

Algorithm of Assessment System in MOOCs Learning: Literature Review

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ABSTRACT

Assessment of learners in the MOOCs online learning platform creates problems for teachers in using appropriate assessment strategies. The change from the traditional face-to-face learning model to the MOOCs online learning model does not necessarily apply traditional classroom assessment strategies to online classes. The traditional and online classroom assessment strategies are far different, teachers and participants do not meet face-to-face and do not know each other physically. The algorithm has a very important role in automating the assessment in accordance with the assessment strategy that is in accordance with the characteristics of online learning MOOCs. The purpose of this study is to identify the use of this type of algorithm in supporting the assessment strategy in the MOOCs system. The method used in this study is through a literature study using the Scopus and sciendirect database sources published between January 2013 to May 2021. The results show that formative and summative assessments are carried out automatically using algorithms classified as artificial intelligence. This can be used as a reference for the development of learning and assessment of adaptive MOOCs in accordance with the characteristics and learning objectives of the course.

Keywords: *assessment, algorithm, moocs, artificial intelligence*

1. INTRODUCTION

The learning models of Massive Online Open Course (MOOCs) are increasingly prevalent in the digital era along with the COVID-19 pandemic, which requires learning to be carried out from their own home[1]. The service of MOOCs learning are needed by all circles of society, especially in the field of education ranging from basic education, middle education to higher education which is carried out cross-sectionally according to the needs of students regardless of educational background, expertise, gender, age, race, language, culture and ethnicity[2]. The principle of MOOCs, first is that it is available to everyone without any limitations on accessibility to the material. The curriculum structure and course assessment mechanism are presented openly using certain algorithms. The second is the number of participants in the class is not limited and even strived to be much larger than traditional face-to-face offline classes. Third, it does not require the physical

presence both the learner or instructor so that all classes are conducted and monitored remotely. The fourth is learning models fulfill the principles of learning theory by providing all learning tools and media. Like traditional learning, learning through MOOCs is also conducted online assessment of all students. However, in its implementation, not all participants can follow the learning until the end due to several factors including interest or self-motivation and also the impression of previous learning experiences. Besides that, MOOCs also do not provide a bond for participants to complete learning until the final exam assessment stages[3].

The main problems in MOOCs is that requirement for doing assessment with students. With a very large number of participants and everything is done via online, of course this is become problem and complexity that is not easy compared to traditional face-to-face learning. It takes a computerized system to perform tests using a particular programming language. However, the successful use of

programming languages in solving systems in MOOC is highly dependent on the scenario of the assessment model. Computer-based automated systems can assist in building student learning processes and outcomes, providing learning feedback easily. The quality of learning outcomes can be improved through the ease of conducting assessments and routines as well as the accuracy of feedback. There are at least 2 challenges in online MOOCs learning in the future, it is the use of the right algorithm and the method or element of the assessment. The use of MOOCs learning assessment methods such as peer assessment, self-assessment, formative, summative and others with various kinds of each flow so that a suitable algorithm mechanism is needed so that it is easy to implemented in programming languages so that the assessment becomes automatic [4]

The literature study on the diversity of assessment instruments and learning outcomes has in previous research [5] reviewed the involvement, academic achievement, and friction of learning outcomes assessment. Peer review identified those published between 2017 – 2019. After going through the excluding and screening process, 65 papers were obtained. Some of the assessment elements are cognitive outcomes (knowledge, intellectual skills), behavioral outcomes (engagement, course completion), affective outcomes (course satisfaction, perceptions of MOOCs experience, Perceptions of MOOCs benefits). Instrument types and characteristics (Assessment instruments of cognitive outcome, Assessment instruments of behavioral outcomes, Assessment instruments of affective outcomes). This review synthesizes the MOOCs assessment study from 2017 to 2019 which is presents an overview of scientific research for assessment in MOOCs, but the existing review has not provided an overview of the use of algorithms for each assessment model.

In the context of assessment in MOOCs, this research is important because it presents challenges that need to be overcome to make the MOOCs system usable in learning and assessment automatically using the right algorithm. The results of the research presented in a systematic literature review are useful for researchers, system developers and decision makers from educational institutions as reference material in developing MOOCs information systems.

It is important to involve algorithms that have an important role to improve the performance and accuracy of the scoring system in learning MOOCs. Researchers can find out the modified algorithm model to improve assessment performance and find out the obstacles faced by previous researchers.

The basis of scientific knowledge is about the role of algorithms for assessment systems in MOOCs learning is reviewed by asking 2 research questions as follows:

- (1) What type of assessment is used in MOOC learning?
- (2) What model of algorithm is used in MOOC learning?

2. METHODS

The researcher conducted data analysis using Mendeley analysis tool. The primary data sources used are from ScienceDirect and Scopus in the form of RIS files. Using the keyword "*assessment algorithm mooc*" obtained 440 papers. The year of research was not limited from the first, but it was finally limited to May 2021. All search results were saved in the RIS file format and then the researchers exported RIS data into Mendeley. Based on the results of the analysis, there are papers that do not complete metadata such as author, abstract and title. There are 9 papers that do not have title metadata. There are 39 papers that do not have title. The researchers excluded 48 papers. The remaining 392 papers. The steps are presented in Figure 1.

The researcher filtered the paper at Mendeley which had the keyword "*assessment algorithm mooc*". From the results of this filtering, 32 papers were obtained. Next, the researchers conducted a study of the contents of the paper using scanning techniques, reading the paper manuscripts starting from the title, abstract, method, results and discussion and conclusions. The results of reading the contents of the paper obtained information on the types of assessments and their algorithms in completing the assessment on the mooc online learning system [6]. Based on the results of the in-depth analysis, there are 21 papers that have information according to the theme and research questions as presented in Table 1.

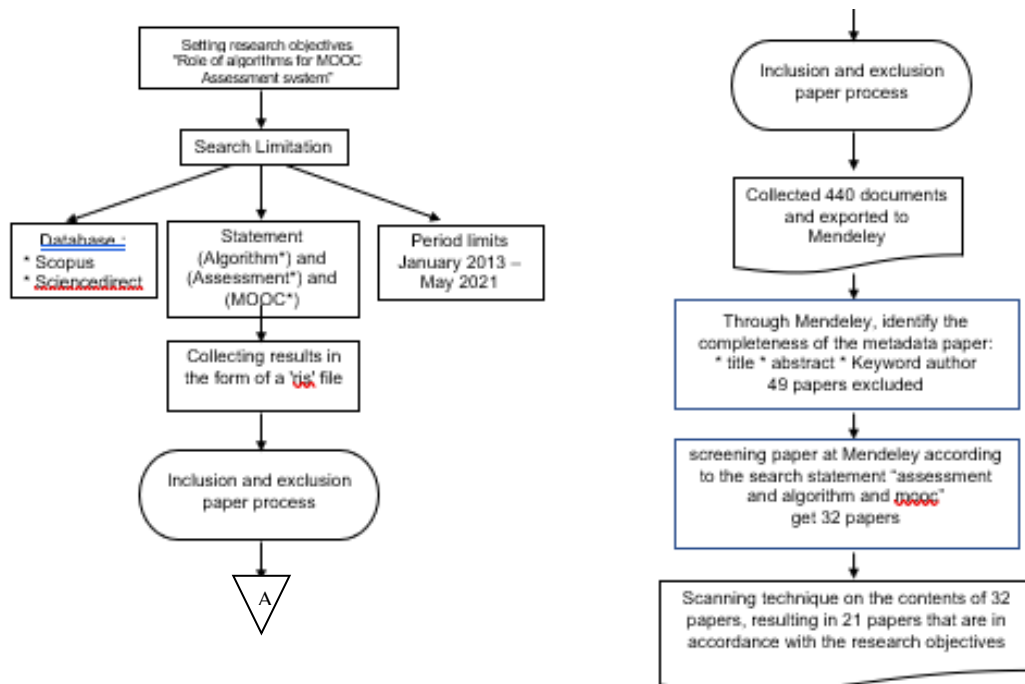


Figure 1 Research stages

Table 1. Summary of research studies on assessment algorithms in mooc

Author	Algorithm	Assessment	Type and Year
Acosta, E S. Otero, J J E	expression regular	Essay Short answer	Journal 2014
Sciarrone, F, Temperini, M	Algorithm K-NN	Peer assessment	Conference 2020
Wong, T.-L.Poon, C K. Tang, C M. Yu, Y T.Lee, V C S	Greedy Algorithm	exercise assessment	Journal 2021
Duru, I.Sunar, A S. White, S.Diri, B	Deep learning	Engagement (page, video, audio), assignment	Journal 2021
Wang, Y. Wang, H. Schunn, C. Baehr, E	The three algorithm : post, pre and submission-queue	Peer assessment	Conference 2016
Xu, J. Li, Q.Liu, J.Lv, P.Yu, G	Inference Algorithm	Peer assessment	Journal 2021
García-Molina, S.Alario-Hoyos, C.Moreno-Marcos, P M. Muñoz-Merino, P J. Estévez-Ayres, I. Kloos, C D	grading algorithm	summative assessment	Journal 2021
Abrache, M.-A. Megder, K. Cherkaoui, C	the algorithm of submissions allocating	Peer assessment	Journal 2018
Yang, T.-Y. Brinton, C G. Joe-Wong, C. Chiang, M	Grade prediction Algorithm	Individual assessment	Journal 2017
He, Y. Hu, X. Sun, G	Monte Carol Markov chain (MCMC) algorithm	peer-assessment cognitive diagnosis framework (PACDF)	Conference 2019
Na, J. Liu, Y	Calculation Algorithm	Self and peer assessment	Conference 2019
Sun, G X. Bin, S	Algorithm LCD Local Community detection	Formative engagement	Journal 2018

Srikant, S	Algorithm grading Machine learning	Automatic assessment	Conference 2014
Sciarrone, F. Temperini, M	algorithm K-NN	peer asesment	Journal 2020
Lan, A S. Vats, D. Waters, A E. Baraniuk, R G	algorithm clustering dan Bayesian non parametric	Homework assignment	Conference 2015
Subha, S. Priya, S B	Algorithm Machine Learning	Hadir, assignment, online test	Conference 2019
Canessa, E. Logofatu, B	Algorithm pinvox	Formative assessment, every end of subject	Journal 2013
Adnan, M. Habib, A. Ashraf, J. Mussadiq, S. Raza, A A. Abid, M. Bashir, M. Khan, S U	Random Forest (RF) Algorithm	Combination of Assessment score and engagement	Journal 2021
Kaur, A	deep learning (DL) algorithms	Formative Engagement prediction	Conference 2018
Bystrova, T. Larionova, V. Sinitsyn, E. Tolmachev, A	learning analytics algorithm	theory tests home assignments, project assignments, the final test.	Journal 2018
Nekhaev, I. Zhuykov, I. Manukyants, S. Maslennikov, A	Bayesian Cognitive Network (BCN)	Test, peer assignment, practices assignment	Journal 2020

3. RESULT AND DISCUSSION

3.1. Assessment in MOOCs Learning

Peer and self assessment. It's an assessment process between peers who are taking the same learning, that is a student assesses classmates or friends in the same subject material. The purpose of peer assessment is to see the development of creative, innovative and learning experiences during the learning process. In addition, peer assessment is also intended to obtain competence information on knowledge achievement and skills from learning outcomes. With peer assessment, dialogue and discussion will appear between students in one class to share learning experiences with each other through the guidance of teachers or instructors[7].

Peer Assessment. Learning through MOOC which has many participants and is not limited in numbers will certainly be a problem in the assessment system, especially from the side of instructors who are not able to complete quickly and accurately to assess the abilities of students objectively. The assessment problem in MOOC is the same as the ability to track participants' learning progress, so that the self and peer assessment methods have a significant role in involving self-assessment and peer assessment[8]. The challenge of using peer assessment in MOOC is the scalability of participants

with different backgrounds such as language, country of origin, culture, values, communication style and participants perceptions of other participants[9].

Self-assessment as one of the formative assessments needs to be tested whether self-assessment is better than peer assessment and whether students are able to track the quality and learning outcomes only through self-assessment. Meanwhile in MOOCs, the evaluation approach has carried out an open-ended assessment model that can provide empirical evidence about a potential causal relationship between the assessment method used and the learning that occurs. In formative assessment, the majority of students at MOOC come from different educational backgrounds, have intrinsic motivation and tend to take only what is needed so that retention tends to be high and drop out in the middle of the way. So that the peer assessment model in cases like this is not suitable for use in the assessment. In contrast, the self-assessment model is considered the most suitable assessment method to fulfill the needs of independent learners [10].

Personalized Student Assessment. Personalized learning is an assessment model that adapts to the knowledge and skills of each student so that they get new experiences in lifelong learning. A personalized assessment system is in the form of feedback from each participant so that more significant assessment results are obtained regarding their knowledge and deficiency[11]

Topic Interaction Model Assessment. Topic interaction model is an assessment model toward students in online learning. A few assessment variable is behavior on the learning, skills student on doing interaction in discussion forum on the level discussion theme that leveled [12]

Engagement assessment is to seeing the activity level of student involvement in learning activities. In online learning using e-learning system tools, some monitored activities are often represented by participants activities in clicking on the system such as auto content, forumpage, subpage, homepage. In addition, engagement can also be observed through the movement of body parts such as eyes, head and mouth [10]. The involvement of students in online learning such as MOOC, LMS, and VLE can be measured using clickstream data from these system services [13].

3.2. Algorithm in MOOCs Assessment Learning

Linear Regression Algorithm. Linear regression is a predictive method using a straight line to describe the relationship between two or more variables to get the target values (Disa, 015).

K-Nearest Neighbor/K-NN. One type of algorithm in machine learning to solve regression and classification problems. The KNN algorithm uses the data and classifies new data points based on a measure of similarity (eg distance function). In its implementation, the K-NN algorithm classifies the most votes against the closest distance. If there are new points added that have closeness or similarity, then the level of accuracy will increase (Sciarrone & Temperini, 2020).

Fuzzy Algorithm. The fuzzy algorithm was originally used to grouping data's. This algorithm has a flexible data structure and easy adjustment to filter context sensitive information [14]. Offers good potential for effective resolution in the uncertainty problem. Values between 0 and 1 represent uncertainty in decision making, which represents the degree of membership [15]. In MOOC learning, fuzzy algorithm functions are developed into data mining techniques to improve learning outcomes. The results of this data mining can be used as material in the development of the MOOC system that provides topic selection services and learning materials referring to previous learning experiences so that it is expected to reduce dropouts[15].

Probabilistic Graph Model. Probabilistic graph model is a statistical model that encodes complex multivariate combined probability distributions using graphs that capable to capturing conditional independence relationships between interacting

random variables. The probabilistic graph model can be used for modeling on gettings reliability levels of students through a peer assessment system using a collection of values from student assignments [16].

Gamification Algorithm. Gamification is to ensure that student feel motivated for participating both in doing activity or correcting them. Gamification technique used as motivation aspects on peer assessment is one of big profit, enabling greater student involvement and their motivation to participate in the process[17].

Greedy Algorithm. It's an algorithm to generalized matching rules from a set of program output variants that are automatic so that it can save time for instructors in making rules and reduce training time achievements [18]

Bayesian Algorithm. Bayesian Cognitive Network (BCN) Algorithm. The BCN algorithm is used to find the events probability to predict solutions based on the closest tasks in the cognitive structure of students [19]. Further research was carried out by [20] the assessment was carried out through observations on the behavior of students watching videos using Bayesian regularization with reverse propagation. Bayesian regularization minimizes the linear combination of squared errors and weights, finds parameters to minimize the number of errors and adjusts the weights and parameters are trained to minimize the number of errors.

Matrix Factorization Algorithm. The factorization method looks for trade-off between the cardinal and ordinal approaches. we use the factorization method to study the usefulness of the function [21].]. This function estimates a consensus sequence of tasks that calculates a rating which can be easily converted into a rating function for each task. describe a factorization approach to scoring, as a scalable method that capable on handling very high volumes of data [22]. This method is also capable of representing the content of the open response using the vector space model of the answer. This factorization method is then completed by extending the assessment model to answers that are not involved in peer assessment, which is then called matrix factorization. Matrix factorization is to learn how to score which includes a method for arranging students' answers in a metric space according to their scores[23].

Epistemic Network Analysis. Epistemic Network Analysis (ENA) is used to analyze and visualized the mathematical representation data of the pattern of relationships between codes in the epistemic frame of discourse. ENA modelled the connections between different concepts and projects them into two-dimensional space as a nondirectional network. This allows comparison between groups by reducing the network edge weights [24].

Grading Algorithm. This algorithm considers both message numbers (quantity) and message relevance that using direct measurable indicators for learner contributions in the course forum but without using text mining techniques [25].

Monte Carol Markov Chain (MCMC) sampling algorithm. This algorithm included to the category for summative assessment. In this case, conducting an assessment of 2 elements, namely peer assessment and cognitive diagnosis in predicting the performance of examinees can also define the relationship between the skills of the examinees and mastery of the problem. The experimental results show that the model can quantitatively explain and analyze the skill proficiency of each examinee, so that it is better at predicting the performance of the examinees[26]

Local Community Detection (LCD) Algorithm. It's an algorithm to detecting interaction in discussion forum groups. What is meant by interaction detection is collecting information about the topics discussed in the discussion, and also evaluating the behavior of users in the group. The purpose of using this LCD algorithm is to produce a more comprehensive and effective evaluation index for students [12].

Learning Analytics Algorithm. It's an algorithm to analyze and predict the behavior of students using several variables, namely demographics, clickstream, and assessments. The benefit of using this algorithm is that it is able to get a score for each participant according to the duration of the learning time. The results of this learning analytics predictive model can facilitate teachers to guiding intervention and direct students who have low learning performance [27]

Personal Identification Number by Voice (PINVOX) algorithm. Pinvox is an algorithm to assist formative assessment through checking the attendance of participants in online learning by identifying online audio PINs and to encourage students attention through randomly selected audio PIN identification from the presented learning video stream. Then the results of the identification of the PIN are recorded and submitted to the teacher.[13]

Deep learning. Deep learning algorithms include algorithms that support formative assessment which involve many elements of student engagement such as facial expressions, body movements, gaze patterns. Deep learning algorithms can assist assessment through the exploration of learner engagement automatically through MOOCs learning[28]

3.3. Mapping Assessment and Algorithm

There are 2 types of assessments for students that use a variety of algorithms. peer assessment uses 6 types of algorithms, engagement uses 6 types of algorithms.

while other assessments use 3 type of algorithm. The following mapping results are presented in Table 2.

3.4. Limitations And Future Research

In the literature review study in this paper, the primary research data sources were taken from the reliable database Scopus and sciencedirect which published between January 2013 to May 2021. The purpose of this study is to explore the results of research on the use of certain algorithms for the appropriate types of assessment in MOOCs learning. The studies reviewed provide an illustration that there are differences in the assessment model in traditional face-to-face learning with online learning MOOCs. The determination of the using assessment model in MOOC online learning affects the type of algorithm used to support the effectiveness of the assessment implementation. This can help researchers, application developers and policy makers in educational institutions in preparing a future online MOOCs assessment system using the right algorithm principle so that the assessment results are accurate.

Table 2. mapping assessment and algorithm types.

Type Assessment	Algorithm
Peer Assessment	<ol style="list-style-type: none"> 1) K-NN Algorithm 2) Calculation algorithm 3) Inference Algorithm 4) Allocation Algorithm 5) Compact and Merge Algorithm 6) Monte Carol Markov chain (MCMC) algorithm
Engagement	<ol style="list-style-type: none"> 1) Deep Learning Algorithm 2) Random Forest Algorithm 3) Bayesian Cognitive Network (BCN)Algorithm

4. CONCLUSION

Based on the results of this study, it can be seen that the algorithm has an important role in the student assessment mechanism. each online learning assessment model uses a specific algorithm that is implemented in the form of an assessment information system application. the type of assessment in online learning has different characteristics from the assessment in traditional face-to-face learning in the classroom. The algorithm used is based on artificial intelligence and machine learning.

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