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# Optimizing Classroom Performance in Higher Education: Efficiency Study with Data Envelopment Analysis Method

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**ABSTRACT**

Higher education has an important mission in human resources development. One of the main reasons for improving the quality of education is the efficiency of classroom management. Good management means that every resource used—lecturers, time for teaching, the number of students, technology, and teaching materials—produces optimal learning outcomes; not every course can attain the same degree of efficiency. This article thus applies the method of Data Envelopment Analysis in calculating efficiency in classroom management and highlights areas where improvement needs to occur. It is, therefore, possible to achieve optimal performances in the higher learning institutions based on the model parameters used: number of lecturers, teaching hours, number of students, student/lecturer ratio, learning resources, and the learning technology. The outcome variables are the average grade of students, students' attendance rate, the percentage of students having grades A, AB, & B, and the percentage of assignments completed on time. This study involved 10 courses as decision-making units (DMUs). The results showed that 9 courses achieved an efficiency score of 1 (efficient DMU), while one course, namely Production Planning and Control (Class A), had an efficiency score of 0.976, indicating inefficiency DMU. Further analysis revealed some factors that made this inefficient: high student-to-lecturer ratios, constraints in the use of learning technology, and shortages in teaching materials. From these, this study therefore finds it necessary to recommend more learning technology, improvement in the student-to-lecturer ratio, and enrichment of teaching materials to achieve better class performance. The result of the study is expected to help the universities focus on ways to enhance education management and thereby take strategic steps to improve the efficiency of the lecture classes.

## INTRODUCTION

The most important role of higher education is in preparing the future generation for the challenging world of work. It is, therefore, the job of the university to provide adequate education, not only in terms of knowledge but also in those aspects that relate to professional life. The resources in terms of lecturers, facilities, and technological aspects must be utilized as efficiently as possible to achieve this end. This efficiency is a key indicator of success in supporting the achievement of optimal educational goals [1], [2]. As technology evolves, online learning in higher education institutions is increasingly being applied. This learning model has some advantages: flexibility in terms of time and place. However, there are challenges that must be faced, especially those related to class management and interaction quality between lecturers and students. Good management is key to ensuring that the online learning process can run effectively. During the COVID-19 pandemic, students' perceptions of online learning and the use of digital technology have been shown to have a major impact on their academic outcomes. Students who feel comfortable using technology and have adequate access to digital resources tend to achieve better academic performance [3].

The success of online learning is greatly influenced by the quality of feedback provided by lecturers. Effective feedback helps students understand the material better while increasing learning motivation. Although done online, active interaction between lecturers and students can enrich the learning experience and encourage better academic achievement [4]. Therefore, the quality of lecturer feedback is one of the important elements in assessing the effectiveness of online learning. In addition, various factors that affect the efficiency of lecture classes in higher education need to be considered carefully. This includes the use of technology in learning, the number and qualifications of lecturers, the number of students, and the availability and quality of learning resources. An in-depth analysis of these factors is essential to ensure that all elements of education can support the achievement of learning objectives optimally.

Data Envelopment Analysis is one commonly used method for measuring efficiency. The methodology will be really effective in gauging the degree to which efficient use of resources has taken place by various units or organizations. Very often, the input-oriented DEA envelopment model is adopted since the concern is the efficient use of inputs to provide optimal output. In the context of higher education, these inputs are the number of lecturers, available facilities, number of students, and other resources, while the measured outputs are students' academic results, attendance rate, percentage of students graduating with good grades, and on-time completion of assignments.

Data Envelopment Analysis (DEA) allows the evaluation and comparison of the efficiency of universities or faculties in utilizing resources. With this method, it can be identified which universities or faculties are more efficient in producing the desired output. DEA can also be applied to evaluate the efficiency of public universities by considering various relevant input and output factors [5]. The results of this evaluation provide a basis for higher education managers to improve the efficiency and quality of education. In addition, the results help determine the necessary improvement steps to support the achievement of better learning outcomes. DEA not only measures efficiency but also provides insight into the relationships between factors that influence educational outcomes. Thus, this analysis helps identify areas that need to be improved to improve the quality of teaching and learning in higher education.

The DEA method is applied for assessing the quality of teaching at universities and analyzing the benefits derived. DEA will be applied to evaluate the relative efficiency of universities by measuring inputs such as teaching staff and means used in the teaching process and outputs such as the quality of education given and student achievement. It also helps in pointing out which universities are working more effectively to improve the quality of teaching, and it points to aspects that need to be changed. DEA proved to be an effective tool for evaluating and analyzing the teaching quality of the education sector by optimizing resources and improving teaching performance in universities, as reported by [6].

Despite the heavy investments in the sector, education efficiency remains a major issue in many developing countries. Resource management is inefficient, teaching is of low quality, and access to education is highly unequal between urban and rural areas. One possible solution could be the use of data-driven and analytical approaches, such as Data Envelopment Analysis, to evaluate and improve the efficiency of education. Identifying weaknesses in the education system means that policies can then focus more on the improvement of teaching and better resource management, which may improve the education outcomes. These opportunities for improvement are key to achieving quality education that can advance developing countries [7].

This study focuses on how to optimize the performance of lecture classes in higher education in order to achieve better efficiency. Some of the main problems discussed in this study are as follows: (i) How to measure the efficiency of lecture class performance in higher education?; (ii) What factors influence the efficiency of lecture class performance?; (iii) How to improve efficiency in class management by reducing the use of resources (input)?; and (iv) What steps need to be taken to improve the efficiency of courses that are not yet efficient?

The objectives of this study are: (i) to measure the efficiency of lecture class performance in higher education using the input-oriented DEA Envelopment Model approach; (ii) to identify factors that influence class efficiency, such as the number of lecturers, teaching hours, student/lecturer ratio, and the use of learning technology; (iii) to analyze and evaluate course performance to find out which ones are efficient and which ones need improvement; and (iv) to provide recommendations to improve the efficiency of lecture class management, especially in courses that are not yet efficient.

## MATERIALS AND METHODS

**Performance Evaluation**. Performance assessment is very important to understand the extent to which an organization or company can optimize its resources to achieve the desired goals. One method commonly used in performance assessment is Data Envelopment Analysis (DEA), which allows measuring the efficiency of various entities, such as companies or industrial groups, in a systematic and objective manner [1], [2]. [8] applied the DEA method in evaluating the efficiency performance of the Large and Medium Manufacturing Industries (LMMI) in the province of East Java in Indonesia. The method can identify more efficient LMMIs and identify aspects that should be improved by the ineffective LMMIs. [9] applied the DEA method in order to analyze the performance of large and medium-sized industries in Indonesia, considering inputs and outputs as efficient. Such a study has shed light on more efficient sectors and therefore pinpoints sectors that need intervention. The objective is hence to help optimize resource use, such as labor, capital, and technology. Furthermore, [10] applied the same method to assess the performance of electricity companies in Indonesia. Considering inputs such as energy production, labor, and investment, this study was able to show companies that were more efficient in providing electricity services. Therefore, it proves that the method is not only applied to the manufacturing sector but also other sectors such as public services too. Hence, this study identified the importance of DEA in performance evaluation and efficiency enhancement for different sectors. This proper understanding of efficiency would ensure better resource management in both the manufacturing and public services sectors [8], [9], [10]. Basically, performance evaluation is the process of systematically measuring the relative efficiency of an organization in utilizing inputs to produce optimum output. This research applies the DEA approach, which can be used for the analysis of the efficiencies of DMUs. Hence, the performance of Indonesian construction companies is evaluated precisely and deeply. This would give indications on efficient organizations, besides which recommendations for improvements for inefficient units will be made according to the best practices [11]. The method of Data Envelopment Analysis combined with a stepwise approach shall be used to analyze the effectiveness of the export-import industry in Indonesia. It could therefore be obtained from the result that the method was highly effective in identifying the business unit, which was efficient as well as inefficient, coupled with factors that influence these performances. This approach offers insight into aspects to be improved in order to achieve optimal efficiency, including resource management and relevant output results. This study also provides guidance for stakeholders to improve competitiveness and resource allocation efficiency in this sector [12].

**Input-Oriented DEA Envelopment Model**. Data Envelopment Analysis (DEA), a linear programming technique, is used to measure performance in integrated models. In certain performance measurements, input and output parameters are employed. It is necessary to minimize inputs, including costs, labor, materials, and so on. One element that must be optimized is output, which encompasses items such as revenue, earnings, and manufactured goods. DEA is used after inputs and outputs have been selected and categorized. In the estimate, the DEA uses decision-making units (DMUs) to represent each business activity, procedure, and entity. To raise an inefficient DMU to the threshold of the efficient DMU criterion, there are two approaches. These criteria can be approached in two main ways: (i) actions that minimize input in comparison to maximizing output at the current level and (ii) activities that enhance output in comparison to minimizing input at current levels. In either case, these methods can be applied to the criteria. The linear programming formula for the DEA model is shown in equations 1 through 4. The model's output criteria are specified at the current level and are designed to minimize input.

$$\theta^* = \min \theta \quad . \quad (1)$$

subjected to the following restrictions:

$$\sum_{j=1}^{n} Xij\,\lambda j \leq \theta\, Xio, \quad i = 1, \ldots, m \quad . \quad (2)$$

$$\sum_{j=1}^{n} Yrj\,\lambda j \geq Yro, r = 1, \ldots, s \quad (3)$$

$$\sum_{j=1}^{n} \lambda j = 1 \quad (4)$$

$$\lambda j \geq 0 \quad j = 1, \ldots, n$$

One of the n mentioned DMUs is DMU0. For DMU0, the symbols Xi0 and Yr0 stand for r-input and r-output, respectively. To determine the DMU number, use λj to represent the unknown weight, where j = 1,..., n. With the notation θ, the solution variable represents the efficacy value. If θ = 1, the solution obtained as stated in the following equation is feasible. When θ* is at its optimal value, it is less than 1. When θ* = 1, it means that the present input level cannot be lowered proportionately, and DMU0 is at the optimal criteria limit. DMU0 is on the edge, and if θ* < 1, the input can be reduced by the same percentage of θ*. Consequently, less input is required to achieve the same level of output [13], [14]. Data Envelopment Analysis is a technique of evaluating the efficiency of DMUs by comparing the output produced to the input used. This technique identifies efficient units and analyzes factors that cause inefficiency in other units. Both classical and sophisticated DEA models are applied in various sectors, including industry, education, and the public sector. With the use of DEA-solver software, it is easy to compute efficiency and identify where improvements must be made. DEA was applied in different case studies aiming at enhancing resource management for organizations to compete in both private and public sectors so as to achieve optimal operational efficiency [15].

**Research Methodology**. This study applies the Data Envelopment Analysis approach in analyzing efficiencies based on the relevant inputs and outputs regarding lectures. The data was gathered from even semester lectures during the 2023-2024 academic year in the Industrial Engineering Study Program, Universitas 17 Agustus 1945 Surabaya, Indonesia. The steps of this research methodology include: (i) identification of input and output variables; (ii) determination of Decision-Making Units (DMUs); (iii) application of the Data Envelopment Analysis (DEA) method; (iv) analysis of efficiency scores; (v) evaluation and discussion; and (vi) recommendations for improvement. Further explanation of each step can be seen in Table 1.

Table 1. Research methodology steps

| Steps | Deskripsi |
|---|---|
| Identification of input and output variables | The input variables are the number of lecturers, teaching hours, number of students, student-to-lecturer ratio, learning resources, and learning technology. The output variables are represented by the average grade of students, the percentage of student attendance, the percentage of students with grades A, AB, and B, and the percentage of assignments completed on time. |
| Determination of decision-making units (DMUs) | The courses analyzed as DMUs include Productivity Analysis A, Productivity Analysis S, Quality Management MT, Strategic Management A, Strategic Management R, Operations Research I D, Operations Research I R, Production Planning and Control A, Production Planning and Control B, and Quantitative Modeling R. |
| Application of data envelopment analysis (DEA) method | This study uses an input-oriented DEA envelopment model, which maximizes output through the minimization of inputs. |
| Efficiency score analysis | An efficiency score of one indicates perfect efficiency, while a score of less than one indicates inefficiency. |
| Evaluation and discussion | This study also analyzes the factors that cause inefficiency in certain DMUs and identifies areas that need improvement. |
| Recommendations for improvement | Based on the results of the analysis, this study provides recommendations to improve efficiency in resource management, such as the number of lecturers, student/lecturer ratio, use of technology, and management of teaching time. |

**Research Gap**. The research gap in this study lies in the lack of application of measurable and systematic methods to assess the efficiency of lecture class management in higher education, especially using the Data Envelopment Analysis (DEA) approach. Although efficiency in higher education has been widely discussed, most studies focus more on the quality of teaching or curriculum, without considering how resources such as lecturers, number of students, technology, and learning materials are used optimally. This study fills this gap by integrating various relevant input and output variables and providing a more objective evaluation tool to improve efficiency in various courses. In addition, there are still few studies that apply DEA in the context of higher education, so this study provides a new contribution to efficiency-based education management.

**Research Originality**. The originality of the research lies in the use of Data Envelopment Analysis methods to measure classroom management efficiency in the higher education institution, still rarely used within the frame of higher education. This study offers a more objective and measurable approach to evaluate the efficiency of the use of educational resources, such as lecturers, teaching time, number of students, and technology and learning resources, in producing educational outputs such as academic grades, student attendance, and assignment completion. In addition, this study also identifies factors that influence inefficiency in classroom management, such as a high student-to-lecturer ratio and limited use of technology. These findings can provide new insights for higher education managers to improve and innovate in classroom management.

## RESULTS AND DISCUSSIONS

### Results

**Data, Input-Output Variables, and Decision-Making Units (DMUs)**. The data used in this study is the lecture data for the even semester of 2023-2024 at the Industrial Engineering Study Program, Universitas 17 Agustus 1945 Surabaya, Indonesia. The lecture data includes (i) the course type. (ii) Number of Lecturers (Total number of lecturers teaching the class); (iii) Teaching Hours (amount of time spent teaching during the semester); (iv) Number of Students (Number of students in a class); (v) Student/Lecturer Ratio (Ratio between the number of students and lecturers); (vi) Learning Resources (number of learning materials such as modules, books, and digital media); (vii) Learning Technology (Level of technology use, %); (viii) Average Student Grade (average academic results); (ix) Attendance (average percentage of student attendance, %); (x) Students Grade A, AB, & B (Percentage of students who achieved good grades, %); and (xi) Assignments Completed (Percentage of assignments completed on time, %). There are 6 courses distributed across 10 classes, including: Productivity Analysis (Class A & S), Quality Management (Class MT), Strategic Management (Class A & R), Operations Research I (Class D & R), Production Planning and Control (Class A & B), and Quantitative Modeling (Class R). These data can be used to determine decision-making units (DMUs) and input-output variables, as indicated in Tables 2, 3, 4, 5, and 6. Table 7 provides a summary of all the data used in this study.

**Data Arrangement in Microsoft Excel Spreadsheets**. Input and output data are arranged on a Microsoft Excel spreadsheet (Table 7). The concept of calculating efficiency scores uses the Input-Oriented DEA Envelopment Model. Next, the MS Excel Solver function was operated to obtain an efficiency score for each DMU.

Table 2. Input variables

| Input | Explanation | Variable |
|---|---|---|
| Number of Lecturers | Total number of lecturers teaching the class | X1_NL |
| Teaching Hours | Amount of time spent teaching during the semester | X2_TH |
| Number of Students | Number of students in a class | X3_NS |
| Student/Lecturer Ratio | Ratio between the number of students and lecturers). | X4_SLR |
| Learning Resources | Number of learning materials such as modules, books, and digital media | X5_LR |
| Learning Technology | Level of technology use (%). | X6_LT |

Table 3. Output variables

| Output | Explanation | Variable |
|---|---|---|
| Average Student Grade | Average academic results. | Y1_ASG |
| Attendance | Average percentage of student attendance (%) | Y2_A |
| Students Grade A, AB, & B | Percentage of students who achieved good grades (%) | Y3_SG |
| Assignments Completed | Percentage of assignments completed on time (%) | Y4_AC |

Table 4. Decision-making units (DMUs)

| Courses | Class | DMU | Courses | Class | DMU |
|---|---|---|---|---|---|
| Productivity Analysis | A | PA_A | Operations Research I | D | OR_D |
| Productivity Analysis | S | PA_S | Operations Research I | R | OR_R |
| Quality Management | MT | QM_MT | Production Planning and Control | A | PPP_A |
| Strategic Management | A | SM_A | Production Planning and Control | B | PPP_B |
| Strategic Management | R | SM_R | Quantitative Modeling | R | QM_R |

Table 5. Input and output data

| DMU | X1_NL | X2_TH | X3_NS | X4_SLR | X5_LR | X6_LT |
|---|---|---|---|---|---|---|
| PA_A | 1 | 28 | 31 | 31 | 7 | 85 |
| PA_S | 1 | 28 | 41 | 41 | 7 | 80 |
| QM_MT | 2 | 28 | 27 | 13.5 | 6 | 95 |
| SM_A | 1 | 28 | 18 | 18 | 12 | 80 |
| SM_R | 1 | 28 | 33 | 33 | 12 | 90 |
| OR_D | 1 | 42 | 40 | 40 | 9 | 85 |
| OR_R | 1 | 42 | 39 | 39 | 9 | 80 |
| PPP_A | 2 | 56 | 41 | 20.5 | 11 | 95 |
| PPP_B | 2 | 56 | 40 | 20 | 11 | 90 |
| QM_R | 1 | 28 | 41 | 41 | 8 | 95 |

Table 6. Input and output data

| DMU | Y1_ASG | Y2_A | Y3_SG | Y4_AC |
|---|---|---|---|---|
| PA_A | 86 | 86.67 | 61.28 | 61.28 |
| PA_S | 86 | 96.67 | 90.24 | 92.68 |
| QM_MT | 86.80 | 100.00 | 100.00 | 100 |
| SM_A | 86.60 | 88.89 | 44.44 | 44.44 |
| SM_R | 86.50 | 93.94 | 78.78 | 90.9 |
| OR_D | 81.41 | 100.00 | 52.50 | 55 |
| OR_R | 81.41 | 97.44 | 38.46 | 38.46 |

| | | | | |
|---|---|---|---|---|
| PPP_A | 88.25 | 100.00 | 97.56 | 97.56 |
| PPP_B | 89.25 | 100.00 | 85.37 | 85.37 |
| QM_R | 86.80 | 97.56 | 85.37 | 61.28 |

Table 7. Data with a solver function in a Microsoft excel spreadsheet

| DMUs | X1_NL | X2_TH | X3_NS | → | X6_LT | Y1_ASG | → | Y4_AC | λ |
|---|---|---|---|---|---|---|---|---|---|
| PA_A | 1 | 28 | 31 | | 85 | 86 | | 61.28 | 0 |
| PA_S | 1 | 28 | 41 | | 80 | 86 | | 92.68 | 0 |
| QM_MT | 2 | 28 | 27 | | 95 | 86.80 | | 100 | 0 |
| SM_A | 1 | 28 | 18 | | 80 | 86.60 | | 44.44 | 0 |
| SM_R | 1 | 28 | 33 | | 90 | 86.50 | | 90.9 | 0 |
| OR_D | 1 | 42 | 40 | | 85 | 81.41 | | 55 | 0 |
| OR_R | 1 | 42 | 39 | | 80 | 81.41 | | 38.46 | 0 |
| PPP_A | 2 | 56 | 41 | | 95 | 88.25 | | 97.56 | 0 |
| PPP_B | 2 | 56 | 40 | | 90 | 89.25 | | 85.37 | 0 |
| QM_R | 1 | 28 | 41 | | 95 | 86.80 | | 61.28 | 1 |

.

| Constraints | Reference Set | | DMU Under Evaluation | 10 | Efficiency 1 |
|---|---|---|---|---|---|
| X1_NL | 21020 | ≤ | 21020 | | |
| X2_TH | 2817 | ≤ | 2817 | | |
| X3_NS | 48931 | ≤ | 48931 | | |
| X4_SLR | 1561 | ≤ | 1561 | | |
| X5_LR | 38767 | ≤ | 38767 | | |
| X6_LT | 78713 | ≤ | 78713 | | |
| Y1_ASG | 309 | ≥ | 309 | | |
| Y2_A | 2622 | ≥ | 2622 | | |
| Y3_SG | 60 | ≥ | 60 | | |
| Y4_AC | 58156 | ≥ | 58156 | | |
| $\sum\lambda$ | 1 | | | | |

Analysis of Efficient DMU, Inefficient DMU, And Comparison. Efficient DMUs have an efficiency score equal to one. Inefficient DMU has an efficiency score of less than 1. The efficiency score (ES) for each decision-making unit (DMU) are shown in Table 8.

Table 8. Efficiency score

| No. | DMU | Dfficiency Score | Status |
|---|---|---|---|
| 1. | PA_A | 1 | Efficient |
| 2. | PA_S | 1 | Efficient |
| 3. | QM_MT | 1 | Efficient |
| 4. | SM_A | 1 | Efficient |
| 5. | SM_R | 1 | Efficient |
| 6. | OR_D | 1 | Efficient |
| 7. | OR_R | 1 | Efficient |
| 8. | PPP_A | 0.976 | Inefficient |
| 9. | PPP_B | 1 | Efficient |
| 10. | QM_R | 1 | Efficient |

The results of this study indicated that efficient DMUs consist of PA_A (ES=1), PA_S (ES=1), QM_MT (ES=1), SM_A (ES=1), SM_R (ES=1), OR_D (ES=1), OR_R (ES=1), PPP_B (ES=1), and QM_R (ES=1). The only inefficient DMU is PPP_A (0.976). The distribution of efficiency scores for each DMU is presented in Figure 1.

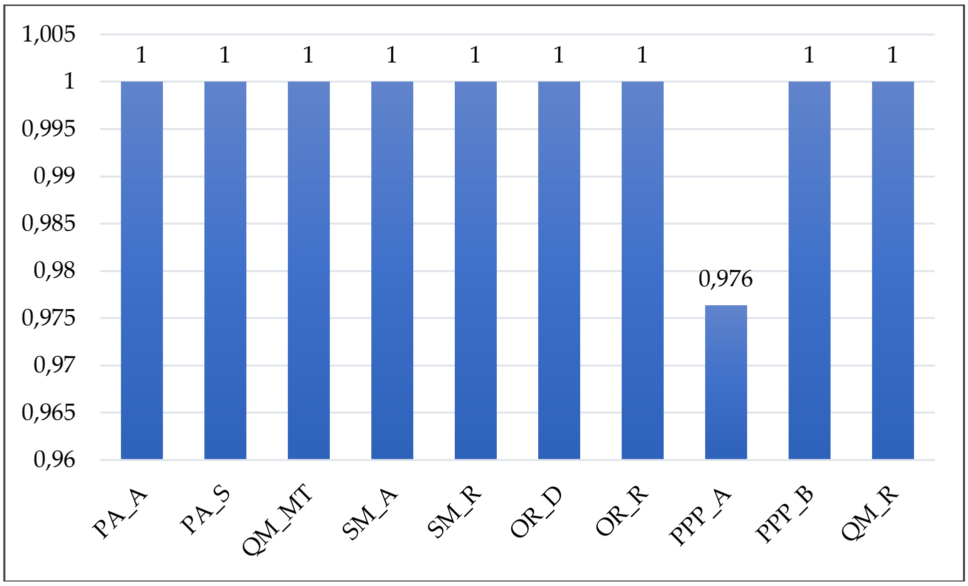


Figure 1. Distribution of efficiency scores for each DMU

The efficiency score (ES) can be used to calculate the proportion of efficient and inefficient DMUs. In Table 9, the quantity and percentage (%) of ineffective and efficient DMUs are displayed. The maximum number is 90% for efficient DMUs, whereas 10% is for inefficient DMUs.

Table 9. Percentage (%) and DMU classification

| DMU Classification | DMU Type and Efficiency Score | Amount | Perc. (%) |
|---|---|---|---|
| Efficient DMU | PA_A (ES=1), PA_S (ES=1), QM_MT (ES=1), SM_A (ES=1), SM_R (ES=1), OR_D (ES=1), OR_R (ES=1), PPP_B (ES=1), and QM_R (ES=1) | 9 | 90 |
| Inefficient DMU | PPP_A (ES=0.976) | 1 | 10 |

## Discussions

**Course Efficiency Score Analysis**. Based on the result of the analysis using Data Envelopment Analysis (DEA), out of 10 courses that were assessed, 9 courses got an efficiency score of 1. This indicates that those courses have optimally utilized the resources (input) for producing maximum results (output). Therefore, they fall into the efficient group. However, one course got an efficiency score of 0.976, which was Production Planning and Control-A, PPP_A. The result indicated that the course has not fully utilized available resources optimally. Hence there is room for improvement toward full efficiency. In the interpretation of efficiency scores, a value of 1 represents the best efficiency, meaning that all inputs have produced maximum output. On the other hand, a score less than 1 indicates inefficiency, meaning that there is still the potential to improve resource utilization so that the results achieved are more optimal.

**Inefficient Course Analysis (PPP_A)**. Inefficiency in the Production Planning and Control A course-PPP_A-proves that resources have not been utilized to their fullest in the attainment of the expected outcome. A number of variables need an upgrade for the learning process to be effective. First is the number of students, X3_NS, and the ratio of students to lecturers, X4_SLR. A ratio that is too high can reduce the lecturer's ability to provide individual attention to students, so that interaction and understanding of the material are less than optimal. Second, the use of learning technology (X6_LT) needs to be improved. Inadequate technology compared to other courses can hinder interactive and interesting learning. The use of technology such as online platforms and interactive applications can help create a more effective learning experience. Third, the aspect of learning resources (X5_LR) must be improved. The availability of complete learning materials, such as books, modules, or relevant digital media, can help students understand the material better. On the outcome indicators side, some points need improvement. Lower average student grades (Y1_ASG) compared to efficient courses signal improvements in quality of learning and evaluation. Low student attendance (Y2_A) points out the lack of motivation or interest in lectures, hence a problem that might arise in the grasping of concepts. The less-than-optimal level of assignment completion (Y4_AC) also indicates the need for better supervision or adjustment of the level of difficulty of assignments to suit students' abilities. All of these factors are interrelated and require improvement so that the PPP_A course can achieve better efficiency. Thus, the quality of learning and the results achieved by students will also increase.

**Comparison of Efficient and Inefficient Courses**. Efficient courses, such as Strategic Management (A) and Operations Research I (R), show optimal use of resources, thus producing maximum output. This can be seen from the quality of learning, student attendance rates, and good assignment completion. On the other hand, those courses that are still not efficient, such as Production Planning and Control-A, PPP_A, can further improve the efficiency of the resources used. The courses' efficiencies and inefficiencies can be seen more precisely when compared in Table 10. Various other key differences that can be analyzed include, in contrast to inefficient courses such as Production Planning and Control A, or PPP_A. First, in efficient courses, the student-to-lecturer ratio is such that there is a proper balance, enabling interaction between the lecturer and students. This assists in effective communication, thereby accelerating the learning process, and gives much-needed attention to each individual student's needs. On the other hand, in the PPP_A courses, there is a higher student-to-lecturer ratio; it is difficult for the lecturer to give enough individual attention to each of their students. This can lower the quality of teaching and interaction inside the classroom, resulting in lesser comprehension of the course material. The second point is related to the use of learning technologies: generally, the courses perceived as efficient have a high level of technology utilization. The use of learning technologies, such as online learning platforms, interactive learning applications, and other types of digital media, provides modern productive learning. The reverse is true for PPP_A courses, which demonstrate less technology use, reducing the presence of students in the learning process, thus making the learning environment much less interactive and dynamic. Third, and in regard to student attendance, efficiently conducted courses usually have high, even above-average, student attendance. This would therefore mean that students are more enthusiastic and interested in attending the lectures. On the other end, the PPP_A course would tend to show low attendance among the students. This perhaps indicates a lower motivation or involvement on the part of the students in the lectures. The low attendance further has a potential to reduce the quality of their understanding of the material being taught. Assignment completion is almost 100% in efficient courses, proving that students can perform well on time and also that they have a great grasp of what is taught in the class. On the other hand, in the PPP_A course, the assignment completion rate is still below the expected target. This indicates a problem in the assignment monitoring system, an inappropriate level of assignment difficulty, or a lack of motivation from students to complete the assignments given. In summary, the key distinction between efficient and inefficient courses has to do with the manner in which resources such as student/lecturer ratio, learning technology, and student motivation are used. Efficient courses utilize resources optimally to maximize learning outcomes, whereas in inefficient courses, several aspects need improvement for higher efficiency.

Table 10. Key differences between efficient and inefficient courses

| No. | Aspects | Efficient Courses | PPP_A (Inefficient) |
|---|---|---|---|
| 1. | Student/Lecturer Ratio | Balanced, allows good interaction | High, reduces individual attention |
| 2. | Learning Technology | High, supports modern learning | Low, less interactive |
| 3. | Student Attendance | High (above average) | Tends to be lower |
| 4. | Assignment Completion | Almost 100% | Less than target |

**Factors Causing Inefficiency in PPP_A Courses**. Inefficiency in PPP_A (ES=0.976) is the result of a combination of several major factors that influence each other. First, the high student-to-lecturer ratio (X4_SLR) causes lecturers to face a heavy teaching load, limiting the personal interaction needed to ensure each student's in-depth understanding. The lessening effectiveness of teaching decreases the fulfillment of student learning needs. Second, another factor that contributes to the situation is the low integration of technology in education or X6_LT; still, technology, as known, in the use of an online learning platform or the use of interactive, intuitive applications and other learning media, has been so minimal, while these are potential factors to enhance engagement and effectiveness in general learning. Third, the limited availability of learning resources in terms of their number and quality—X5_LR (like a lack of modules, books, or teaching materials related to curriculum needs)—makes it difficult for students to access information that could help in their understanding. The low motivation of the students themselves is one significant factor in the inefficient capacity to attend classes and submit the assigned work by a lecturer on time, lower as compared to other courses, showing the least interest in and involvement with their learning processes. High lecturer workload, combined with a very minimal integration of technologies, limited learning resources, and low motivation of the students in their learning, all synergize to create critical barriers that reduce overall program effectiveness, thereby affecting expected student learning outcomes.

**Recommendations for Improvement in the PPP_A Course**. Improvements to attain Class A's utmost efficiency for DMU (Production Control = PPP_A) in general must be planned and carried out systematically based on analysis factors causing inefficiency. Some suggestions for areas needing improvement based on the evaluation result are optimizing student and lecturer ratios, use of learning technology, and richness of learning resources and motivating the students. Each of these steps for improvement is expected to overcome the existing obstacles and reach better efficiency in the learning process. The improvement steps can be explained further in Table 11.

Table 11. Improvement steps in the PPP_A Course

| Improvement Steps | Explanation |
|---|---|
| Optimization of student/lecturer ratio | Reducing the number of students in one class so that interaction between lecturers and students is more intensive. |

| | |
|---|---|
| | Increasing the number of teachers, if possible, so that attention to students can be more evenly distributed. |
| Improvement of learning technology | Using technology such as learning management systems (LMS) or interactive learning applications to increase student engagement. Utilizing digital media such as learning videos or simulations to enrich the learning experience. |
| Enrichment of learning resources | Providing more references, such as e-books, learning modules, and video tutorials that can help students. Ensuring that all learning resources are easily accessible to students. |
| Student motivation | Developing more engaging teaching methods, such as project-based learning (PBL). Providing more structured feedback on student assignments to increase their motivation. |

## CONCLUSION

The results of this study indicate that most of the courses analyzed have achieved full efficiency, indicating that the management of learning resources has been carried out well to produce optimal output, such as high academic grades, good attendance rates, and completion of assignments that are almost on target. However, there is one course, namely Class A Production Planning and Control (PPP_A), which is not yet efficient, indicated by inefficiency in the utilization of resources both in terms of input and output. The PPP_A course requires further evaluation, especially related to several main factors such as the ratio of students to lecturers that is too high, the use of learning technology that is still minimal, and suboptimal student motivation. The high ratio of students to lecturers limits the opportunity for lecturers to provide adequate attention, which also reduces the quality of interaction and learning. The use of technology that is not yet optimal reduces the opportunity to create an interactive and interesting learning process. Besides, low motivation among students, as seen from the level of attendance and suboptimal completion of assignments, is also an obstacle that needs to be overcome. Some steps, such as balancing the ratio between students and lecturers, the increasing use of learning technology, and increasing student motivation, would provide expected improvements in the efficiency of the PPP_A course. If carried out accordingly with effectiveness, all courses should achieve full efficiency and therefore support institutions in providing good-quality education to the students.

The weakness of this study lies in the limited data that only uses certain input and output variables, such as the number of lecturers, teaching hours, and student/lecturer ratio, so it does not cover all factors that affect the efficiency of lecture classes, such as the quality of lecturer-student interactions or other external factors. In addition, this research included only 10 courses at one university; therefore, the results have less generalizability. Another limitation of the applied approach is that DEA only gives the technical efficiency, but in the qualitative factors, the in-depth analysis is not extended to greater detail. These deficiencies could be improved by increasing the number of variables and samples, including more universities in the sample, and by combining other methods of analysis to reach deeper and more representative results. In addition, other studies can be conducted in regard to qualitative factors like the motivation of students and teaching quality, analyzing how educational policies or quality improvement programs influence the efficiency of lecture classes.

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