Automatic Programming Assessment to Measure Programming Problem-Solving Skills

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Abstract. Problem-solving skills today form an integral part of the curriculum and meet student needs because they have become a problem in the dominant field of education. Computer programming is a subject that requires problem-solving strategies and involves a large amount of logical programming activity. Therefore, one alternative method of introducing problem-solving skills is through computer programming. With the development of programming software and industrial needs, which are supported by operations in the industry, progressing so fast, the existence of software that is able to automatically assess the results of student work and assignments is needed, especially in vocational schools. This research generally aims to implement an automatic assessment tool that can help teachers make corrections on student work related to computer programming. This type of research is quantitative and descriptive; the results are presented in the form of a research report with data analysis using SEM. The results showed that the automatic assessment system used was reliable, and the instrument for measuring the problem-solving skills of subjects had good construct validity, with the LF of each indicator worth 0.50.

Keywords: automatic scoring system, problem solving skills, computer programming

1 Introduction

Problem solving skills are considered as very important and needed, to be able to function effectively and efficiently in meeting the demands of the world of education [1]. The ability to interpret new information efficiently and effectively will become more important than a person's specialized knowledge. This is an important reason why many countries have included problem solving as a central competency in the curriculum [2]. With the development of programming software and the industrial needs supported by operations in the industry progressing so fast, the existence of software that is able to automatically assess the results of student work and assignments is needed, especially in vocational schools. Taking into account the above background, a research was conducted that aims to implement an automatic assessment tool that can help teachers/teachers to make corrections on student work related to computer programming.

1.1 Automatic scoring system

The automatic assessment system in this case is used for computer programming assessment, namely automatic programming assessment, which refers to software that was originally designed for programming competitions. Automatic Programming Assessment is a tool commonly used by teachers as an automatic assessment tool [3]. This application can help

teachers evaluate programs made by students in the computer programming subject. In addition, it can improve students' programming knowledge and skills. This automatic scoring system has several criteria that are expected to provide an objective and transparent assessment [4]. With the development of internet technology and the development of program analysis techniques, a web-based tutor system can assist the teacher's role in teaching and training programming. Making automatic programming assessments can ease the teacher's task of evaluating student practicum assignments so that teachers have more time to concentrate on the materials that will be given to students to improve their skills and follow the progress of the students' progress.

1.2 Computer programming problem solving skills

The initial originator related to problem solving is John Dewey, who defines problem solving as a systematic and scientific operational function that includes five steps, namely (a) problem definition, (b) problem analysis, (c) solution, (d) criteria, and (e) implementation. [5]. Problem solving is a process to overcome the difficulties faced in achieving the expected goals. In computer science, problem solving must be mastered by students to solve programming problems. As already mentioned, it is related to algorithms, logic, and programming. Problem solving includes higher-order thinking processes such as visualization, association, abstraction, manipulation, reasoning, analysis, synthesis, and generalization, each of which needs to be managed in a coordinated manner. [6]. Creative competence and problem solving are part of the so-called 21st century skills. The creative use of digital technology to solve problems is also related to computational thinking as a set of cognitive and metacognitive strategies in which students engage in active design and creation processes and mobilize concepts of computational methods. [7]. Problem solving cannot be separated from critical thinking skills because critical thinking skills are fundamental to solving problems. Having problem-solving skills will help students acquire new knowledge and provide them with the necessary skills to successfully enter society and adapt to new conditions in the face of adversity [8].

1.3 Empirical study

Teachers often have difficulty validating hundreds of programming assignments for their students. A framework was created that can help teachers validate program code, called a system for automatic assistance in programming practice correction (SAC) using a web platform [9]. This application allows teachers to define and describe program assignments and practices, and students just upload the results of their work. In a relatively short time, students can see feedback from their answers. In programming exercises, students must learn to solve problems that produce precise, compliable, and efficient program code. Another advantage that can be obtained is that the human factor no longer affects the program. When the program is assessed manually, it usually allows the subjectivity factor to be influenced by giving excessive assessments or awards to certain students. However, when the use of automatic assessment is implemented, this will not happen. Programming abilities and skills need to be mastered by all students, often through intensive training related to programming [4]. The longer the more students do the exercises so that the assessment of programming exercises makes the teacher's workload heavier. Then it proposed an automatic assessment using a verification program with random input that had been tested on basic programming learning; the results show that the assessment can run well. This "automated grading system" automatically compiles and runs student-generated programs and evaluates them against the

verification program. Students and teachers are faced with several problems during learning, both from programming concepts and language syntax, which can be an obstacle for students to learn programming and an inhibiting factor for motivation among students [10].

2 Research Method

This research is a quantitative descriptive with the aim of knowing the implementation of an automatic assessment system to measure computer programming problem solving skills in vocational students. Data collection was carried out on a sample of students from SMK Negeri Surabaya, classes XI and XII, with expertise in information and communication technology, software engineering, and multimedia expertise programs, totaling 202 students who had received basic programming subjects. The research instrument used was an essay test to measure problem-solving skills. Before compiling test questions, the indicators must be determined in advance, namely: (1) problem identification; (2) making mathematical equations or models; (3) algorithms; (4) debugging; and (5) problem solving quality, with the total number of questions being 5 questions related to computer programming. The creation of essay test questions is also accompanied by the creation of an assessment rubric for each question. Data collection is carried out when essay questions have been prepared on the automatic assessment device application so that respondents only need to access the application. This type of test question requires respondents to answer in accordance with predetermined stages. These stages are the implementation of the problem-solving stages. In accordance with the answer keys and assessment rubrics that have been made, each answer from the respondent will be automatically matched and given an assessment. Furthermore, the data were analyzed using SEM (structural equation modeling), namely confirmatory factor analysis (CFA), which includes testing the validity and reliability of the instrument.

3 Results and Discussion
3.1 Results

An automated assessment system application developed on a web-based basis and used by students in learning Basic Programming in Vocational High Schools by displaying a different interface according to the needs of the user's level. The main features of this application are as shown below.
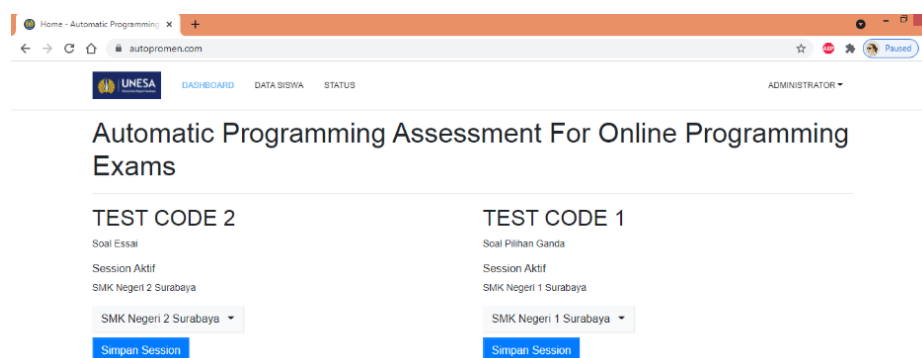

Figure 1. Aplication Dashboard

This application has two levels of users, namely administrators (teachers) and students. In the picture above is an administrator page who has wider access rights than students, because all application operations are under the control of the administrator. In the figure below is a user page (student) who only has access rights to work on questions/instruments only.
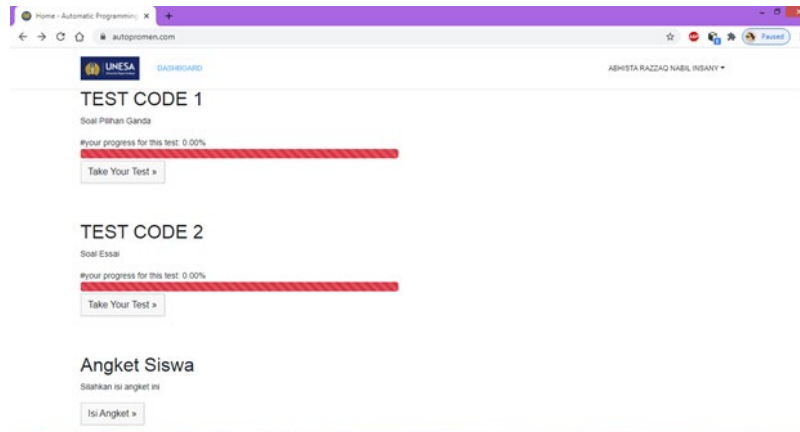

Figure 2. User Page (Student)
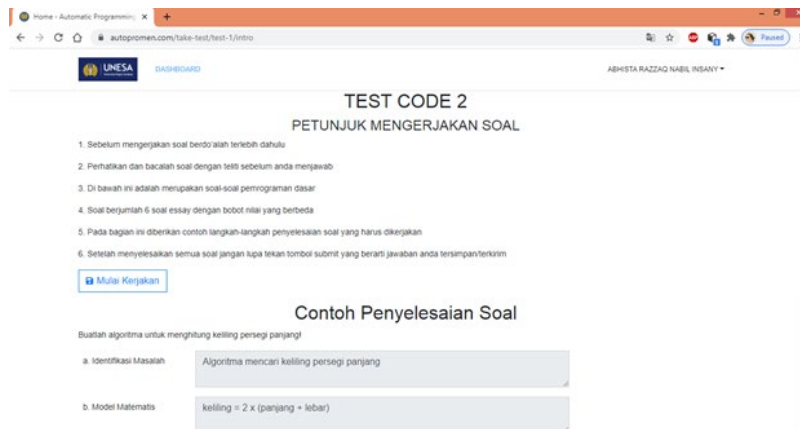
Figure 3. Navigation TEST CODE 2

Data retrieval is done by students working on problem-solving skills essay questions that have been prepared in the application of the automatic assessment system. The essay question is included in the TEST CODE 2 feature, as shown in the figure above. Furthermore, the system will automatically assess student work according to the assessment rubric, and the teacher just downloads the results of the student work assessment.

3.2 Discussion

The measurement model is a modeling process in SEM that is directed at investigating the unidimensionality of the indicators that explain a variable. In this measurement model, a

partial measurement model is used, namely, a measurement model that is carried out separately or on each construct (single measurement model). The following is a measurement model for problem-solving skills:
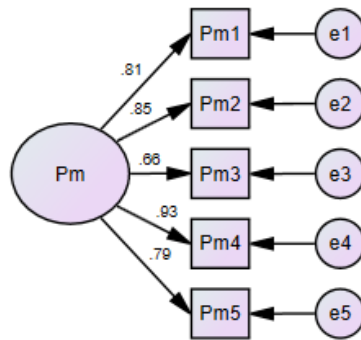
Figure 4. Problem Solving Skills measurement model

The figure above is a model for measuring problem-solving skills with 10 estimated parameters, namely 5 loading factors and 5 error variances.

Based on the results of the analysis of reliability and construct validity, the five indicators that make up the variable problem-solving skills are declared reliable and valid. The five indicators, consisting of identification, equation, algorithm, debug, and quality, have standard loading factors (SLF) and construct reliability (CR) values that match the criteria. From these values, it can be seen that the indicator that has the highest loading factor value is Pm4, namely debug (0.93), which means that the indicator provides the largest contribution to explaining its latent construct. On the other hand, the indicator that has the lowest loading factor value is Pm3, which is the algorithm (0.66), which means it has a weak contribution to explain its latent construct. Meanwhile, the indicator with the highest CR value from the analysis results is the PM4 indicator, namely debug (16,008), which means that the indicator has good reliability, and the one with the lowest CR value is the PM3 indicator, namely the algorithm (10,180). From the two analyses, it is shown that the PM4 indicator gives the greatest contribution to the latent construct.

Some of the advantages that can be obtained by using an automatic assessment system include better system accuracy, faster, objective feedback to students and also a reduced workload for teachers/teachers. Teachers have a burden of responsibility that continues to increase every day, so the process of assessing programming tasks that are done manually takes a long time, so a possible solution is to use the help of automatic programming assessment methods.

4   Conclusions

These problem-solving skills have valid indicators because, basically, these indicators are used to compile items of test instruments that are proven to be able to measure what will be measured. This is indicated by the results of the CFA analysis, which show that the loading factor value of the problem-solving skills variable towards each indicator has a value of 0.50.

Acknowledgements

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