of Science (Mathematics) in UPSI. In this course, students are introduced to the C++ programming language, especially on computational and applied mathematics. The topics and assessments of this course are organized to be completed in 14 weeks of the semester. Table 1 shows the topics of C++ programming language introduced to the Diploma students of

UPSI in one semester. The assessments are conducted based on the individual and group assessments, including the C++ project.

Table 1: Programming in Mathematics course for Diploma students

Week	Topic	Assessment
Week 1 – Week 7	Introduction to Programming Basic Programming Loops Branching Arrays and its Applications Input Output (I/O) Files User-Defined Functions	Quizzes, individual and grouping assignments are scheduled within this period.
Week 8 – Week 14	Project Based Learning in C++ Project	C++ Projects
		Presentation / Evaluation of C++ Projects Writing Test

In general, the course outline for the first 7 weeks of semester includes the C++ compilers and an introduction of basics knowledge in C++. The software used in this course is Microsoft Visual C++ Express 2010. The introduction of the C++ covers the basics of the C++ programming, built-in functions, looping, branching, arrays, input and output files and user-defined functions. Within the first 7 weeks, it is expected that the students are able to write a C++ program for a given mathematical problem. For the remaining 7 weeks of this course, the teaching and learning focus on the development of the C++ project, which is based on the PjBL learning style. Throughout the semester, the students are exposed to various example of C++ codes, in order to strengthen their understanding and to increase their confidence in writing a C++ program, especially on mathematical problems.

THE PjBL IN C++ PROJECT

The project based learning (PjBL) is an instructional model that involves students in investigations of compelling problems that culminate in authentic products [6]. Projects which encouraged stronger classroom learning opportunities are widely varied in terms of subject and scope, and also delivered at different grade levels. The projects nurtured out challenging questions and therefore put the students in an active role such as problem solvers, decision makers, investigators, or documentarians.

By exposing the students with hands-on activities, such as writing a C++ program for a given mathematical problems, it helps them to relate the programming to the real-life scenarios. It gives them an idea about how programs can be used outside classroom in the real world. The C++ projectis designed with the aim to garner the student's interest. The detailed project requirements and instructions would not be listed as these are unique for every

given project. These requirements and instructions aim to help students in completing the project, especially on preparing the C++ programming.

PjBL Procedures

Based on [4], the PjBL consists of 4 general elements, which are group tasks, priority on student's centered learning, incorporate technology in the project making process and presentation of project final product. For this C++ project, the PjBL elements are implemented through the 6 stages, as shown in Figure 1.

Firstly, students are introduced about the PjBL and the C++ project, such as the topics, requirements, references, and suggested timeline of the project development. The C++ project is a group work of 3 to 6 students per group, in which the members of the group are decided by the students. The themes, rules and requirements of the project are also briefed to all students to ensure they achieved the objectives of the project.

Secondly, each group are required to present their reviewed references and draft of C++ program for the project after two weeks of preparation. Two slots of 15 to 30 minutes per group are allocated for the students to discuss their findings to the lecturer. At this stage, students are assessed individually, in order to ensure all group members of the project play their roles correctly.

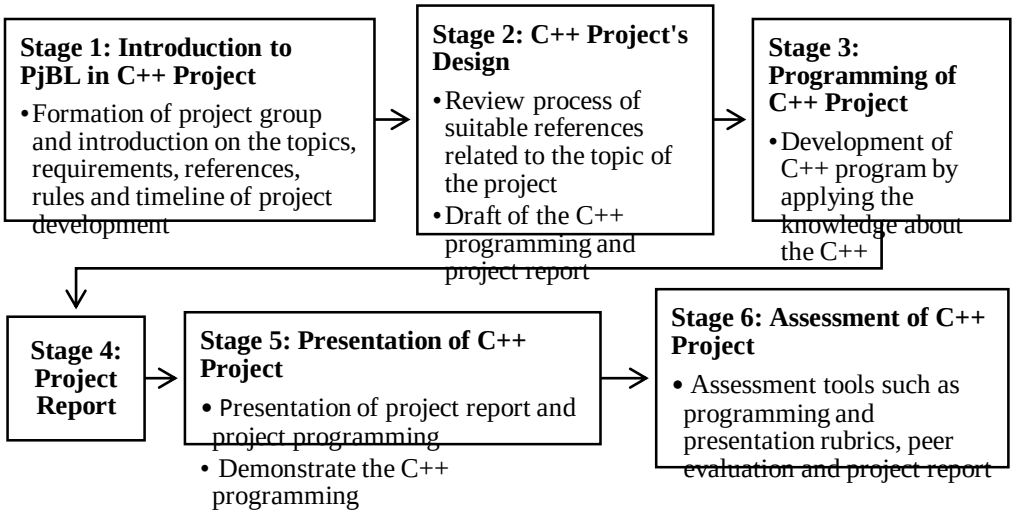

Figure 1: PjBL procedure in development of the C++ project

The third and fourth steps are mainly on the development of C++ program and preparing the project report. Some of the requirements for the project report are:

- Introduction of the project theme
- C++ elements implemented in the project
- Development process of the C++ program
- Advantages and disadvantages of the developed C++ program
- Conclusion / Difficulties / Challenges

- C++ program

Students are reminded to crosscheck the rules and requirements of the projects while preparing their C++ program and the project report. In Week 14, all project groups are gathered to present their final products. At this stage, the audience is not limited to the students of C++ course only, but to all interested students and lecturers. The last step of the PjBL for this C++ project is about the assessment of this project.

PJBL assessments

Tasks of the C++ project are arranged and divided by the students based on their group project discussions.This is an important part of learning how to program, in which the students learnt how to translate a problem into smaller pieces, followed by combining all the pieces to form the group final product.Assessment tools such as quizzes, tests, assignments and projects are part of the tools used for courses in pre-university and university. In general, the assessments of the C++ project considered 3 dimensions, which are the student, peer and lecturer. Therefore, it is expecteda comprehensive and well-balanced assessment of the project. Table 2 shows the assessment tools based on the stages of the PjBL for this project.

Table 2: Assessment tools based on the stages of PjBL procedures in C++ project

Stage	**C++ project assessment tools**				
	Individual Progress Report	Group Progress Report	Rubrics	Peer Assessment	Self-Assessment
Stage 1: Introduction to PjBL in C++ Project		✓			✓
Stage 2: C++ Project's Design	✓				✓
Stage 3: Programming of C++ Project		✓	✓	✓	✓
Stage 4: Project Report		✓	✓	✓	✓
Stage 5: Presentation of C++ Project			✓	✓	✓

Progress report

Progress report is an important document for a project as the students will receive the feedback and corrections periodically from the instructor. This is one the ways to keep the students on track with the task, improve their work, and success in the final output. The progress report for the C++ project is applied in two ways, individual and group reports. In Stage 2, each student

should submit the individual progress report, in which the students report verbally and individually about the progress of their assigned tasks. This is to help the students clearer about the C++ project. With regard to the group progress report, each group is requested to write a short report about the group progress on the project, and followed by 15 to 30 minutes presentation to the instructor. By dividing the tasks, all group members are responsible to ensure the good final product of their group project.

Rubrics

Rubric score sheet is an efficient way of providing feedback to assess large classes. During the presentation, the rubric score sheet is used to assess the C++ code and group presentation. Besides, as the project report may be different between the groups, a rubric score sheet isalso used in the assessment of the project report.

Self-assessment

Self-assessment is an important part of the summative evaluation because the written feedback is more personal and specific. It allows the students to reflect on their successes, mistakes, and goals in preparing the project. As a result, the students will be well prepared and highly motivated to take any kind of projects in the future.

Peer Assessment

Peer assessment provides information about the group project teamwork, and students' perspective about their group members' efforts and contributions on the project. In this project, the peer assessment form is compulsory, in which all group members are listed and assessed in by the students.

STUDENTS' ACHIEVEMENTS ON C++ PROJECT

Practical group projects encourage students to be directly involved in the development of project's coding as they understand its significance and usefulness. The main requirement in the development of the C++ project is to ensure that at least 6 of the basics elements in the C++ programming are implemented in the project. Parts of the elements are

- Variables
- Arrays
- Mathematical built-in functions
- Looping
- Branching
- Static memory allocation
- Dynamic memory allocation
- Application of vectors and matrices
- Input and/or output files
- User defined functions

Algorithm A and Algorithm B are two examples of C++ project developed by the students. The theme of the project is about the mathematical games in C++. Algorithm A is a mathematical version of Hangman Game. In this algorithm, quizzes based on matrices are included in the Hangman Game. Players are allowed to determine the dimension of matrices to be used for the game; 3 to 6 rows and columns.

Table 3: Algorithm of Matrix Hangman Game

ALGORITHM A: Matrix Hangman Game

INPUT:

- Variables and arrays:
- Include header files:`iostream.h, conio.h, time.h, Windows.h, MMSystem.h, fstream.h`

STEPS:

Step 1 Initiates the loop indefinitely

Step 2 Narration, rules of the game and set the number of players

Step 3 Players select the number of rows and columns for their matrices

```
for (i=1; i<=row; i++)
for (j=1;j<=column;j++)
        a[i][j] = rand()%20;
```

Step 4 Players solve 5 quiz questions using the matrices. Player's life will be deducted for the wrong answers. The game is over if players loss all the given life (3 life).

Each player is occupied with 3 game life. The game life is deducted for the wrong answer and the player is considered lost if losing all the game life. The winner is based on the shortest time taken in answering the 5 matrix questions.

```
Player 1 : ABU
QUESTION 3:     What is the answer for a[4][1] X a[2][2]: 5

Your answer are false.
Your life count now is 1

Player 2 : RAVI
QUESTION 3:     What is the answer for a[3][1] + a[2][2]: 27

Your answer are true
Your life count now is 3


Player 3 : JENNIE
QUESTION 3:     What is the answer for a[2][3] - a[4][3]: 9
Your answer are false.

Your life count now is 0
YOU LOSE


**************************************************

        19      7       11


        17      14      1
```

Figure 2: Console output 1 of Algorithm A

Figure 2 shows an example of 3 players for the Matrix Hangman Game. All the questions are based on the dimension of a matrix chose by the players.The game life of all players are updated after the players answered the quizzes. Figure 3 shows the sample of final result for the Matrix Hangman Game.

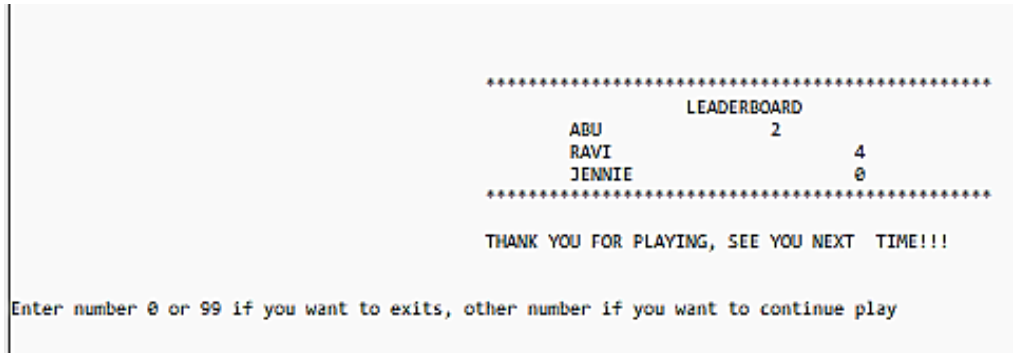

Figure 3:Console output 2 of Algorithm A

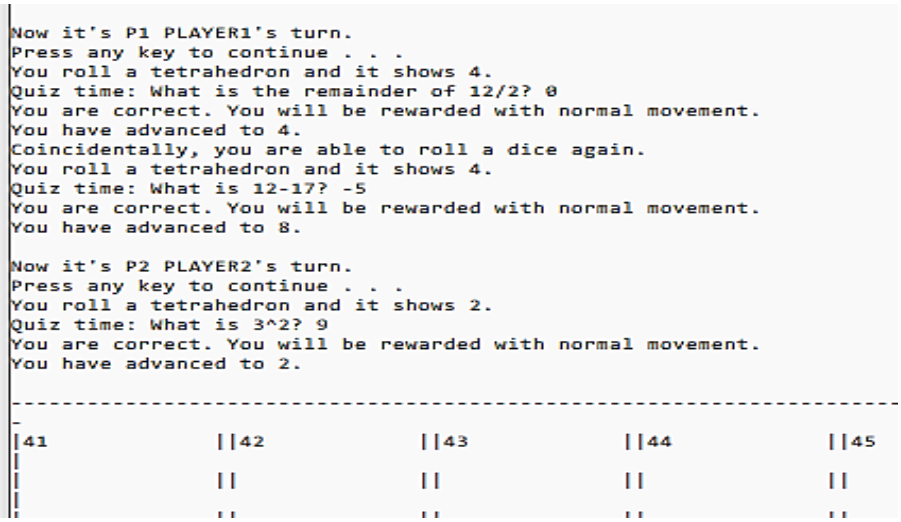

Figure 4: Console output 1 of Algorithm B

Algorithm B is a mathematical version of Snake and Ladder Game, named Brainy Snake Game. The players compete to reach the 50th box. During the games, the players are required to solve mathematics quizzes which are occupied with rewards and penalties. The snake boxes and ladder boxes are similar to the classic version of Snake and Ladder Game.

Table 4: Algorithm of Brainy Snakes Game

ALGORITHM 1: **Brainy Snakes Game**

INPUT:

- Variables and arrays:
- Include header files:`iostream.h, iomanip.h, fstream.h, conio.h, time.h, Windows.h, MMSystem.h`
- User-defined functions

`1) void Question(int O, int N1, int N2)`
Mathematical operation for the quiz:
N_1^2 or $N_1 N_2$ or $N_1 - N_2$ or $N_1 + N_2$ or remainder of N_1 / N_2.
`2) void dicetype(int n)`
Types of dice: tetrahedron/cube/octahedron/dodecahedron/icosahedron
`3) int diceroll(int n)`
Display value after dice rolled.

```
int side, t;srand(t=(int)time(0));
side=(rand()%4)+1; or (rand()%6)+1; or (rand()%8)+1; or
side=(rand()%12)+1; or (rand()%20)+1;
```

`4) bool Answer(int O, int N1, int N2, int A)` To check player answers in the quiz
`5) void Rules()` Game rules.
`6) void Narrative()` Displays the narration of the game plot.

STEPS:

Step 1 Initiates the loop indefinitely until there are about 2 to 4 players
Step 2 Narration, rules of the game and set the players turn
`Narrative();Rules();`
Step 3 Displaying the game board; 1 to 50 boxes
Step 4 Players rolling the dice
Step 5 Player solve the quiz

```
N1=(((rand())+(rand()))%25)+1;N2=(((rand())+(rand()))%25)+1;
Operator=rand()%5;
Question(Operator, num1, num2); cin>>testing; ans=atof(testing);
if (Answer(Operator, num1, num2, ans))
```

Step 6 Checks the answer either if it is right or wrong.Correct, normal movement, `p=1`; or incorrect, half movement, `p=0.5`
Step 7 Update position of player if lands on snake/ ladder's tile

```
Slot[i]+=(int)ceil(p*Side);
       if Slot[i]<50, Tile=((rand())+(rand()))%10;
       if Tile==3, Initiates the ladder mechanic, answer quiz
       if Tile==6, Initiates the snake mechanic, answer quiz
```

Step 8 Update the position of players after each round, display the updated game board
Step 9 The looping is continuous, until the break condition is satisfied (player on 50th

There are four types of dice may be selected by the players to roll the dice. Figure 4 and Figure 5 show the sample of console outputs for the Brainy Snake Game. As mentioned in Figure 5, half movement is applied for the wrong answer.

Table 5: Sample of students enrolled for Programming in Mathematics course

Batch	**Number of students**
E192	90

E191	23
E182	67
E162	41
E161	94

To show the achievement of students in the C++ project, 5 batches are selected as the sample of this study. Table 5 shows the number of students considered for the 5 batches. Figure 6 shows the average marks of C++ project for the 5 batches. It shows that the average marks for the C++ project are 71% to 91.5%, which reflected that the students well performed in the project. Figure 7displays the details of students' achievements for the 5 batches.

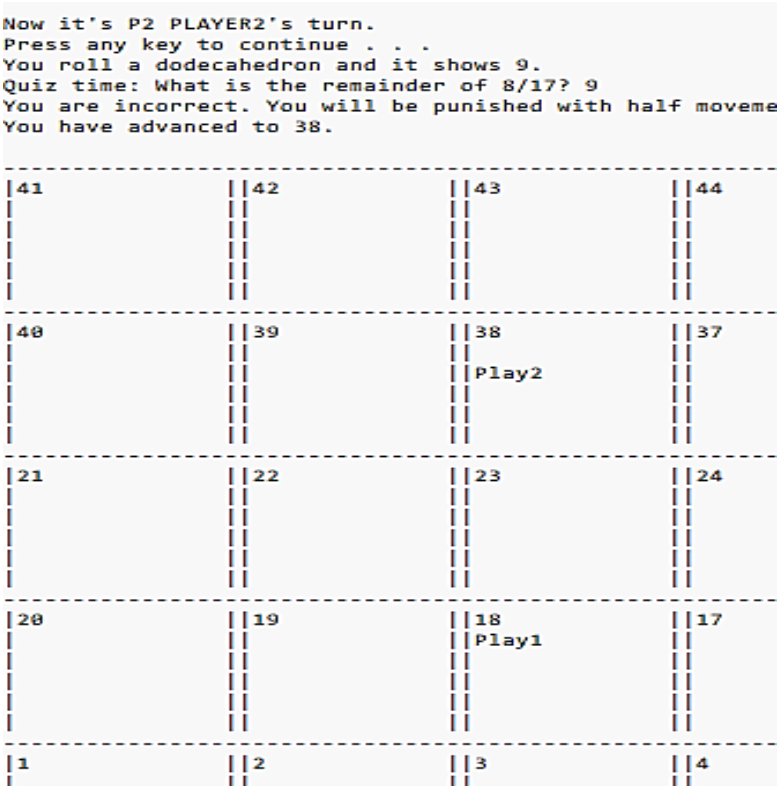

Figure 5: Console output 2 of Algorithm B

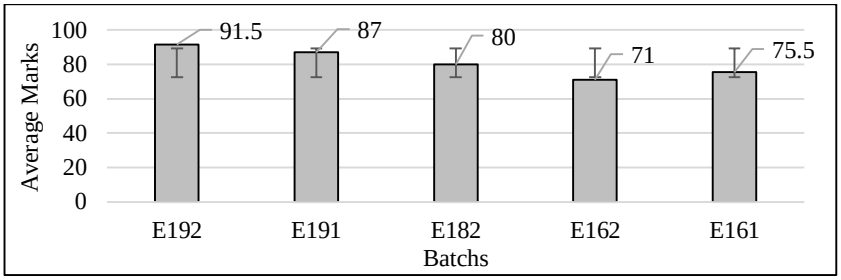

Figure 6: Average marks (%) for C++ project

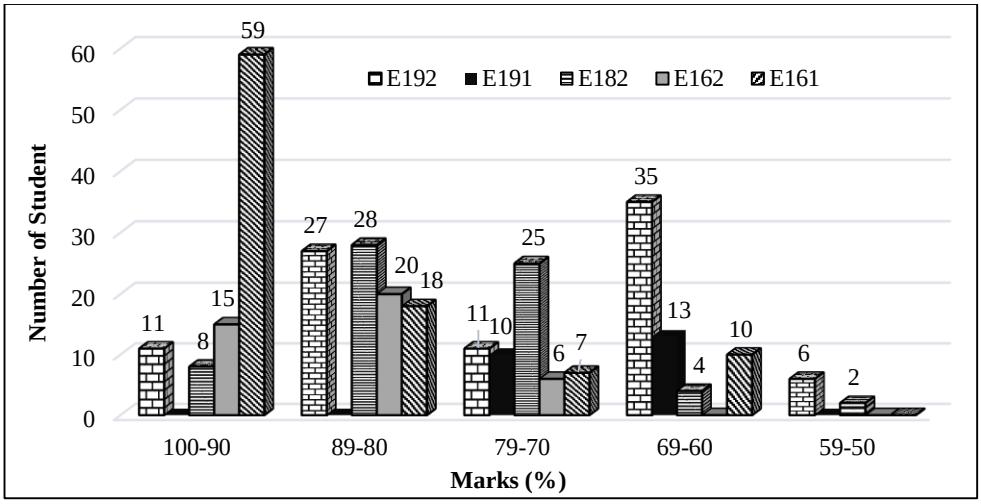

Figure 7: Students achievement in C++ project for the 5 batches

Based on the results illustrated in Figure 7, a total of 8 students obtained 59%-50% for the C++ project while 93 students obtained 90%-100%. The total number of students considered in this study are 315 students. As overall, students' achievement in the C++ project are excellentas per all of them obtained marks more than 50% for the C++ project.

CONCLUSION

Implementation of the PjBL learning styles for the C++ project allows the learning process to be done comprehensively and effectively. The students reached the desired learning objectives of the C++ project as the students participate actively. Moreover, the results indicated that 93 students scored 90%-100% and 315 students of 5 batches obtained more than 50% for the C++ project. In order to improve the students interest on the programming language course particularly the C++ programming, the C++ project should be done in a longer time period, for example in 10 weeks of the semester. Thus, the quality of the project, level of implemented C++ knowledge and students interest on programming can be improved. Besides, the way of implementing the PjBL way of learning may be improved to incorporate the creative and critical thinking skills among students.

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