Design of Computer Programming Training Assessment System with Machine Learning Approach

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Abstract. The development of information technology has a significant impact on the field of training. One trend is the integration of Artificial Intelligence into aspects of computer programming training. Artificial Intelligence-based assessment systems have the ability to analyze data in real-time, provide adaptive feedback, and assess learning outcomes objectively and efficiently. The Machine Learning approach allows the system to learn training data patterns, such as task completion performance, completion time, and difficulty level. This study aims to design a computer programming training assessment system based on Artificial Intelligence with a Machine Learning approach. The designed system can identify the strengths and weaknesses of training participants. The methods used include task analysis with supervised learning algorithms and predictive models that provide real-time adaptive feedback. The design model uses Agile including Requirements, Design, Develop, Testing, and Deploy. System testing uses the ISO 25010 standard including functionality, usability, reliability, performance efficiency, and compatibility.

Keywords: training assessment systems, computer programming, machine learning.

1 Introduction

Competence in computer programming is inseparable from mastery of programming languages. A programming language is a standard set of instructions for controlling a computer. A programming language is a set of syntactic and semantic rules used to define computer programs [1]. There are various programming languages that can be used for different things such as HTML (for creating websites), Python (for making websites responsive), JavaScript (for making websites responsive etc.), C/C++ (for developing software), Java (for developing games) and so on [2].

The activity of writing program code, often referred to as coding in computer science, produces output in the form of source code. Programming training also involves issues related to source code. The rapid development of information and communication technology has also had a significant impact on education and training. According to reports [3], digital technology has increased access to education by up to 65% in developing countries, as well as accelerated the

ICIESC 2025, September 16, Medan, Indonesia

DOI 10.4108/eai.16-9-2025.2361036

adoption of technology-based learning methods worldwide. One of the main trends is the integration of artificial intelligence in supporting various aspects of learning, particularly in computer programming training. Computer programming is a highly sought-after skill in this digital era, both for software development, data analysis, and the implementation of artificial intelligence-based technology [4].

The programming learning process often faces significant challenges. Many learners struggle to grasp basic programming concepts, complete practical tasks, and develop algorithmic logic [5]. A study by [6] showed that 70% of beginner-level programming trainees needed more than three attempts to complete loop- and recursion-based tasks, indicating a gap in their understanding of basic algorithm concepts. These challenges can be exacerbated by less adaptive traditional assessment methods, such as written exams or manual grading, which require significant time and effort from instructors. As a result, trainees' potential cannot be identified and developed optimally.

Artificial Intelligence-based approaches, particularly those involving machine learning, can provide solutions. There are three main types of learning in machine learning: supervised learning, unsupervised learning, and reinforcement learning. Supervised learning is used when training data has clear labels, such as grades or categories. This algorithm is often used to predict student success based on historical data [7]. Unsupervised learning is applied to group students based on their behavioral patterns or learning styles. This technique is useful for identifying groups of students who may need additional intervention or a different teaching approach [8]. Reinforcement learning methods were developed to create adaptive assessment systems. In this approach, the system learns from feedback on previous actions. The system adjusts its assessment strategy based on these results to provide more targeted challenges or support. This aligns with the concept of personalized learning, which is currently trending in digital education [9].

Artificial Intelligence-based assessment systems have the ability to analyze data in real-time, provide adaptive feedback, and assess learning outcomes objectively and efficiently. The Machine Learning approach allows the system to learn patterns in trainee data, such as performance in completing tasks, completion time, and level of difficulty encountered. Based on this analysis, the system can provide specific and personalized recommendations to improve trainee abilities [10]. Artificial Intelligence-based assessment system is relevant to the needs of an increasingly dynamic workforce. According to [11], 85 million jobs are expected to undergo transformation due to technology adoption, while 97 million new digital-based roles will emerge by 2025. Such a system allows trainees to prepare themselves with skills that are more adaptive and relevant to market demand. Today's industry seeks individuals who not only possess technical skills but are also capable of independent and adaptive learning. An Artificial Intelligence-based assessment system can help identify trainees' strengths and weaknesses, allowing them to focus their learning efforts on areas that require improvement [12].

This research aims to design an Artificial Intelligence-based computer programming training assessment system with a Machine Learning approach. The methods used include collecting participant training data, task analysis using a supervised learning algorithm, and an Agile development model to provide real-time adaptive feedback. The designed system is expected to be able to provide adaptive assessments to support the programming training process more effectively, which ultimately can improve competency in the field of computer programming.

2 Method

This research uses the System Development Life Cycle (SDLC) approach with the Agile development model. The Agile model supports close collaboration between developers and users, ensuring that the designed applications are in accordance with their real needs and can effectively support adaptive learning. The concept of Agile Software Development represents a paradigm in software creation that emphasizes collaboration, adaptation, and evolution [13]. Thus, the core values of Agile, namely flexibility, responsiveness, and continuous improvement can be realized on an individual scale, allowing developers to respond to project dynamics with the same agility as in larger team collaboration [14]. The stages of Agile development consist of a continuous cycle that includes five main phases, namely:

2.1 Requirements

The requirements phase identifies the functional and non-functional needs of the assessment system. These needs can be obtained through interviews, surveys, or observations of potential users such as lecturers, instructors, and students. In the context of AI and ML, requirements also include data required for model training, evaluation parameters, and expectations for the system's prediction results. This requirements analysis will form the initial system specifications that can be gradually adapted throughout the development process [15].

2.2 Design

The design phase aims to develop the system architecture and interface based on predetermined requirements. In AI-based systems, the design includes the structure of the Machine Learning model used and the data flow from participant input to assessment results. The design also considers the integration of NLP or ontology to support comprehensive assessment. Furthermore, the user interface is designed to be user-friendly and intuitive for both instructors and participants. The iterative design approach in Agile allows the team to continuously evaluate and improve the developed prototype.

2.3 Development

The development phase is the process of implementing a system based on an agreed-upon design. Development is carried out incrementally and gradually over short sprint cycles, typically two to four weeks. Each sprint produces functional components that can be tested and deployed. In the context of AI, this process includes training ML models with curated datasets, testing the models on test data, and integrating these model modules into the assessment system. Collaboration between data scientists, software developers, and educators is key to completing this phase effectively [16].

2.4 Testing

The testing phase is carried out iteratively each time a function is added or changed. In AI systems, testing involves evaluating model performance, such as accuracy, precision, and recall, as well as validating assessment results against manual assessments by educators. Testing should also address data security, resilience to disruption, and ease of use. Through an Agile approach, test results are immediately communicated to the team for refinement before moving on to the next iteration [17].

2.5 Deployment

The deployment phase includes implementing the system in a live environment and monitoring its performance directly. This process should be supported by user training, technical documentation, and a support system for troubleshooting. In Agile practices, deployment is carried out in incremental releases so users can immediately utilize initial features while the system continues to be developed. Evaluation of user responses and assessment results are used to refine the system in subsequent iterations. This approach ensures that system development is dynamic, adaptive, and sustainable, tailored to educational needs.

3 Result and Discussion

3.1 Result

The Artificial Intelligence-based computer programming training assessment system with a Machine Learning approach is designed so that instructors and students have the convenience of accessing grades and also providing assessments and additional learning materials with devices that students often use, namely Android smartphones.

In the requirements stage, researchers selected technology for the development of an Artificial Intelligence-based computer programming training assessment system with a Machine Learning approach. This includes the programming language used by researchers. In this study, researchers used the Typescript programming language. For the frontend, researchers used the React Native framework, while for the backend, developers will use NestJS. The React Native framework was chosen by researchers because it has good stability and is specifically designed for Android application development. Meanwhile, the NestJS framework was used because it supports the development needs of this application. NestJS offers an efficient and scalable architecture, which is very important in developing applications that may need to handle large data volumes and complex operations, such as value analysis and adaptive learning with a Machine Learning approach. The Node.js framework provides high performance and ease in managing asynchronous operations that often occur in web-based and Android applications. In addition, NestJS fully supports Typescript, providing more structured and secure development by utilizing Typescript features such as static typing and object-oriented design.

The design phase involved creating a Use Case Diagram and Entity Relationship Diagram (ERD) for the Artificial Intelligence-based programming training assessment system with a Machine Learning approach. The purpose of creating a Use Case Diagram was to simplify the development process and identify the features to be developed. The Use Case Diagram design for this development can be seen in Fig.1 below:

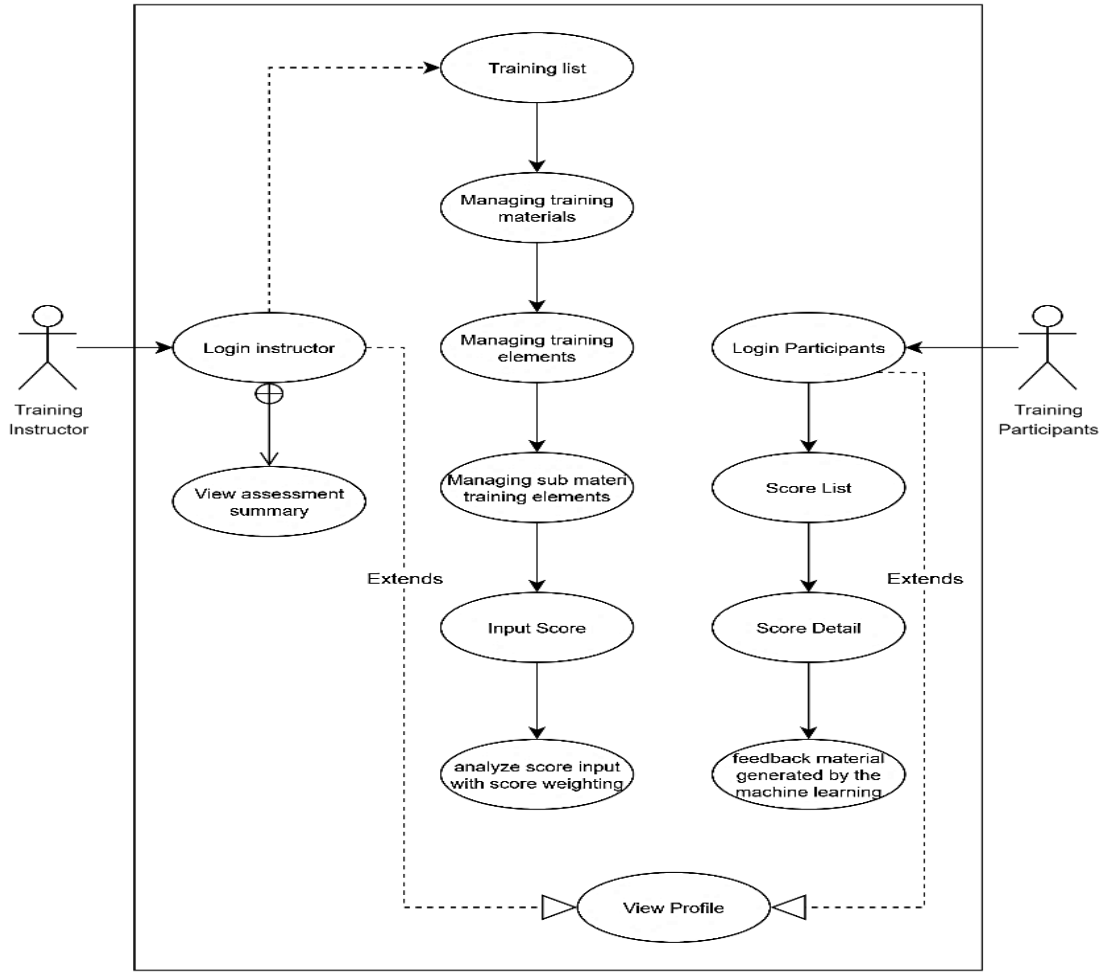

Fig. 1. Usecase diagram of Artificial Intelligence-based assessment system.

Researchers also designed an Entity Relationship Diagram (ERD) to simplify the development process, particularly in the backend. The Entity Relationship Diagram (ERD) design can be seen in Fig.2 below:

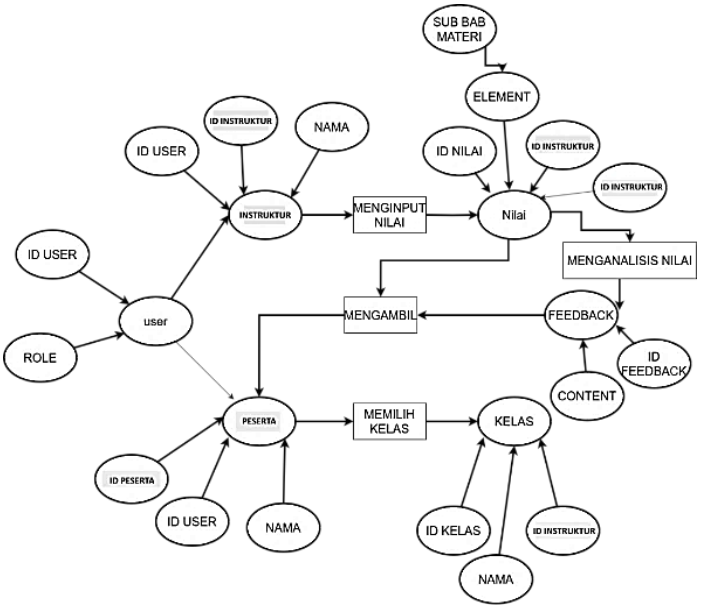

Fig. 2. Entity Relationship Diagram of Artificial Intelligence-based assessment system.

In the development phase, the researcher set up the backend environment by installing and configuring NestJS. The backend setup also included the database configuration to be used, along with the API endpoint that would facilitate communication between the application's frontend and the server. In the frontend development phase, the focus was on the user interface (UI) design that had been designed into an interactive and responsive application, using React Native as the main framework. In the backend development, the researcher implemented important functions such as user authentication, session management, grade input, and a reporting mechanism that would be used by instructors. Next, the researcher integrated an Artificial Intelligence algorithm into the backend, which was responsible for analyzing grades and generating relevant adaptive learning content. The use of Artificial Intelligence enabled the application to provide personalized feedback. The feedback display in the form of looping material can be seen in Fig.3 below:

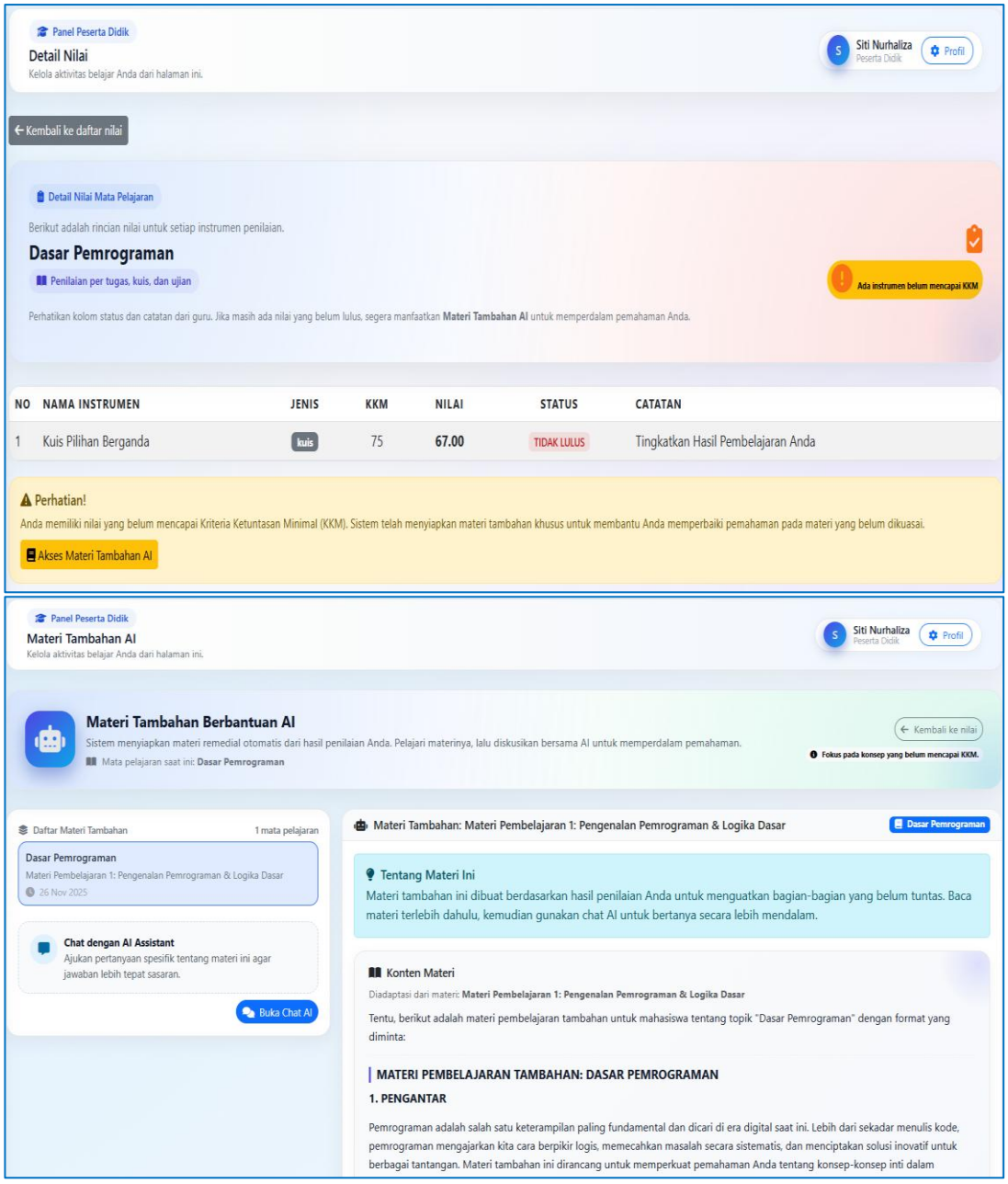

Fig. 3. User interface of repeated material.

In the testing phase of the computer programming training assessment system design based on Artificial Intelligence with a Machine Learning approach, researchers ensure the reliability and functionality of the application. This process begins with unit testing, where each component of the application, both on the Frontend and Backend sides, Next, researchers conduct integration

testing that ensures that all application components, when working together, produce the expected output and meet the established specifications. This is important to ensure that the integration between the frontend developed with React Native and the Backend run by NestJS runs smoothly. The researcher's backend testing process utilizes the postman feature to test each endpoint, as can be seen in Fig.4 below:

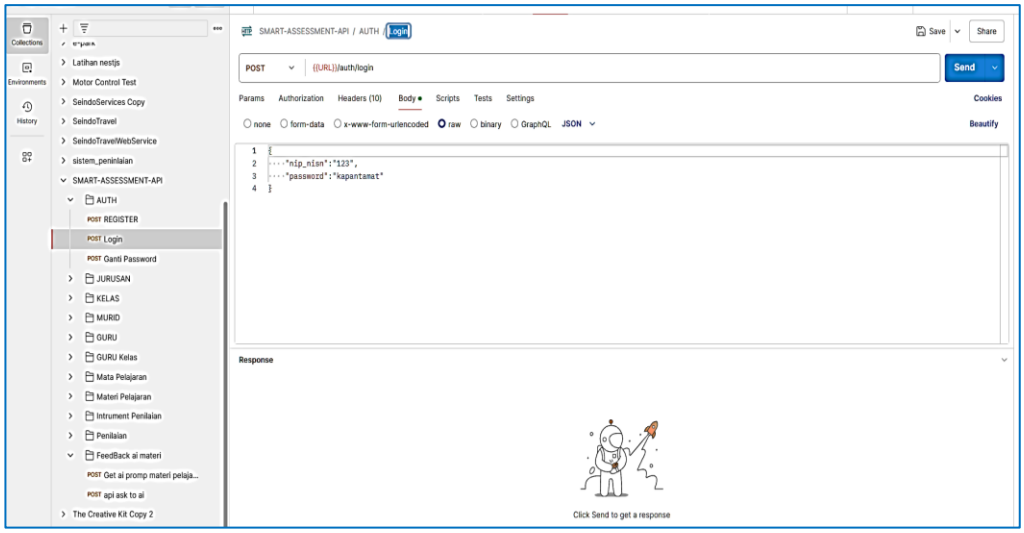

Fig. 4. Backend Testing with Postman.

The deployment phase is the phase in which the application, which has been thoroughly developed and tested, is ready to be launched and used in a real-world environment. The Deployment process begins with the collection of all completed application components, including optimized front-end code, a stable back-end, and a well-structured database.

After designing the backend, the next step was to integrate the API into the VPS (Virtual Private Server). In this stage, the researcher created a repository on GitHub to store the author's code. The use of GitHub as a code repository can be seen in Fig.5 below:

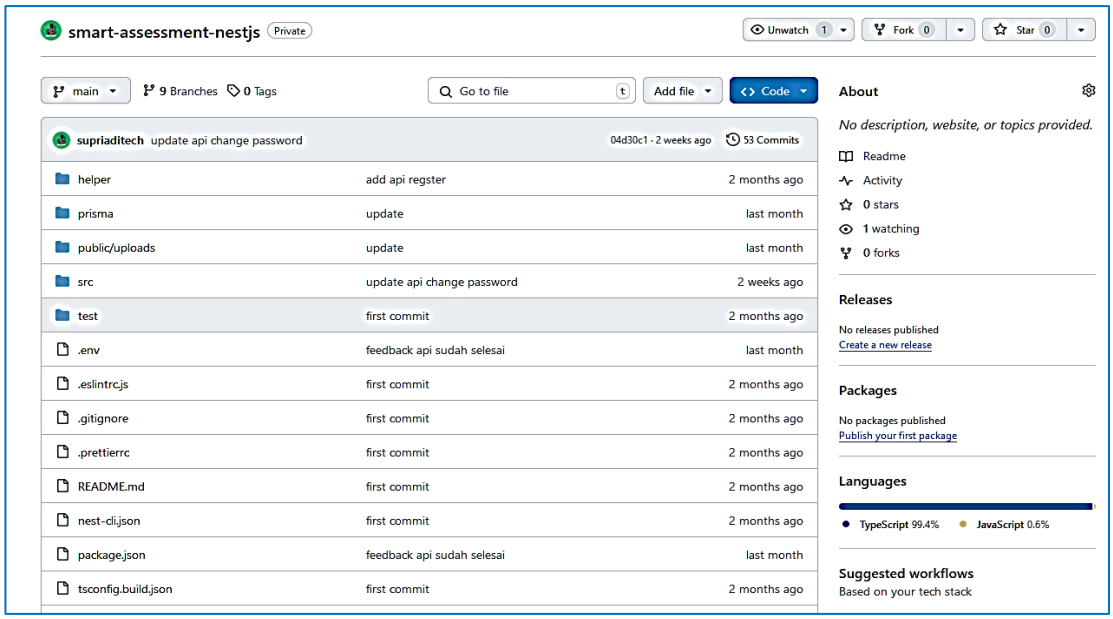

Fig. 5. Using GitHub as a code repository.

3.2 Discussion

The integration of Artificial Intelligence and Machine Learning in programming assessment systems creates a new, smarter, more adaptive, and more efficient approach. This system not only assesses the final results of participants' programs but also analyzes their thought processes and problem-solving patterns. This technology enables real-time, data-driven assessments. In the context of programming learning, both are used to build automated source code evaluation models. These models are capable of detecting syntax and logic errors, and providing specific feedback to participants. The system's strength lies in its ability to provide continuous feedback throughout the learning process.

Assessment accuracy is enhanced because the system can compare thousands of solutions from different participants. Machine learning enables comparative analysis of different approaches to solving tasks, allowing participants to understand where they stand compared to others. This supports the development of more informative and reflective formative assessments. Furthermore, artificial intelligence can be used to automatically design questions based on the participant's ability level. With adaptive algorithms, questions are tailored to previous work, maintaining a balance between challenge and competence. This promotes personalized and engaging learning.

The Artificial Intelligence system is capable of analyzing recurring error patterns and automatically recommending remedial materials. This system is very helpful in addressing understanding gaps early on without having to wait for instructor intervention. As a result, teaching time is more efficient and focused on the real needs of students. Artificial Intelligence-

based assessments with a Machine Learning approach also support authentic assessment through simulations and problem-solving based on real cases. This system can evaluate not only right or wrong answers but also students' strategies, efficiency, and creativity in completing tasks. This adds a depth of assessment that is difficult to achieve with conventional assessments.

The use of an analytics dashboard is a key feature of this integration. Instructors and learners can view skill development over time through visualization of learning data. This facilitates advanced learning planning and evidence-based decision-making. Real-world examples of this integration can be seen in platforms like CodeGrade, Mimir, and Codio. These platforms offer automated assessments, instant feedback, and progress tracking based on Artificial Intelligence and Machine Learning. Their success serves as a benchmark for the development of similar, more contextual and flexible systems.

The design of this system requires thorough testing and validation to ensure fair and unbiased results. The use of representative training data and transparent algorithms are crucial to ensure fairness in assessments. Without proper controls, the risk of discrimination and inaccuracy can increase. With its numerous potential and benefits, the integration of Artificial Intelligence and Machine Learning into programming assessment systems is a strategic step in technology education reform. This system can support self-directed learning, increase motivation, and create a more responsive and purposeful learning environment [17].

4 Conclusion

This study has described the design of computer programming training assessment system with machine learning approach. The design phase used refers to the design steps according to the Agile development model. After the design of the computer programming training assessment system with machine learning approach is determined, the next step that is the target of the researcher is to develop and implementing the system. This stage consists of installing the required software, creating a basic bot and inputting the source code. This stage will be completed in the next research stage.

Acknowledgments. Thank you to the Institute for Research and Community Service in particular and the Leadership of Medan State University who have funded this research so that the design of a computer programming training assessment system with a machine learning approach can be implemented..

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