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Analysis of Big Data Literacy Skills of Prospective Mathematics Educators Through Case Method-Based Learning

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ABSTRACT

The aim of this research is to analyze the big data literacy skills that a prospective mathematics educator needs to master. Specifically, the ability to read, analyze, make conclusions, and think based on data and information, especially large amounts of data, so that mathematics education students have a broad mindset, and can carry out new innovations. Kemmis and McTaggart's Classroom Action research model was used as the research method. Its stages have four, namely planning, action, observation, and reflection. The planning and action stages took the form of preparing and validating case method-based learning tools in the Operations Research course and were implemented in 3 classes. Lectures are divided into 3 stages: problem-based learning, case method learning from the business world, and case-based learning (Case Method). During the learning process, observation and reflection are carried out. Learning involving the business world, namely Astra Financial and an expert in data sciences, provides opportunities for students to process company big data. The data literacy ability indicators used are the ability to group data, check data, clean data, do qualitative coding, eliminate data, and develop models. The learning results show that students have carried out all big data processing steps in the very good category (> 80%), except for the developing model phase (65.38%). Mini research field studies at partner institutions for the application of operations research in the community. Learning completeness reached 83.11%, and learning activeness reached 82.14% in the very active category. Learning results show an increase in the Big Data Literacy skills of prospective educators and lecturers, even though mastery of big data processing software still needs to be improved.

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1. INTRODUCTION

Since technology is so important in the digital era, the current generation is very technologically literate. Technology has become more prevalent in education because of both this rise in literacy and technical advancements [1]. The world of education is changing rapidly with technological advancements in big data, AI, and machine learning [2]. To meet the demands of the digital era, educators must revise their competency profiles. To empower students in the digital age, teaching methodologies must adapt, and teacher competences must be enhanced. At different stages of the educational system, professional development on an ongoing basis is one of the goals of educational professional requirements based on teacher competency frameworks [3].

According to Boyd and Crawford (in [4]), big data is a "socio-technical phenomenon" that calls for "the capacity to search, collect, and cross-reference large data sets." This includes, among other things, identifying patterns and producing frequently used categories, profiles, or scores for predictive analysis and decision-making. The emergence of big data in recent years has brought fresh perspectives to the digital divide, which is an obstacle that human society has faced since the invention of computers [5]. In the era of digitalization, big data is a massive amount of data that is generated continuously through various means, and this data is called Big-Data sets/collection [6]. Big Data is an ever-expanding, enormously complicated collection of data [6][7]. The development of big data literacy in the field of statistics has been carried out by several people, such as [4], [6], and [8] to support the needs of a constructive, caring, reflective society and education in 3T (underdeveloped, frontier, and outermost) locations. In the meantime, literacy refers to an individual's ability and aptitude for analyzing data and comprehension when engaging in reading and writing tasks [7]. Students who will be future leaders are required to develop into a group of individuals who can intentionally use data and its urgency to enter the digital era, also known as the period of revolution 4.0. When studying current technical advancements like big data, students need to be more perceptive. The big data literacy skills of prospective mathematics educators are needed not only in competing to fill job needs but also in carrying out new innovations or creating new jobs in the future.

The COVID-19 pandemic has had an impact on education throughout the world. A major change in the world of education is the shift from classroom-based teaching and learning to online/virtual instruction, which can be given in one of three pedagogical approaches: synchronous, asynchronous, or hybrid/blended learning strategies [9][10][11]. The most practical approach to adopt is the blended online learning strategy, which combines the benefits of synchronous and asynchronous learning approaches [11]. Then [12] defined hybrid or blended learning as learning that simultaneously takes place in a real (on-site) and virtual (online) environment to combine and maximize the advantages of both settings to increase the student's participation in their own learning process. Because it facilitates knowledge sharing between instructors and students who are not in the same class, hybrid learning is still expanding. For hybrid learning to be a viable learning solution, students completing MBKM (Merdeka Belajar Kampus Merdeka) at partner institutions while continuing to take lectures (up to 4 credits) in a hybrid format are not required to leave their places of employment.

One of the methods used in the learning system in higher education that supports the digital era in improving big data literacy skills is the case method and project-based learning. The case method originates from the Socratic dialogue or questioning technique, Aristotelian logic, and the argument and counterargument process. It is a very effective teaching tool [13]. Harvard School of Law was the first to adopt this method in the 1920s [14]. Furthermore, the case method is a discussion-based, interactive teaching approach that helps students develop their communication, critical thinking, and group dynamics abilities. Nowadays, the case technique is applied in fields like education. During class, students can work on a case in small groups or as a whole [15]. They can gather information, analyze it, weigh their options, and come to both individual and group decisions. The case method of instruction requires students to prepare thoroughly, participate fully, show their thinking from several angles, analyze the scenario, and draw conclusions [14]. In mathematics classes, cases are used to test theories, refute hypotheses, question assumptions, develop solution methods, debate solutions, and solve problems.

Project-based learning is a learning method that uses projects/activities as media. Project-based learning is a student-centered learning model to carry out an in-depth investigation of a topic [16]. The project-based learning approach encourages active learning by giving students the chance to work together for extended periods of time to explore important issues, come up with solutions, manage time and

resources, evaluate, and present findings [17]. Students will constructively deepen their learning with a research-based approach to problems and questions that are meaningful, real, and relevant.

Furthermore, the learning approach used is STEM (Science, Technology, Engineering, and Mathematics). The definition of STEM is that mathematically literate students not only know how to analyze, reason, and communicate ideas effectively; they can also mathematically pose, model, formulate, solve, and interpret questions and solutions in science, technology, and engineering. Mathematics education provides foundational content and processes that bridge the STEM disciplines [18]. Basic procedures and content in mathematics education serve as a link between the STEM fields. Modeling with real-world data and its cross-disciplinary applications, including using engineering design to improve problem solving and mathematical research, are two examples of how STEM is being applied. STEM-based learning methods apply knowledge and skills simultaneously to solve a case. This learning approach is used to produce quality human resources with cognitive, psychomotor, and affective qualities, which will later be directly proportional to increasing the quality of capabilities in the field of big data literacy.

The SCOpe Research Group's roadmap details upcoming projects pertaining to learning analysis and the creation of educational resources for the study of combinatorics, statistics, optimization, and related subjects. The research output is a STEM-based learning analysis that makes use of project-based learning and the case method. The application of project-based learning that involved STEM, has been carried out by [19] and [20] in inquiry-based instructional practices and problem solving, which has an impact on student learning outcomes. Also, [21] and [22] publications provide some relevant research. Taking mathematics as a human activity, making sure it has meaning for students, and encouraging mathematical thinking about ideas rather than just absorbing a set of disconnected and static knowledge and skills have been suggested as alternatives to current approaches to mathematics education that also demonstrate how the alternatives apply to STEM education [23].

The aim of this research is to describe the analysis of prospective mathematics educators' big data literacy skills through STEM-based case method learning. The benefits of research are to improve the quality of learning by preparing prospective educators and adding experience and skills in Big data literacy to face education in the digital era. It is hoped that learning tools will be more directed towards outcome-based learning.

2. RESEARCH METHODS

Research Design: The model used in this research is the Kemmis and McTaggart model with four stages of classroom action research (CAR), namely: Planning. Action, Observation, and Reflection; see Figure 1.

Planning, at the planning stage, what is carried out is determining competency standards and basic competencies that will be used for research, planning learning methods that will be applied in the teaching and learning process, preparing learning tools, developing evaluation formats, and conducting field observations.

Action, the second stage of CAR, includes procedures and actions that will be carried out in accordance with plans that have been made previously, as well as improvement processes that will be carried out.

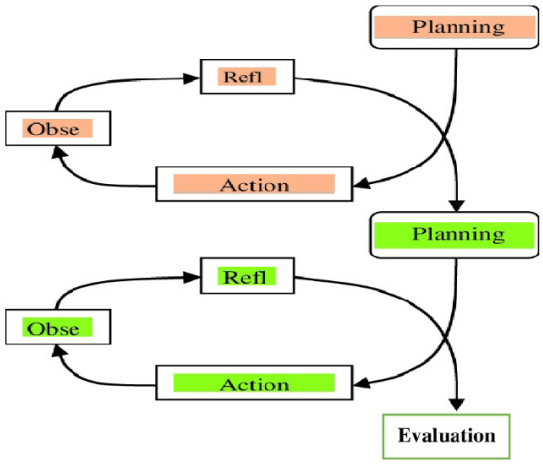

Figure 1. Kemmis and McTaggart's Classroom Action Research Cycle Model [23]

Observation, the third stage of CAR, includes procedures for recording data about the process and results of implementing the actions taken.

Reflection, describes the analysis procedures for monitoring results and reflection on the process and impact of corrective actions taken, as well as criteria and action plans for the next cycle.

Data research, data sources, data collection techniques, and data analysis from this research are as follows:

1. Validation of learning tools, validated by two learning tools experts, at least 75%.
2. Observation results for lecturer and student activity during the implementation of the STEM-based case method learning model are at least 75%.
3. Completeness of student learning outcomes during the learning process is at least 60%, and classical completeness is at least 70%, including:
    a. The percentage of achievement of the five Big Data Literacy Skills Indicators (grouping, checking, cleaning, qualitative coding, eliminating, and developing models) is at least 60%.
    b. STEM-based research as project-based learning, reports, and mini-presentations application Research Operations, minimum 70%.

3. RESULTS AND DICUSSION

Based on the CAR research implementation mechanism (Figure 1), planning activities, action, observation, and reflection are explained as follows:

Planning, At the planning stage, what is carried out is an initial observation of the state of the operations research course to identify problems. More specifically, it is determining competency standards and basic competencies that will be used for research, planning learning methods that will be applied in the teaching and learning process, preparing learning resources, developing semester learning plans (RPS), developing student worksheets, developing evaluation formats, and developing formats. field observation.

The results of initial observations are that the Operations Research learning tool is recommended for use by the business world, both as practitioners teaching in lectures and as students carrying out case studies. The initial survey results show that students understand the meaning of the words big data literacy through the various sources of information they have, but their understanding of big data literacy is still low, namely 38%. Therefore, to improve literacy skills, additional skills in using IT in processing big data, understanding the results of data processing, and utilizing the business world as teaching practitioners in lectures are needed.

Preparation of STEM-based case-method learning tools, including syllabus, RPS, lecture contract, student worksheets (LKM), student assignment design (RTM), and evaluation design. The validity test of the learning tools was carried out by two learning experts. The average validation score was 3.92, or 97.92%, and the device was declared **valid** for use with improvements. Improvements have been made to the Course Learning Outcomes (CLO) 4 sub-editorial and publication integration on the device.

Action: The valid learning tools were then revised and used in three parallel classes in the Operations Research course. There are classes A (15 students), C (32 students), and D (22 students). Lectures were held in 16 meetings, with 4 of them in a hybrid manner, and lecture activities were administered at mmp.unej.ac.id. Lectures are broadly divided into 3 stages: 1) problem-based learning and STEM; 2) case-method learning from the business world (DUDI); and 3) case-based learning (Case Method and STEM).

In the first stage, lectures begin with a lecture contract and continue with a discussion of each problem-based topic using discussion methods and IT-based LKM performance testing at meetings 1–8. Lectures are focused on problem-based learning and student skills in using primary information technology. The information technology used in this course is QM software for Windows, MS-Excell, Matlab, and Maple. Students are required to develop mathematical literacy and data literacy when solving given problems. During the learning process, students are actively involved in discussing and searching for information via the internet.

The 2nd stage was carried out at meetings 9–12, lectures with practitioners in a hybrid manner, practitioners from PT Astra Finance, and an expert in data science from Gunadarma University. Furthermore, in the last 4 meetings as the 3rd stage, students carried out mini-research on operations research applications at partner institutions and reported the results of the mini-research through presentations.

Lectures involving practitioners from DUDI, in this case Astra Financial. The practitioner is a risk management advisor at Astra Financial; her experience in big data processing was conveyed in two online meetings, one synchronous and one asynchronous. Presentation related to credit scoring modeling using machine learning to process big data. One of the programs used is R and Python, presented in an interesting way. Six modeling steps, which are then used as indicators to measure students' big data literacy skills, are: 1) grouping data; 2) checking data; and 3) cleaning data. 4) qualitative coding; 5) eliminating data; and 6) developing models. At the end of the first meeting, students were given real simulated data for simulation exercises in processing big data and building models.

Improving the Big Data Literacy Capabilities of Prospective Mathematics Educators from an Expert in Data Science from Gunadarma University, carried out in a hybrid manner. The resource person said that data literacy can help organizations improve data quality, collaborative communication, creativity, and work process efficiency. As a result, data literacy provides more benefits for good data management. Data literacy is the ability to read, write, analyze, and interact with data.

The case method and project-based learning that are applied are projects in the form of a course capstone, namely the implementation of mini-research on operations research applications with real cases at partner institutions. Mini research partner institutions are small and middle businesses such as batik, tape, tofu, chips, coffee, etc., located in Jember City and its surroundings. Reports in the form of papers and presentations in PPT or poster form. During the presentation, students used information obtained from the surrounding environment, then defined variables, defined relevant functions, and solved problems using information technology that they mastered.

During the learning process, observations are made of student and lecturer activities, as well as recording data about the process and results of implementing the actions taken. The lecturer did everything that had been planned in the RPS. Student assessment of the lecturer's activities was an average of 6.5 out of a maximum score of 7, or 92.86%, in the very active category.

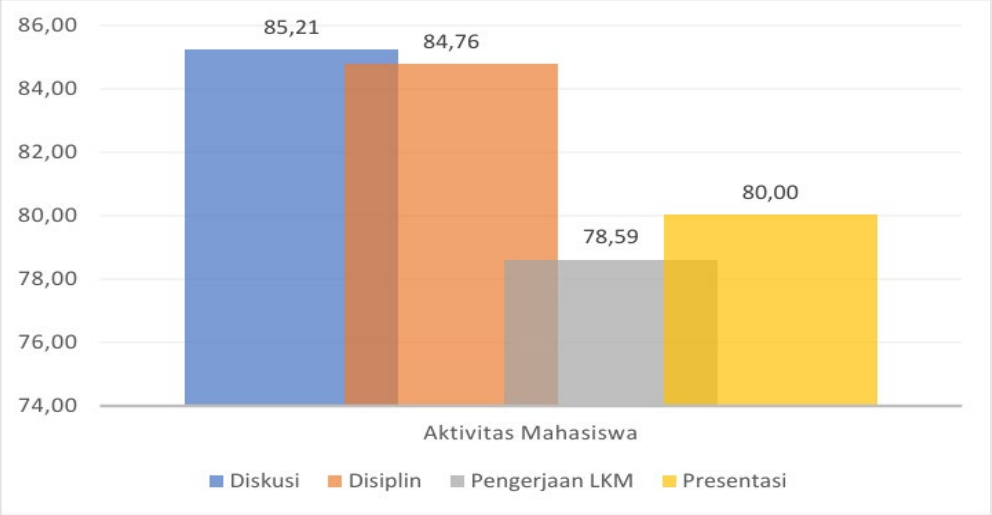

Figure 2. Student activities in participating in the learning process

Student activities in participating in the learning process, which include discussion activities, punctual discipline in carrying out assignments, and presentations, amounted to 82.75% (very active). More details can be seen in Figure 2. Students stated that studying with practitioners could open their insight into the application of mathematics in finance; 45.9% said it was good, and 41.9% said it was very good.

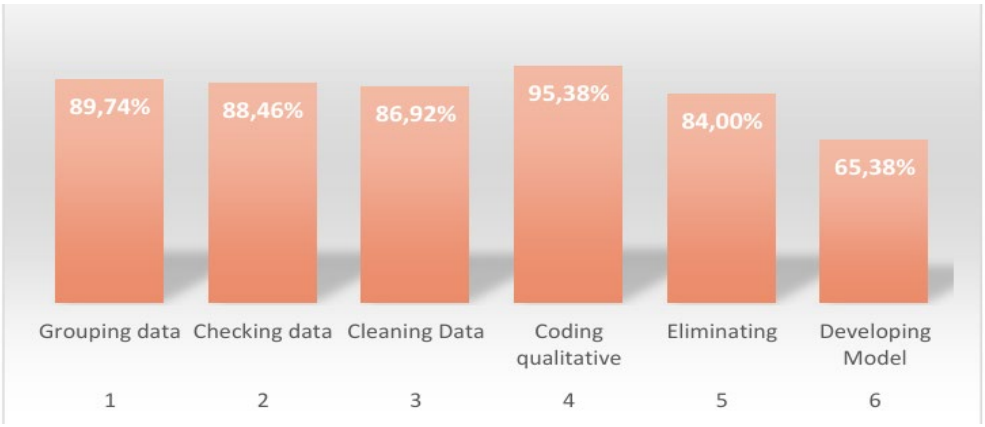

Figure 3. Big data simulation analysis

Based on the big data literacy skills indicator, it appears that students have carried out each step of big data processing well or above 75%, except in the developing model phase (65.38%). However, for big data processing, the use of software still needs to be improved, such as R, Python, Anaconda software, and Colab services. This software can be introduced and used by students and lecturers, both in operations research courses and in other supporting courses such as inferential statistics and programming algorithms. Improving the quality of teaching lecturers needs to be done through big data analysis training or other similar training.

The 3rd stage of learning assessment, namely mini-research, includes data processing using IT, formulating appropriate mathematical models, novelty of mini-research, design of PPT or poster presentations, and communication during presentations, as shown in Figure 4. The average of the STEM-based research mini-assessment was 77.52, including the very good category. Big data literacy skills appear in assessment aspects 1 and 2. Both aspects show that big data literacy skills are good but still need to be improved.

The completeness of learning outcomes for big data simulations and mini research is 83.11%; students have achieved learning mastery. For students who have not finished studying, remediation is carried out by revising assignments.

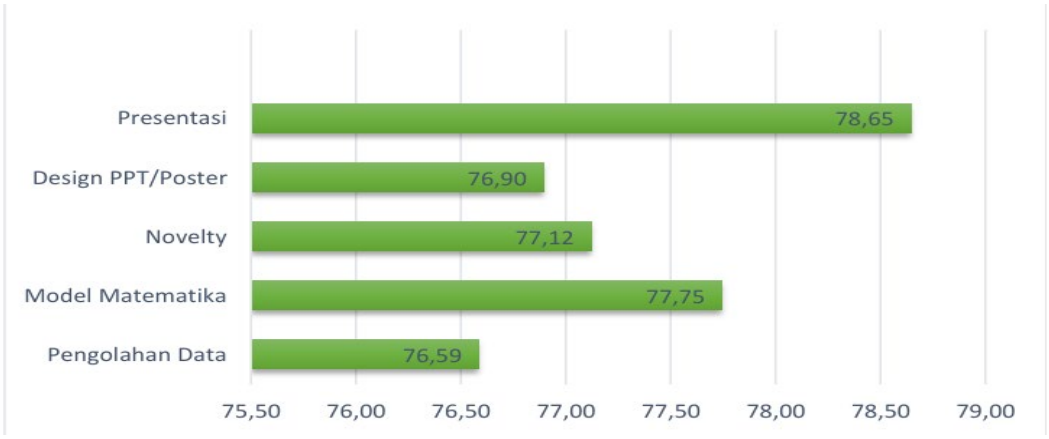

Figure 4. Analysis of the results of STEM-based mini research

Reflection (reflecting), from the case method and STEM-based Operations Research course learning process activities, shows positive things in terms of big data literacy skills, both for lecturers and students, among others.

1. Students have simulation experience processing big data.
2. Students have the opportunity to learn about the problems often faced by the business world related to mathematical models.
3. Students can apply operations research to society, especially small and medium businesses.
4. Learning completeness reached 83.11% and learning activeness reached 82.14% in the very active category, so it can be said to have met all the indicators.

Indicators of achievement of learning outcomes, especially in big data processing skills, have been completed, except for developing models. This is due to time constraints, and the probabilistic model introduced is still a new topic for students. Meanwhile, big data literacy skills in STEM-based project-based learning activities, namely mini-research, show an increase in quality in data processing, building mathematical models, and presenting the results, even though the operations research application carried out is still very simple. Mastery of software for both lecturers and students still needs to be improved through training or capacity building.

4. CONCLUSIONS

Analysis of operations research learning tools, resulting in a reconstruction of STEM-based learning tools that apply the case method and project-based learning in operations research courses. Learning involving the business world from Astra Financial and data science experts from Gunadarma University has been able to improve the big data literacy skills of undergraduate Mathematics Education study program students, especially Operation Research course participants. Suggestions, lecturers, and students still have minimal knowledge of machine learning, so further research, training, and capacity building are needed in addition to procuring supporting software.

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