THE DEVELOPMENT OF AUTOMATIC PROGRAMMING ASSESSMENT TOOL (APAT) THAT APPLIES LEARNING TAXONOMY AS ITS GRADING MODEL

MUHAMMAD HUZAIFAH BIN ISMAIL

SULTAN IDRIS EDUCATION UNIVERSITY

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MUHAMMAD HUZAIFAH BIN ISMAIL

05-4506832 pustaka.upsi.edu.my Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah PustakaTBainun ptbupsi

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ABSTRACT

Currently, it is difficult to effectively grade students' programming assignments. As a result, the objective of this work was to create an Automatic Programming Assessment Tool (APAT) with a Bloom Taxonomy-mapped grading rubric. To guarantee that such a novel tool has appropriate quality attributes, the development of APAT was carried out based on the Software Engineering (SE) principles, namely software specification, software development, and software verification. The evaluation of this novel tool focused on its usability and effectiveness. The assessment of the tool's usability was carried out using Heuristic Assessment involving eight lecturers from the Faculty of Art, Computing, and Creative Industry, Sultan Idris Education University where data were gathered through WebUSE. The assessment of the tool's effectiveness in assessing student learning was performed through Analysis of Variance (ANOVA). The results of the analysis of the survey data showed that the lecturers gave the proposed prototype a high rating. The findings of the ANOVA test revealed that there were significant differences in the learning outcomes of the students between groups. Overall, according to both findings, APAT is highly usable and effective from the standpoints of practicality and assessment, respectively. Thus, teaching professionals can use this innovative assessment tool to enhance the grading of students' programming works.

PEMBANGUNAN ALAT PENILAIAN PENGATURCARAAN AUTOMATIK (APAT) YANG MENGGUNAKAN TAKSONOMI PEMBELAJARAN SEBAGAI MODEL PENGGREDANNYA

ABSTRAK

Buat ketika ini, penggredan tugasan pengaturcaraan pelajar tidak dapat dilakukan dengan berkesan. Maka, kajian ini dijalankan dengan tujuan untuk membangunkan Alat Penilaian Pengaturcaraan Automatik (APAT) yang melibatkan rubrik penggredan yang dipetakan kepada Taksonomi Bloom. Pembangunan APAT dijalankan mengikut prinsip-prinsip Kejuruteraan Perisian yang terdiri daripada spesifikasi perisian, pembangunan perisian, dan pengesahan perisian agar ianya mempunyai atribut kualiti yang tinggi. Penilaian terhadap APAT melibatkan dua aspek, iaitu kebolehgunaan dan keberkesanan. Penilaian terhadap kebolehgunaan alat ini dilaksanakan melalui Penilaian Heuristik yang melibatkan lapan tenaga pengajar Fakulti Seni, Pengkomputeran dan Industri Kreatif (FSKIK) di Universiti Pendidikan Sultan Idris (UPSI) di mana data dikumpulkan melalui WebUSE. Manakala, keberkesanan alat penilaian ini dalam menilai pembelajaran pelajar dilakukan melalui Analisis Varian (ANOVA). Dapatan analisis data kajian menunjukkan prototaip yang dibangunkan diterima secara positif oleh tenaga pengajar berkenaan. Manakala, dapatan ANOVA menunjukkan terdapat perbezaan yang signifikan dalam pencapaian pembelajaran pelajar antara kumpulan yang terlibat. Secara keseluruhan, kedua-dua dapatan ini menunjukkan kebolehgunaan dan keberkesanan APAT adalah tinggi dari sudut kepraktisan dan penilaian pembelajaran pelajar, masing-masing. Oleh yang demikian, alat penilaian inovatif ini boleh digunakan oleh tenaga pengajar dalam meningkatkan penggredan tugasan pengaturcaraan para pelajar.

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LIST OF ABBREVIATIONS

APAT	Automatic Programming Assessment Tool
ASL	Assessment-Specification-Language
BT	Bloom's Taxonomy
CA	Classroom Assessment
CBSD	Component-Based Software Development
DA	Dynamic Analysis
DSL	Domain-Specific Language
FA	Formative Assessment
FR	Functional Requirement
HSD	Honestly Significant Difference
LSA	Latent Semantic Analysis
MVC	Model-View-Controller
SA	Summative Assessment
SAUCE	System for AUtomated Code Evaluation
SDD	Software Design Description
SE	Software Engineering

UNITEN	Universiti Tenaga Nasional
UPSI	Universiti Pendidikan Sultan Idris

APPENDIX LIST

A Software Requirement Specification For Prograders Version Prototype 1.0

B Software Design Documentation For Prograders Version Prototype 1.0

C Software Testing Documentation For Prograders Version Prototype 1.0

D Lab Assessment Sample

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter will explain on the research background, formulation of the research problem, research questions, research objectives, research scope, the conceptual framework of the research, the significance of the research, the operational definitions and last but not least the overall summary of the chapter one.

1.2 Research Background

Programming in the context of computing, is an activity of writing instructions to tell the computer how to process specific information (Mata-Toledo & Cushman, P. 46, 2003). It is an essential practical skill that needs to be obtained especially by those who want to pursue a career in Computer Science (CS) field. This is because the ability of programming contribute many things in CS field especially in the software development. It is an essential practical skill that needs to be obtained especially by those who want to pursue a career in Computer Science (CS) field. Therefore, undergraduate students who enrol in CS course at University will involve many programming assignments as part of its Classroom Assessment (CA). Usually, for the introductory programming course, the instructor will design the programming assignment that requires the students to develop a complete program where it can perform problem-solving. Traditionally, the lecturer will do the assessment by executing the student program and examines whether the program's functionality behaves the same as defined in the assignment's requirement. In this study, the traditional assessment can be defined as the manual assessment.

Nonetheless, the manual assessment of assessing the programming assignment can prone to an inaccuracy of assessment and large time consumption of the assessment process due to a large number of student (Cheang, Kurnia, Lim, & Oon, 2003). This is because each of the student program's code can have multiple approaches but it also can lead to the correct solution (Mustapha, Samsudin, Arbaiy, Mohamed, & Hamid, 2016). Therefore, it is difficult for the instructor to determine the correctness of the

program's functionality and it is a slow tedious process because the instructor have to examine the code line by line and test it thoroughly each of the student programs. Due to this issue, researchers have come up a solution where the programming assignment can be automatically assessed. This solution is known as Automated Programming Assessment Tool (APAT).

The earliest example of APAT that was introduced which was in the year 1960 by Hollingsworth (Douce, Livingstone, & Orwell, 2005; Hollingsworth, 1960). In his work, a grader program was run against a student program and it will produce two types of result whether it returns "wrong answer" or "program complete". It is the first APAT that can assess student program automatically regarding its correctness. Ever since then, myriad version of APAT were developed by researchers and developers so that the improvisation of APAT can be achieved.

1.3 Research Problem

Bloom's Taxonomy (BT) is a method of categorising cognitive skills by increasing order of complexity and can be used as a means to organise task and for CA activities (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956) and have been widely used for measuring student's learning achievement (Masapanta-Carrión & Velázquez-Iturbide, 2018). BT is consider an important element for CA that includes in assisting the instructor to design lesson plans and helps the instructor to formulate more challenging

sets of questions for the student to answer either during class exercises, class assignments, and class tests (Cullinane, 2010). In other meaning, the taxonomic of BT including its learning domains can ease the instructor on measuring student's learning achievement through their CA grading which consequently improves the student's level of thinking. In fact, this argument has been discussed in Caiza and Alamo (2013) and also in (Lajis, Baharudin, Kadir, Ralim, & Nasir, 2018) where most existing APAT are lack of common grading model which can be refer as BT.

In several studies of APAT, most of the authors proposing the application of Bloom's Taxonomy in APAT as an instrument for measuring student's competency through making a scale for assessment of CA tasks. For example, in the work of (Ullah et al., 2019), The authors is proposing a new approach on assessing programming assignments in APAT where it maps to the corresponding cognitive level directly from the student's source code. It does automatically gives results of the student's level of competency according to BT. Nonetheless, the proposed approach is not giving the grades according to BT in their APAT prototype. Thus, in order to fill this gap, this study decides to develop a new prototype of APAT where its grading model is applying BT. This allows the assessment of the student's programming assignments becomes more accurate and easier for the instructor to measure their student's learning performances. As a result of this study, a new APAT prototype which is improved in its assessment approach is introduced through this study.

1.4 Research Questions

The following are the research questions for this study. Each of these research question are defined due to its relevancy on what does this study is trying to achieve.

a) What is the weakness of the current APAT studies?
b) What is an existing rubric that is suitable to be integrated with the proposed APAT?
c) How to develop the proposed APAT prototype?
d) How to evaluate the effectiveness of the proposed APAT prototype based on usability evaluation scores among the instructors and the significant difference in the mean of student's assignment scores?

1.5 Research Objectives

The following are the research objectives of this study. Each of these objectives are defined due to ensuring the successfulness of this study is achieved.

a) To identify and highlight the weakness of the current APAT studies.
b) To identify and select an existing rubric that is suitable to be integrated with the APAT.
c) To develop the new prototype of APAT based on Software Engineering (SE) practice.

d) To evaluate the effectiveness of the proposed APAT prototype based on the usability evaluation scores among the instructors and the significant difference in the mean of student's assignment scores according to student's level of achievements.

1.5 Research Hypothesis

The appropriate hypotheses has been identified throughout this study which are needed to evaluate in order to determine the effectiveness of the proposed APAT. The following are the research hypotheses for the context of this study.

H_0: There is no significant difference for all the mean of the assignment scores based on the student's level of achievement.
H_1: There is one significant difference for all of the mean of the assignment scores based on the student's level of achievement.

Figure 1.1. The Hypotheses Of This Study

1.6 The Conceptual Framework

As indicated by McGaghie (2001), a conceptual framework is a "sets of stage" for demonstrating specific research question that drives the investigation being reported.

In a simpler meaning, the conceptual framework represents the summarization of the literature of the study based on the problem statement. It represents a structure that combines the parts in a research to form the whole research.

Based on the research objectives (see section 1.5 for details), there are three identified parts which is integral in fulfilling the goal of this study. The three parts are the application of theoretical basis, development of the proposed tool and evaluation of the effectiveness of the proposed tool. In Figure 1.2 shows the conceptual framework diagram that this study applied.

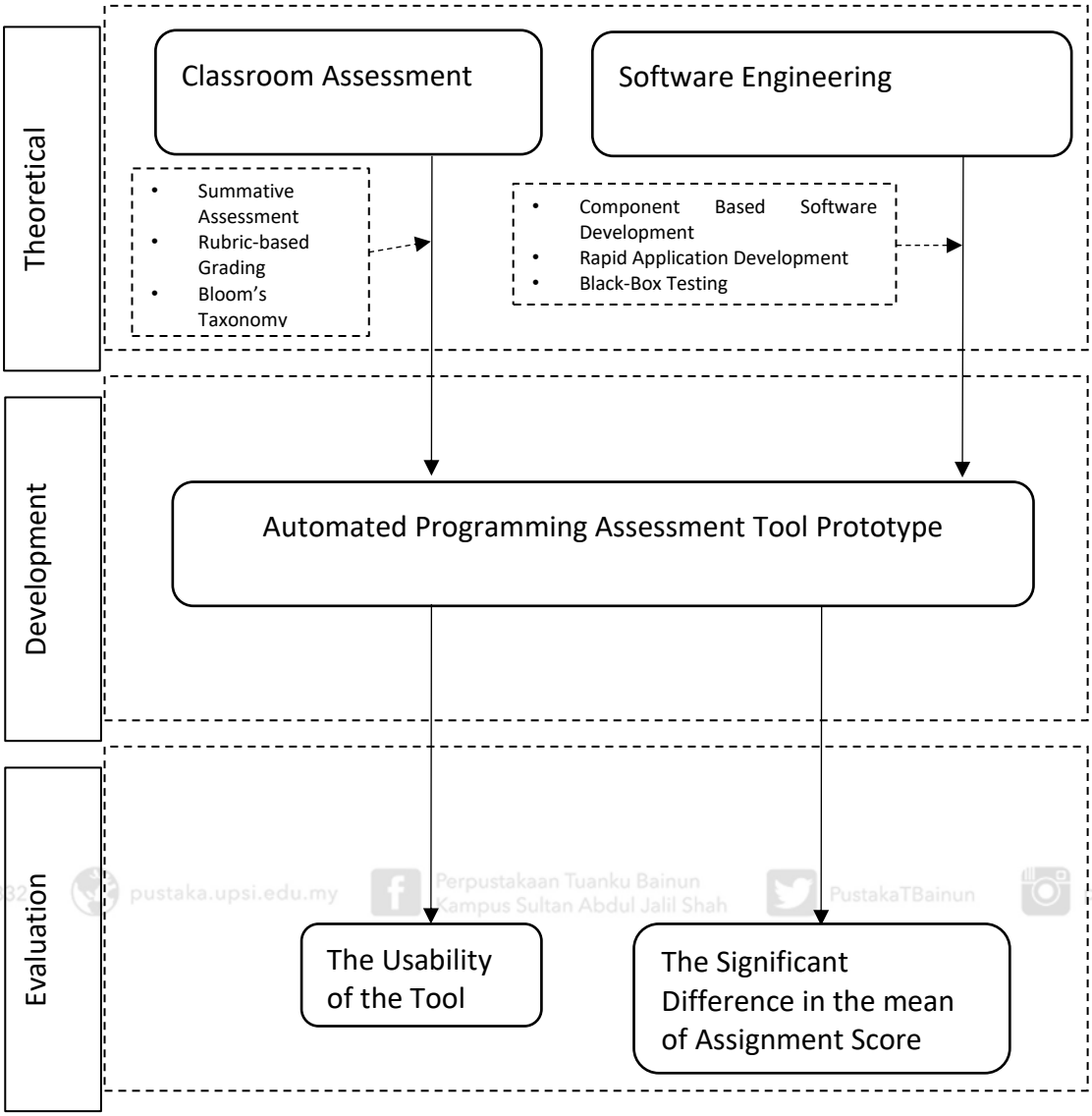

Figure 1.2. Visual Representation of The Conceptual Framework That This Study Are Applying.

1.7 Research Scope

The scope of this study is to propose an APAT prototype where it uses BT as part of its grading model which is the gap that needs to be address by this study. Generally, the grading model of the proposed APAT must be able to maps it's grading and scoring

according to BT level of domains in order to improve its assessment accuracy. Other than that, this study is only focusing on introductory level of programming course. As stated in Universiti Pendidikan Sultan Idris (UPSI) course outline for Diploma Computer Science Course, introductory level of programming course usually provides lesson on problem solving techniques and the programming language itself ("[Diploma] Guide Book," 2019). Therefore, the proposed APAT is only cater on introductory level of programming course regarding its grading model where the grading model should be able to assess only for the functional of the submitted program by the student. The reason why the introductory level of programming course is chosen over the advance is because there are no other APAT that has solve this gap in pertaining to introductory level of programming.

1.8 The Significance of the Research

The significance of this study is to improve the accuracy of the assessment of programming assignment among the instructors at the Higher Education Institution (HEI). As explained before, the most common approach practice by instructors when it comes to assessing programming assignment is to examine the code line by line and test it thoroughly each of the student programs. However, this can leads to inaccuracy of assessment and large time consumption due to a large number of student that enrol within the course. There are existing tools that can assist these instructors but all these tools do not apply BT for its grading model. Due to this issue, this study is proposing a

new APAT prototype that it is improved in its assessment approach since it applies to BT as its assessment instrument for its grading model. So, there is no doubt that the significant of incorporating BT and APAT able to solves the inaccuracy of assessing of programming assignments especially with a large number of student.

1.9 Operational Definitions

There are a number of terms are being used specifically for these study. These includes:

i) Student

The term student is very broad in Malaysia since there are number of levels and categories involves. In order to make things more clarify, the term student in the context of this study are the undergraduate student that are taking programming courses within their studies. Thus, this study excludes the student who are studying programming subject at high school whereas it is only focusing on the undergraduate student who are enrolling at Higher Education Institution (HEI) which includes public universities, private universities and polytechnics.

ii) Programming

Same as for this term since programming has many definitions depends on what context is used. Therefore, this studies applies the term of programming where it relates to computer programming context that involves with the development of computer programs.

iii) Programming Assignment

There are many types of programming assignments and the instructors can choose any of it as long it helps the student to practice programming. The usual type of programming assignment that the instructor gave to the student as a CA task is where the student needs to develop a full functional program. This study will be focusing on the programming assignment where it requires the student to develop the full functional program that able to perform problem solving.

iv) Instructor

Instructor in this study are refers to the lecturer of programming course at the Higher Education Institution (HEI). The instructors includes the lecturers or the tutors as long it involve in teaching or assisting in assessing programming assignment.

v) Automatic Programming Assignment Assessment (APAT)

APAT is a specialized software tools that is used to assess computer program full or semi-automatically. Specifically this study focusing only on APAT that are used to assess programming assignments.

1.10 Thesis Chapters Arrangement

This thesis consists of 6 chapters which includes the introduction, literature review, research methodology, system development, data collection and analysis and the summary of the study. The following are a brief description on each of the chapters:

Chapter one defines the research background in brief description, the research problem statement, research questions, research objectives, the visual representation of the conceptual framework that applies within this study, research scope, the significance of the research, and the operational definitions of each terms that this study specifically used.

Whereas in chapter two is detailing the literature review of the CA, the rubric scoring, BT and its three learning domains, the traditional method of assessing programming assignment, and the mechanism of APAT. In addition, the systematic literature review (SLR) also has been conducted in this chapter. The purpose of conducting SLR is for determining the current weakness of APAT so that it can be filled throughout this study.

In chapter three, the research methodology of this study is discussed in more details. In research methodology, it has a number of phases depends on the research objectives that has been set. Each phases requires a specific methodology to be conducted in order to complete each of the phases. In addition, the experimental design are also being discussed that includes the sampling technique being used, the sampling sizes and the instrument used during the experiment setup.

Chapter four is explaining the overall of the system development of the proposed APAT prototype. In this chapter, the list of features of the APAT prototype

is being discussed. Other than that, the development and the implementation of the APAT prototype is explain in more details.

Chapter five is demonstrating how the data is being collected and what conclusion can be made throughout the end of the experiment result. This chapter will use the descriptive and the inferential statistic method that are used to analyse the data collection. The result from the experiment of this study shows that whether the propose APAT prototype is usable among the instructor which is being describe within this chapter.

Last but not least, chapter 6 is where the summarization of this study is being discussed such as the findings and its limitation. In addition, this chapter also discussing on the future research suggestion of the APAT studies for other researchers to conduct so more improvisation of APAT can be achieved.

1.11 Summary

Technically, chapter one is discussing the research background, formulation of the research problem, research questions, research objectives, research scope, the conceptual framework of the research, the significance of the research and the

operational definitions. The next chapter which is chapter two will discuss the literature review of the study.