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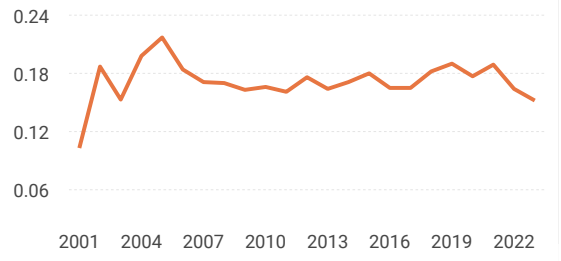

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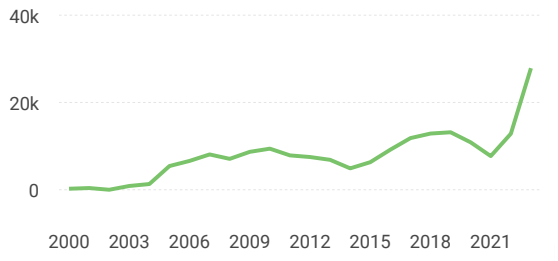

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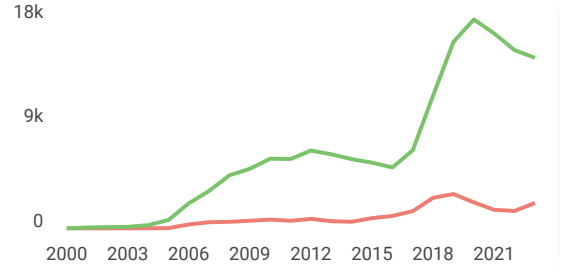

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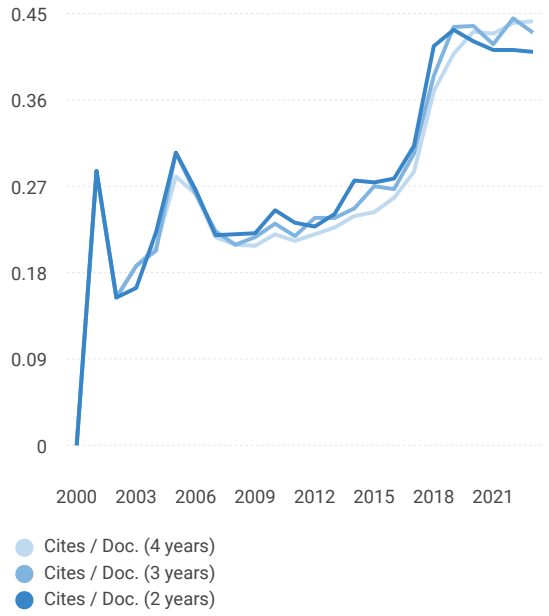

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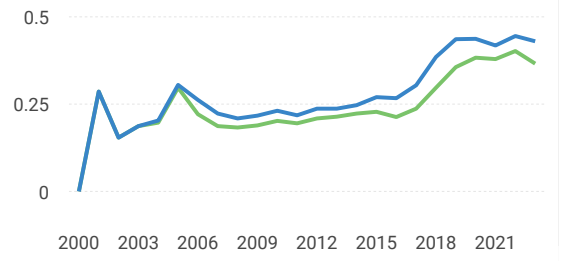

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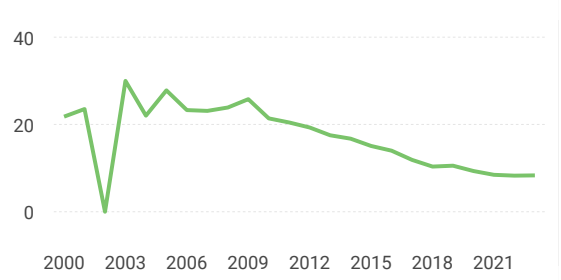

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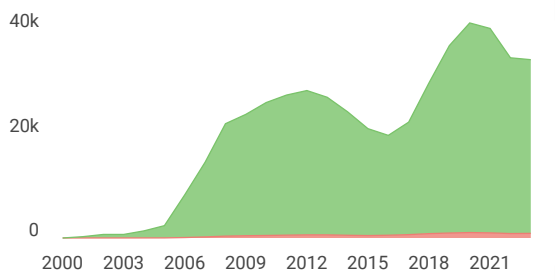

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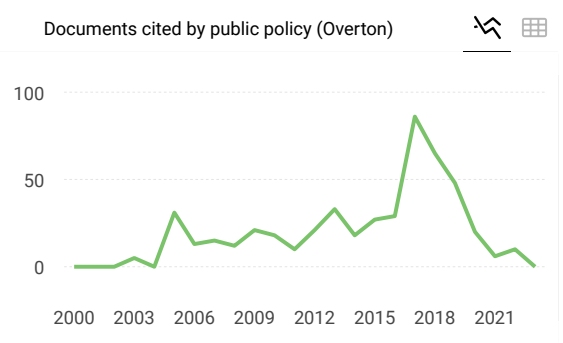

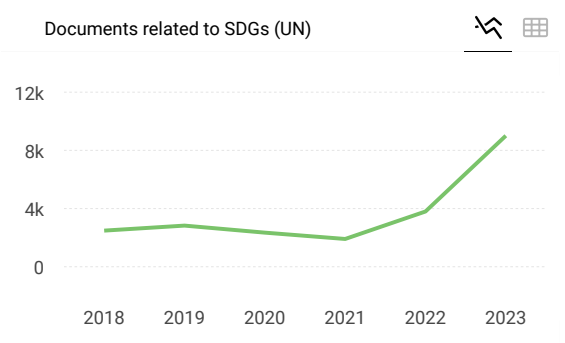

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University of California San Diego,
San Diego, CA, USA

Javier E. Garay is a professor in the department of Mechanical and Aerospace Engineering and the Materials Science and Engineering Program at the Jacobs School of Engineering at University of California, San Diego (UCSD). He received his B.S. in Mechanical Engineering, his M.S. and Ph.D in Materials Science and Engineering all from the University of California, Davis. During his PhD studies, he also worked at the Lawrence Livermore National Laboratory where he studied material defects using positron annihilation spectroscopy. Prior to his position at UCSD, he was a professor at UC Riverside where he also served as Chair of the Materials Science & Engineering Program.

As the director of the Advanced Material Processing and Synthesis (AMPS) Lab at UCSD, Professor Garay focuses his research on materials property measurements, the integration of materials in devices with application in optical devices, magnetic devices, thermal energy storage/ management, and materials synthesis and processing with an emphasis on designing the micro/nanostructure of bulk materials/thin films for property optimization. He is also particularly interested in understanding the role of the length scale of nano-/ micro-structural features on light, heat and magnetism.

A.T. Charlie Johnson Jr.
University of Pennsylvania,
Philadelphia, PA, USA

A.T. Charlie Johnson is a professor of physics in the Department of Physics and Astronomy at the University of Pennsylvania. He received his B.S. in physics from Stanford University and his Ph.D. in physics from Harvard University. He did postdoctoral fellowships at the Delft University of Technology (Applied Physics) and NIST (Cryoelectronic Metrology). His honors include the Christian R. and Mary F. Lindback Foundation Award for distinguished teaching at Penn, the Jack Raper Outstanding Technology Directions Paper Award of the International Solid State Circuit Conference, an Alfred P. Sloan Research Fellowship, and a Packard Fellowship for Science and Engineering.

Dr. Johnson's research is focused on the nano-scale transport properties (charge, energy, spin, etc.) of nanostructures and single molecules, including carbon nanotubes, graphene, DNA, synthetic proteins, and other biomolecules. He is particularly interested in the physical properties of hybrid nanostructures and their use in molecular sensing. Other research interests include the development of scanning probe techniques for electronic property measurement of nanomaterials and nanodevices, molecular electronics and nanogaps, local probes of nanoscale systems, and nanotube and nanowire electronics.

Ben Slater
University College London (UCL), London, United Kingdom

Ben Slater is a professor at UCL Chemistry. He received his BSc in chemistry from the University of Nottingham and was awarded his PhD at the University of Reading. He did postdoctoral work at the Royal Institution of Great Britain (Ri) and became an assistant director of the Davy Faraday Research Laboratory at

the Ri in 1999. He joined UCL Chemistry in 2007 and was awarded the Royal Society of Chemistry Barrer prize in 2008.

Dr. Slater's research is focused on using atomistic computer simulation to understand and predict the structure and properties of materials. He has published extensively in the area of porous materials (including zeolites and metal-organic frameworks) and water ices. He has a particular interest in defects in materials and surface mediated processes, such as crystal growth.

Masaaki Tanaka
The University of Tokyo,
Tokyo, Japan

Masaaki Tanaka is a professor at the Department of Electrical Engineering & Information Systems Graduate School of Engineering, University of Tokyo. He received his Ph.D. in electronic engineering from the University of Tokyo in 1989. In 1992, he joined Bell Communications Research (Bellcore) at Red Bank, New Jersey, as a visiting research scientist. Since 1994, he has been at the University of Tokyo as an associate professor and professor.

Dr. Tanaka's main research field is spin electronics ("spintronics"), in which the spin degrees of freedom are used in artificially synthesized materials. Among the areas of his specific research are epitaxial growth, structural characterizations, electronic/optical/magnetic/spin-related properties (in particular, spin-dependent transport and mageto-optical properties), and device applications of various new structures. His research on structures and devices includes ferromagnetic metal / semiconductor hybrid structures, III-V-based magnetic semiconductors and their heterostructures, group-IV-based magnetic semiconductors, ferromagnetic nanoparticles and semiconductor hybrid heterostructures, delta doping of magnetic impurities in semiconductor heterostructures, and new spin transistors (e.g., spin-MOSFET) and reconfigurable logic devices.

Enge G. Wang
Peking University,
Beijing, P. R. China

Enge Wang is a professor of physics and President Emeritus of Peking University. He also chairs the Advisor Board of the Institute of Physics, Chinese Academy of Sciences (CAS).

Dr. Wang's research focuses on surface physics; the approach is a combination of atomistic simulation of nonequilibrium growth, chemical vapor deposition of light-element nanomaterials, and water behaviors in confinement system. He and his coworkers also predicted a three-dimensional Ehrlich-Schwoebel barrier, which attracted News and Views in Nature (June 2002). Another contribution is the model proposal and experimental validation of a true upward atomic diffusion. This was reported in Physics News Update in June 2003 and News and Views in Nature as well as Science Week in June 2004.

His work on water-surface coupling and the strength of hydrogen bonds at the interfaces provides a fundamental understanding of water on surface at the molecular level.

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Development of experiment module using physics virtual labs application in optics subject studies for secondary high school students

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Developing physics teaching material Newton's law based on local wisdom: Plait

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Study of students group dynamics in online learning on science teaching practice

Wahyu Hari Kristiyanto

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Development of tree-tier type diagnostic test instruments to identify misconceptions in mechanics and static fluids

Demeryati Langtang; Ruth N. K. Mellu; Yabes Olbata

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Developing physics learning tools based on the local community traditionabout global warming to improve student's understanding

Landiana E. Laos; Vivi E. R. Husin; Sonya Y. Manafe; Sonya V. Ch. Benu

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Identification of misconceptions causes of misconceptions of prospective physics teacher candidate using a three-tier diagnostic test with CRI on kinematics of motion static fluids

Ruth N. K. Mellu; Demeryati Langtang; Yabes Olbata; Landiana E. Laos

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Maintaining the quality of the Master's degree programme in physics education at Universiti Teknologi Malaysia

Nina Diana Nawi; Fatin Aliah Phang; Nor Farahwahidah Abd Rahman; Noorzana Khamis

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Drone technology for primary school students in learning STEM

Fatin Aliah Phang; Jaysuman Pusppanathan; Nina Diana Nawi; Fauzan Khairi Che Harun

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The utilization of augmented reality on online learning: The impact for students' physics problem-solving ability

Bramianto Setiawan; Reza Rachmadtullah; Lukman Nulhakim; Endang Wahyudiana; Vina Iasha

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Measuring student's creative thinking ability about simple circuit in physics: An analysis approach modern test theory

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Integrating whole person education in physics asynchronous learning about rainbow

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Student perceptions and achievements of online learning: Machine learning approaches

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Student Perceptions and Achievements of Online Learning: Machine Learning Approaches

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Abstract. The Covid-19 pandemic has been changing all aspects of human life. In education, the online learning method has been selected as one of the ways to prevent the spread of Covid-19. The classical learning method turns into online learning using information technology facilities. There are many challenges to implementing a class online. However, online learning could provide a new perspective for student learning. The study aims to analyze student perceptions of the online learning process. Their perception would be used as an independent variable to predict the student achievement index. The research data were obtained from a student questionnaire. Students provided an assessment through a questionnaire about the online learning methods they experienced during the Covid-19 pandemic. The machine learning algorithms, namely Random Forest and Support Vector Machine, were applied to examine the dataset. The study focused on the criteria (variable importance) that affect student perceptions of the online learning process. The results described that the student achievement in online learning is influenced by: 1) technology to access online learning, 2) student efforts, and 3) active and independent learning. The study contributes to improving the online learning method for the student.

INTRODUCTION

The Covid-19 pandemic has changed almost all aspects of human life, and education is no exception. For example, schools are closed, and an online learning process is implemented. Even though many schools and universities have used online learning in the daily learning process, however, many challenges must be met by lecturers, students, and all stakeholders. Some of the challenges faced include:

a) The classroom changed to digital form (e-learning), and lecturers are expected to deliver material online.
b) Online learning has never been imagined or anticipated for Lab classes.
c) Issues on the use of information technology.
d) Online learning requires internet access. On the student side, it has financial consequences.

Therefore, learning methods need to be continuously developed by analyzing student perceptions, either in-class or online. A study to determine student satisfaction in online learning using a questionnaire has done by Wu *et al.* [1]. The interaction of lecturers and students is an essential point in the questionnaire. Thus, the person in charge of education can determine whether the entire learning process can help students develop and obtain adequate knowledge [2].

Input from student perceptions became essential data and was used as helpful information to develop the learning process. Thus, a more comprehensive picture will be obtained to develop the learning process in class and online [3]. Therefore, it is necessary to analyze the collected data. This data is in the form of student track records and learning processes. Analyzing and evaluating large amounts of data requires tools, i.e., data mining and machine learning, to provide more accurate information [4]. The Data Mining and Machine Learning algorithm approaches can provide an overview of the learning process based on student questionnaire data. Machine learning algorithms such as Random Forest, Naïve Bayes, Support Vector Machine, and Artificial Neural Networks could be implemented.

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A previous study conducted by Ali [5] showed that data mining applied in the education sector could be used for various research, especially in prediction, classification, clustering, and associations associated with the learning process. Data were stored, processed, and analyzed to become information or knowledge, known as Data Mining [4]. Data analysis relating to education and its results to provide input to the learning process development is known as data mining in education [6]. Some researchers also mentioned the role of data mining and machine learning as a research tool in the field of education, for example, to predict applicants [7], study program selection [8], performance lecturers [9], and curriculum development [2]. Kushik *et al*. [10] studied student performance in the online learning process. The research focused on online test problems. The machine learning approach method is used to predict student performance in the online learning process. The research results showed that choosing learning strategies can significantly increase student test scores [10].

In recent years, data mining education has been more and more applied to improve the quality of learning. However, the use of machine learning algorithms to find the variable importance and predict the student achievement index in online learning has not been undertaken. The study aims at two things. The first is to determine which potential factors influence the student semester achievement index. The student achievement index indicates the success of the education process. Academic achievement cannot be separated from learning activities, and many factors could influence the student achievement index. Academic achievement describes the output of the learning process [11]. Therefore, predicting the student semester achievement index by knowing the potential factors is essential. We could prepare and help the student to create a good learning environment. Predicting students' achievement index can prepare students to face courses and prepare lecturers to make teaching materials to understand the lessons correctly. In addition, if the students are predicted to get low students achievement index, the lecturer can accompany the student more intensely. From the student's perspective, student achievement index predictions can also be used for self-assessment. If the students' index achievement is predicted to have a low score, students are asked to focus more on learning. The second is to examine whether the machine learning method could predict student semester achievement index based on their perception of online learning. Random Forest (RF) and Support Vector Machine (SVM) algorithms are proposed to analyze the dataset from the student questionnaire. We examined three criteria: students' perceptions of online lectures, the roles of students and lecturers, and the relation to access and use of information technology.

By knowing student perceptions of the online learning process, the stakeholders could obtain helpful information for improving the online learning process. The results provide a new perspective on data mining and machine learning as tools in the education area. Therefore, to design a better learning process following lecturer and student expectations, we proposed that these study results contribute to online learning development.

METHODS AND DATA COLLECTION

To evaluate whether the online learning process is running well, we conducted a survey to determine the challenges and difficulties of online learning. The survey includes five elements considered necessary in online learning, i.e., self-management aspects, student efforts, technology utilization, student perceptions of self-role, and lecturer role. Moreover, in this study, the five primary elements were examined further and focused on three main student perceptions of their learning online. The three student perceptions are: 1) student perceptions of online lectures, 2) student and lecturer roles in online learning, such as student independence, learning methods from lecturers, and time management, and 3) access to and use of information technology.

Data were collected from 8531 student surveys from the Quality Assurance and Internal Audit Institution (known as LPMAI) Sanata Dharma University, Yogyakarta. From December 2020 to February 2021, students could provide their opinion and perception of the online learning method. The data consist of 33 questions on a Likert scale (disagree, neutral, agree, strongly agree) and Yes-No questions. The 33 questions could be grouped into three main criteria, i.e., the student perceptions, the student and lecturer preparation on online learning, and how to access and use information technology on online learning. The respondents come from eight departments: Business, Pharmacy, Education, Postgraduate, Psychology, Science and Technology, Literature, and Theology. However, in this study, we only used questionnaires from Science and Technology students with 1931 respondents. As the target label, we added the student semester achievement index.

This study applied RF and SVM algorithms using R programming to analyze data. The data processing results focused on student perceptions of the online learning process, including three main criteria in the questionnaire. Data were processed following the steps in Knowledge Data Discovery. First, we grouped the respondents into each department. Furthermore, to analyze data, in the beginning, we have undertaken pre-processing data such as examining

the missing values. After completing the imputation step, we transformed the raw data by converting the questionnaire answer to numerical values such as the yes-no answer become 0 and 1, where no is equal to 0, and yes is 1. When all data were ready, we continued the process to normalization. In this step, we converted all data to be valued between 0 and 1. Lastly, we separated data into training and testing datasets in 70:30 portions.

Next, we performed two main processes. The first process is to find the variable importance. In this process, we applied the RF algorithm to obtain three groups of variable importance, i.e., important, tentative, and unimportant attributes. The second process is to use the crucial attributes to predict the student semester achievement index. We have carried out RF and SVM regression. The Root Mean Square Error (RMSE) value predicts the testing dataset's dependent variable. A low RMSE value indicates a similarity between the predicted data and the actual data. Variable importance is needed to provide an overview of the independent variables that have the most influence in determining the RMSE value. In this study, if we want to understand the online learning implementation better, then the variable importance must be the focus of change. Figure 1 presents the methodology used in this study.

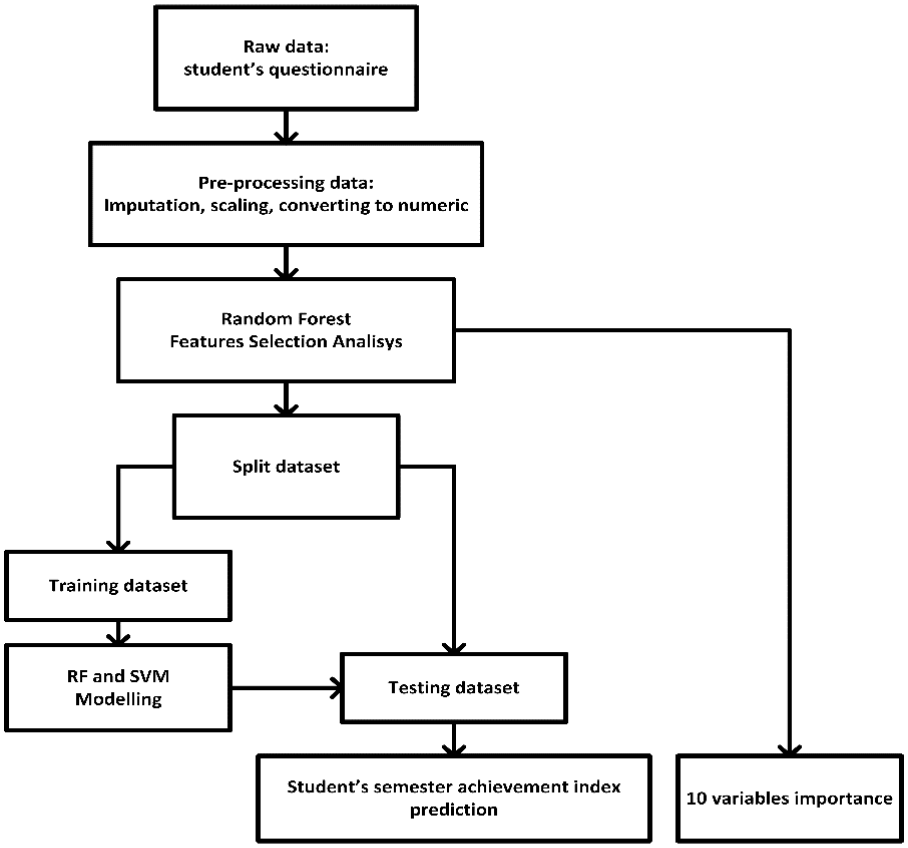

FIGURE 1. The methodology used in the research

RESULTS AND DISCUSSIONS

Firstly, we performed variable importance analysis using the RF algorithm. Figure 2 shows the 10-best attributes (green color). They have a significant factor in predicting the student semester achievement index.

Table 1 describes what factors influence the student semester achievement index. We eliminated the tentative and unimportant attributes as a part of the feature selection process.

In general, we could do grouping these ten important attributes into three significant factors on student perceptions to make successful online learning, namely, the use of technology (1, 2, 5, and 6), student efforts (3, 4, and 9), and creating independent learning conditions (7, 8, and 10).

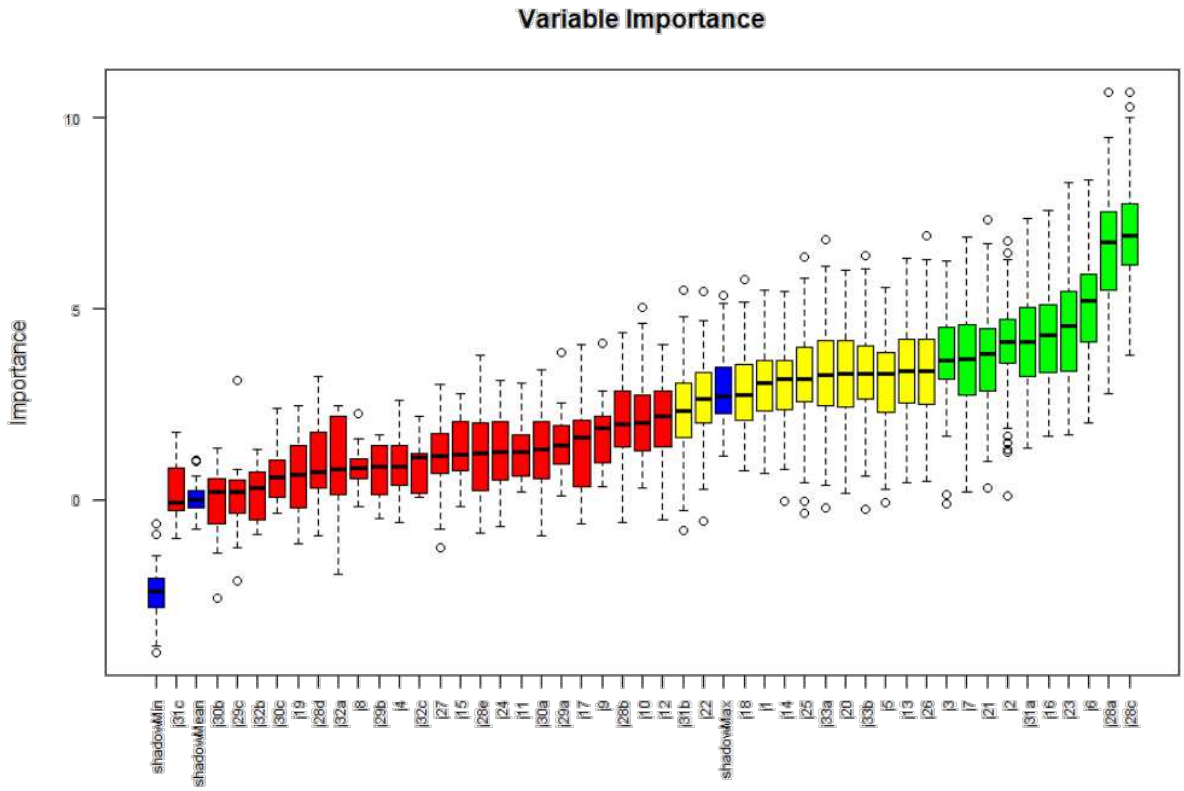

FIGURE 2. Variable importance. The Green color shows the significant attributes, the yellow color is a tentative variable, and the red color is unimportant. In this study, we used only the significant variable that is represented in green color.

TABLE 1. The ten variables' importance.

Number	Variable's Importance
1	The recorded lecture on YouTube is the best tool for learning.
2	The Learning Management System is beneficial
3	Students need more time to learn
4	Students do not encounter any significant problems when they discuss or work in groups.
5	The features used in LMS make students easier to learn.
6	Students need a good internet access
7	Online learning makes students more independent
8	Online learning makes students more enthusiastic to learn
9	Students could explore a new knowledge easily
10	Students are enthusiastically attending the class even though it is online using Zoom

It is believed that technology is a crucial aspect of online learning. Therefore, respondents put this aspect into first and second vital things for successful online learning, followed by using various technological tools for online learning. Students also know how to use technology tools for online learning (e.g., handphone, computers, Google Classroom, Zoom, WA). This is not separated from information technology becoming a mediator, which has an increasingly significant role in this online learning mechanism.

However, Engeström [12] claimed that tools refer to two levels: primary tools (cellphones, computers, internet, books, study rooms) and secondary tools (experiences, language skills, ideas, hopes, motives). Moreover, activity systems in the context of online learning are mediated by five other primary elements, i.e., tools, rules, community, division of labor, and object. Technology plays a crucial role in education allows teachers to design meaningful

learning experiences that embed technology. This is not a new area for students; teachers ought to have considered the tools and resources that may best support learning methods for students. However, advances and accessibility of technologies have made everything possible [13]. The lack of access to information technology due to unsupported equipment and the internet creates frustration, decreasing student motivation and self-confidence [14]. Even though technology has become the primary tool, online learning is the learning process revolution enabled by the new technologies that will present an effective and efficient learning process that did not exist before. Learning Management Systems (LMSs) are responsible for learning activities, while other systems are responsible for handling any supporting learning activities. All systems shall integrate and interoperate together to support educational institutions and online learning [15].

Considering that students as the main subject, we should not focus only on the technology itself. The variable importance also mentioned how student efforts to obtain the excellent semester achievement index. In Cultural-Historical Activity Theory (CHAT), the primary unit is students (as the main subject) who carry out various activities (objects) to achieve outcomes. Information technology in online learning mechanisms is a fundamental component in constructing knowledge based on human consciousness [16]. Learning performance between students who do well and those who ultimately fail has been a concern of researchers since the mid-1970s. What makes students successful compared to those who are not successful in learning? The main differences were in the way of learning.

Doing well in learning performance shows the ability to self-manage (self-regulation). Their metacognitive skills are much better because they can assess their strengths and weaknesses. They can find solutions and compensation that can overcome their weaknesses or shortcomings. The ability to self-regulate metacognitive skills refers to a series of interrelated activities, including the ability to set learning goals and orientation; determining the strategies that will be used to achieve the stated goals; management of various existing resources; the implementation; appropriate reactions to feedback from others; and the meaning of the resulting product. If a series of skills has never been possessed or developed, students will undoubtedly fail to develop regulation of metacognition skills [17].

The survey described that students could do more independently based on their interest through online learning. The student's high self-confidence is related to completing their studies in the online learning process. This factor is mainly determined by the availability of supporting tools in the form of technological equipment, and at the same time, the ability to use various existing technological tools. LMS features and good internet access have created student self-confidence. This finding differs from studies published that have confirmed the strength of feelings, isolation, and growing frustration because of this learning experience in the context of the Covid-19 Pandemic [14].

Independent learning is related to student self-confidence and the ability to manage the time to learning. The previous study on independent learning showed that developing online teaching approaches incorporating other techniques and tools is necessary [18, 19]. For that reason, in its implementation, lecturers provided complete access to communication and problem-solving. Thus, students do not feel separated from their lecturers because of this kind of emotional closeness. It becomes the basis of the formation of mutual trust. Three main elements to build this kind of well-being are communication skills, social tolerance, and creativity. The loss of encounters with lecturers and fellow students has erased the social structure where students could share their burdens and care for each other. Data related to student preferences regarding the role of lecturers in adapting learning material to increase relevance to online learning reflects the tension that has been unconsciously built up so far.

On the one hand, this shows the lecturers' concern for their students, prioritizing well-being orientation or comfort [20]. However, this also shows a strong indication of the existence of fundamental weakness in students, that is, the level of learning independence among students is still relatively low among students [21]. In other words, courses should be designed and taught with their specific strengths and needs in mind. Based on this variable importance analysis, we inferred that the student's perception from the questionnaire could predict the student semester achievement index.

Moreover, we performed prediction analysis using ten attributes as an independent variable by applying RF and SVM algorithms. The target label (a dependent variable) is the student semester achievement index. We compared the prediction result using the default and tuned parameters (a grid search technique) for RF and SVM algorithms, see Table 2.

To determine the best parameter, we implemented a grid search technique. Table 3 expresses the best parameter for prediction analysis.

Two algorithms, RM and SVM, were implemented, and the RMSE results are presented in Table 4. The results showed that we obtained the optimal predicted RMSE value using RF-tuned algorithms compared to other algorithms.

TABLE 2. The default and tuned parameter on the prediction analysis.

Default Parameters	Values	Tuned Parameters	Values
SVM		SVM	
Gamma	0.1	Gamma	$2^{(-5:5)}$
Cost	1	Cost	$2^{(-5:5)}$
Epsilon	0.1	Epsilon	0.1; 0.01; 0.001
RF		RF	
Mtry	1	Mtry	1; 1.5; 2
Ntree	500	Ntree	500; 1000; 2000
Maxnodes	24	Maxnode	24
Maxsize	14	Maxsize	14

TABLE 3. The best parameter.

Algorithms	Parameter Values
SVM-tuned	
Gamma	0.03125
Cost	0.0625
Epsilon	0.1
RF-tuned	
Mtry	1
n-Tree	2000

TABLE 4. The RMSE results on the training and testing dataset.

Algorithms	Training Dataset	Testing Dataset
SVM-default	0.410	0.472
SVM-tuned	0.452	0.460
RF-default	0.367	0.465
RF-tuned	0.440	0.451

CONCLUSION

Machine learning approaches could be used as an alternative way to describe student perceptions of online learning. We predicted the student semester achievement index through the student questionnaire and the semester achievement index and obtained some inputs for successful online learning. The results showed that three things greatly influenced student perceptions in implementing online learning. Technology becomes the most crucial factor when the university wants to establish online learning. Students believed that information technology such as zoom technology, YouTube, and University Learning Management Systems are the main elements supporting their study's success. Students hope that the learning material needs to be changed and adapted to the online learning process or method. In other words, lecturers are asked to change the format for delivering learning material.

Two aspects, the second and the third, are related to students and study environments. Students acknowledged that they need more time to learn to catch new knowledge. They also recognized that they could do some discussion between students to enhance their knowledge. This happens through LMS, where they found that the LMS features are easily used and are helpful. In the online learning process, the lecturer-student relationship is a crucial factor significantly influencing the learning process. Online learning is also conceded as having made students more enthusiastic in learning and completing their assignments.

Finally, the suggestions to the university stakeholders are necessary to re-examine what kinds of materials and technologies can be used to be more acceptable to students as a learning process to gain broader knowledge. It is also necessary to learn about how to prepare students to face the new learning methods.

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