Multimedia-based Information System for Technology and Vocational Education Laboratory

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Abstract

The significance of Technological and Vocational Education (TVE) lies in producing professionals with competencies that are required to support the academic community. The aim of this study was to build an Information System of Laboratory (ISLab) that would improve the performance of the technical and vocational educational laboratory. The proposed information system was built based on multimedia featuring text, graphics, 3D images, grassroots access, and top-down reviews. The study used the System Development Life Cycle (SDLC) technique, and the data was analyzed using descriptive, gain-score, and inferential factorial design. The study findings proved that ISLab operated in accordance with laboratory standards and achieved a performance of 90.3% according to user needs. Furthermore, laboratory management using ISLab was found more effective than conventional management system, and the proposed method of management enabled interaction with user groups that led to an increase in performance of laboratory staff and lecturers. The results of this research indicate that ISLab was suitable to be used in managing technical and vocational educational laboratories.

Keywords

Laboratory Management, Information System, Laboratory Standards, Multimedia.

1. Introduction

Technological and Vocational Education (TVE) is now a global phenomenon as it produces graduates with appropriate skills to hold middle-level positions in industry. The domain of TVE responds to the needs of stakeholders by providing graduate competencies along with the demands of development (**Pavlova**, 2013). The domain also shows the readiness to support higher education and teaching, especially through laboratories that support lectures and research activities (**Irjus *et al.***, 2020). Since the TVE graduates have a crucial role and function in the laboratory, proper management is needed to ensure the performance of the laboratory in supporting education, training, and research, as required by the academic community. Laboratory management is of utmost importance as the quality of its services determines the attainment of the learning outcomes. When there is an appropriate laboratory management in place, there must also be a compatible information system built in accordance with the requirements of laboratory management namely classification, forecasting, performance records, and inventory control systems.

The province of North Sumatra, located in the western region of Indonesia, prioritizes TVE to meet the needs of personnel in areas of development such as Medan Modern Industrial Estate, namely KIM Belawan, KIM Tanjung Morawa, KIM Kuala Tanjung, and the Sei Mangke Creative Industrial Estate. However, these efforts have not been achieved because the educational process has not been effective, especially in laboratory practices (Jean-Claude & Sarma, 2022). A preliminary study found that technology and vocational laboratories in North Sumatra province did not support optimal education and training. One reason for this could be because they were conventionally managed (Rajesh Bose et al., 2022). Laboratory functions cannot be supportive if laboratory inventory management is inefficient. This inefficiency deters TVE institutions from preparing skilled workers (**Munyaka; Yadavalli**, 2022; **Prita; Nageswar; Pranati; Satyajeet**, 2019). Furthermore, it can internally disrupt the continuity in laboratory-related work owing to the threat of damage and loss of inventory due to manual and conventional inventory management (**Makarova; Pavlicheva**, 2021). A need is therefore felt to address this problem immediately, and one solution is to develop innovative information system in laboratory management.

1.1. Research Problem

Inefficiency in laboratory management has been experienced by Universitas Negeri Medan (Medan State University), which has the largest number of TVE institutes and other public and private universities in the region (**Qurbasari *et al.***, 2019). Institutions that manage inventory equipment, in large and diverse quantities, face challenges when using conventional management techniques (**Panhwar *et al.***, 2020; **Moumtzoglou; Kastania; Archondakis**, 2015). Inefficiencies in laboratory management, especially the lack of data and information on equipment, utilization records, usage circulation, and maintenance schedules, will increase the chances of the occurrence of damage and loss of inventory (**Boyar *et al.***, 2021; **Sembajwe; Shamu; Machingura; Chidawanyika**, 2018).

Among several solution, developing an information system that can accommodate the requirements of the laboratory is considered the most appropriate for improving laboratory performance (**Bose; Mondal; Sarkar; Roy**, 2022; **Munyaka; Yadavalli**, 2022). Till date, the management of educational laboratories has been performed either conventionally, or using a partial recording system, which has many weaknesses. Therefore, it is necessary to develop an appropriate information system based on user needs. There are several problems that need to be prioritized in system development research, which have been stated in the following research questions:

1. What specific needs should be accommodated to assist laboratory users?
2. What kind of information system model is suitable to improve laboratory performance?
3. How are the results of the integrated information system performance test developed?
4. How is the performance of laboratory management based on information systems?
5. How does the interaction of user groups and forms of management affect the laboratory performance?

The aforementioned problems are stated based on the characteristics of the TVE laboratory, which is limited to only the state level universities in North Sumatra Province, which represent the TVE in this province.

1.2. Objectives and Urgency of Research

The current research was based on a study which was funded by the government of the Republic of Indonesia that argued that an appropriate management information system model can increase the performance of educational laboratory. The aim of this research was to develop an application for the information system of laboratories (ISLab) program to improve the performance of the educational laboratory. Specifically, the research addresses the following objectives:

1. Identify the specific needs of educational laboratory users.
2. Build the ISLab information system that accommodates user needs.
3. Test the ISLab performance.
4. Analyze the effectiveness of laboratory management, based on the ISLab.

It was premised that a well-developed information system can be designed to accommodate those specific needs of users that cannot be met by conventional management techniques. The advantages of the proposed ISLab included: (1) The system had five access domains based on user needs, namely (a) manager system, (b) coding and numbering, which is quite extensive, (c) circulation-specific transactions, (d) maintenance program, and (e) reporting system; (2) The system provided input-output access facilities, on a top-down and bottom-up basis, for inventory clustering; and (3) The proposed information system could display inventory information in the form of text, graphics, and 3D visuals. Additionally, the ISLab information system, developed based on user needs, would provide the following benefits:

1. Increased quality of educational laboratory management, especially in management activities such as planning, organizing, actuating, and controlling.

2. Availability of representative, accurate and integrated inventory data as the basis for management activities, and decision making
3. Improved quality of programmed and planned inventory management, and maintenance of laboratory services.
4. Reduced risk of damage and loss of inventory due to management negligence.
5. Improved laboratory management efficiency.
6. Improved laboratory performance in supporting education, training and research of TVE institutions, leading to increasing competence of graduates.

The study thus succeeded in building an ISLab application based on laboratory management standards and criteria that accommodated the specific needs of users and also met the requirements. The effectiveness of laboratory management using the ISLab application was proven to significantly improve laboratory performance to meet the user needs. The newly built laboratory management using the ISLab also performed significantly better than conventional management.

2. Literature Review

2.1. Technology and Vocational Education Laboratory

Technology and Vocational Education (TVE) produces middle-level workers, equipped with the appropriate skills to work within the field of science and technology, and boost the continuity of further education (**Pavlova**, 2013). The North Sumatra Province, Indonesia has been experiencing many problems related to the quality of TVE graduates, particularly their low competency levels. The lack of laboratory practicum was found to be the leading cause of low competency levels of TVE graduates (**Munyaka; Yadavalli**, 2022). In addition, other issues that impacted negatively on the skill set of the graduates included a lack of practicum equipment, out of date equipment, and deficiencies in management (**Bose *et al.***, 2022). Specifically, shortcomings of the management negatively impacted the performance and efficiency of the laboratory, due to their adherence to conventional methods. The weaknesses in conventional laboratory management are lie mainly in maintaining the accuracy of inventory data and updated equipment records; besides, monitoring significant functions like usage circulation, equipment maintenance, and reporting (**Cadavid; Zuluaga**, 2011; **Makarova; Pavlicheva**, 2021). Another weakness found is the frequent occurrence of inventory damage due to the lack of planned maintenance; and losses occurring due to weak manual recording methods being adopted (**Panhwar *et al.***, 2020; **Boyar *et al.***, 2021).

Many past studies have revealed similar problems associated with laboratory management. For example, **Suseno; Harjati, and Dedy** (2019) reported that school laboratories in Indonesia generally had many weaknesses, namely (1) incompetent and unqualified laboratory staff having no certification of expertise in their fields; (2) laboratory management being carried out manually with fragile inventory records; (3) unavailability of SOPs and regulations related to laboratories. These studies have emphasized greatly to improve the role and function of the laboratory, as a support to academic activities and build proper management in place, which includes carefully regulating work, planning and organizing, and controlling laboratory activities (**Panhwar *et al.***, 2020). Furthermore, management functions must also be able to synergize in one management system. Due to the issues highlighted in previous studies, the measured levels of performance of science and technology laboratories is of particular significance.

2.2. Information System of Laboratory

Laboratory management determines the quality of the performance in providing services to users. The laboratory must be managed properly with an appropriate management system that cannot be separated from the use of information systems (**Panhwar *et al.***, 2020). The information system that is built must be designed to accommodate several aspects of laboratory management, namely classification, forecasting, performance records, and inventory control systems (**Cadavid; Zuluaga**, 2011). Classification is an inventory clustering method that contains data on inventory specifications, quantity (volume), and inventory procurement time, while forecasting is related to inventory estimates such as average usage, average service life, estimated maintenance time, repair, and replacement time. The aspect of inventory control systems comprises an inventory control system for transactions, which includes items such as circulation of the type of inventory, the amount used, the control system inventory, inspection, calibration and maintenance, and periodic monitoring and evaluation.

Several eligibility criteria for laboratory information systems are also stated in previous studies, that have emphasized the need to systematically accommodate user needs, including (1) organizational structure and SOPs; (2) laboratory usage time planning; (3) laboratory usage regulations and mechanisms; (4) arrangement of activity schedules, laboratory staff, and persons in charge; (5) accurate and complete recording of inventory; (6) regulating

the use of merchandise; (7) inspection and control; (8) scheduling of maintenance; (9) management of finances; and (10) reporting (**Paszko**, 2019; **Weiss; McKenna; Lord-Toof; Thompson**, 2011; **Farzandipour; Meidani; Sadeqi Jabali; Dehghan Bnadaki**, 2019; **Hao; Zheng; Wang; Jiang**, 2021). Therefore, the information system built should meet the work needs of administrators and laboratory users, to include inventory classification and coding, equipment transactions and circulation, scheduled maintenance, inventory history, and reporting systems (**Bose *et al.***, 2022). In addition, laboratory performance indicators, such as utility, reliability, availability, maintenance, and efficiency, must be accommodated (**Paszko**, 2019; **Sun; Wu; Fan**, 2021). In addition, there are six factors interrelated as a system such as service accuracy, speed to respond, consistency, efficiency, user satisfaction, and performance quality that determine the performance of the laboratory to provide services to users. **Panhwar *et al.*** (2020) stated the need to evaluate the effectiveness of laboratories covering all aspects of service and guarantee quality standards, through acknowledgment of accreditation by authorized institutions, to ensure standardized laboratory quality standards.

3. Research Method

Research and development design was used to conduct this study. The System Development Life Cycle (SDLC) method was adopted to design an Information System of Laboratory (ISLab) application program. This model was implemented in four stages: investigation, analysis, design, and implementation (**Whitten; Bentley**, 2007). This research was conducted at four state universities in North Sumatra Province, Indonesia, by taking a sample of 20 TVE laboratories, with 20 laboratory staff, 40 lecturers, and 80 TVE students as respondents, for feasibility and effectiveness testing.

The ISLab application system was developed using the CodeIgniter Framework software and PHP 7.2. The databases MySQL and PostgreSQL were used considering the advantages of portability, open-source, multi-user, performance tuning, various data types, complete commands and functions, layered security systems, scalability and limitations, connectivity, program blocks, API interfaces, client and online tools, and the flexibility of the table structure (**Laudon; Laudon**, 2014). Analysis and performance testing of the ISLab followed a life cycle procedure which verified that the program met system requirements. Stub testing and unit testing comprised system testing. Furthermore, black box and white box testing were carried out and finalized with integration testing to determine the interaction between modules to ensure that the flow of information, between processes, ran correctly (**Whitten; Bentley**, 2007).

To test the feasibility of the ISLab system, a feasibility test was conducted, based on information system criteria and aspects of user needs, by comparing program performance with standard criteria (**Weiss *et al.***, 2011; **Bose *et al.***, 2022). Furthermore, laboratory performance tests were performed using laboratory management effectiveness instruments to meet user needs (**Cadavid; Zuluaga**, 2011). Performance analysis included descriptive analysis, management effectiveness, and comparative analysis. The descriptive analysis revealed laboratory performance achievements in meeting the needs of user groups, and management effectiveness analysis compares laboratory performance achievements, based on both conventional management and the ISLab application, which were then analyzed using the gain-score technique. The comparative analysis used inferential analysis to compare the performance of conventional laboratory management and ISLab for the three user groups. Their interactions were analyzed using a two-way Anova (**Chua**, 2009).

4. Results and Discussion

The development of the ISLab information system was carried out using the SDLC model. Two activities were carried out at the investigation stage: preliminary studies and feasibility studies to enable problem definition, designing alternative solutions, system development, operational feasibility, technical, economic, and time feasibility. The system analysis stage began with an analysis of the current system. It then determined the needs of the new system and the procedure for converting logical specifications into the design model. The system design formulated features and structures, established software requirements, and displayed criteria, configurations, and system approvals. Meanwhile, the system implementation stage included an integrated system, system testing, and transition from the old system to the new system.

4.1. Design and Construction of Information System

The system design provides three groups of users: administrator, operator, and user. To ensure that no crashes occur, a database (*dbsivenris*) was created to store data tables that could be shared with other users. This relationship is presented in Figure 1.

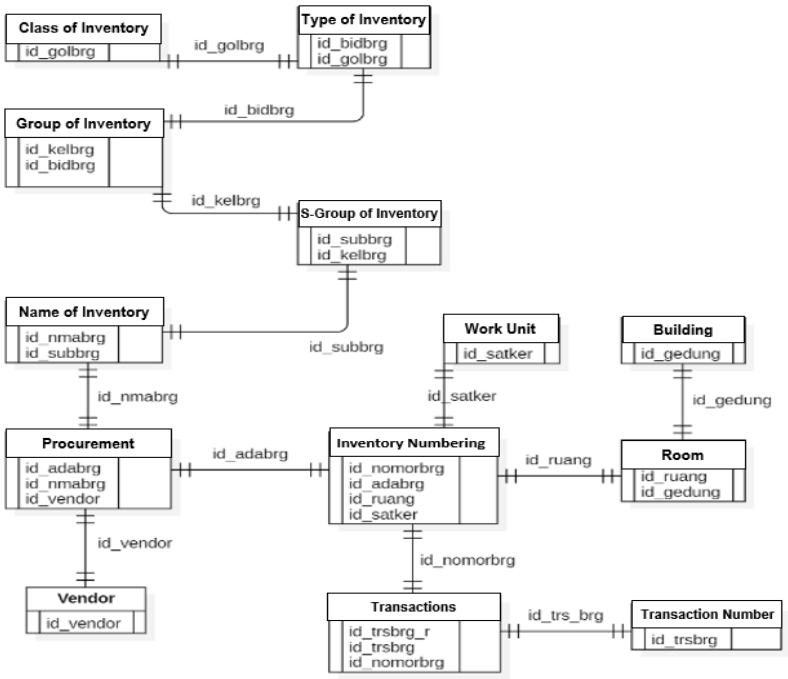

Figure 1: Design and Construction of the ISLab.

The operational system, inventory data connectivity and report are displayed in Figure 2 and 3. There are five access domains, with a login system as the main access gate. The program database schema includes system login, menu manager, inventory data, circulation and transactions, maintenance, and reports.

Figure 2: Connectivity of inventory.

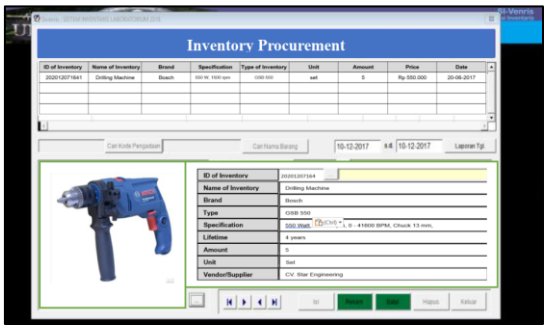

Figure 3: Specification of Inventory Data.

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Print Preview

No	ID of Inventory	Name of Inventory	Brand /Type/ and Specification	Amount	Price	Vendor
1	20201207164	Drilling Machine	Bosch,/ GSB 550 550 Watt, 0-2800 rpm, 0 - 41600 BPM, Chuck 13 mm,	5	Rp 550.000	CV. Star Engineering

Figure 4: Report of Inventory.

The performance of the system was designed to meet the standard output criteria based on laboratory inventory management regulations and the specific needs of users to accomplish connectivity of inventory data as shown in Figure 2. The Figure 3 shows an example of recording inventory data by type, group, identity number, inventory name, specifications, and placement. Figure 4 shows an example of a screen display for recording inventory data.

4.2. Feasibility of System

The next step was to test the feasibility of the system using a feasibility test instrument. This feasibility test was carried out after the system had been built, following the SDLC rules and meeting the stub testing, unit testing and integration testing criteria. The feasibility test of the ISLab application system was carried out using a feasibility instrument. The test results are presented in Table 1.

Table 1: Summary of the ISLab Feasibility Test.

No	Feasibilities Aspect	Conv. Man*	ISLab*	ð-Score*	Grad of Feasibility
1	Program Operating	5.60	8.60	3.00	feasible
2	Data entry	3.60	9.50	5.90	high feasible
3	Transaction	3.10	8.80	5.70	feasible
4	Output system	2.40	8.60	6.20	feasible
5	Controlling	3.20	8.90	5.70	feasible
6	Report	4.07	8.93	4.86	feasible
7	Security system	5.60	9.40	3.80	high feasible
8	Accuracy	4.60	9.60	5.00	high feasible
9	Friendly	4.30	8.60	4.30	feasible
10	Reliability	4.60	9.40	4.80	high feasible
	Mean	4.11	**9.03**	4.93	high feasible
**Score range: 0 – 10*					
Conv. Man: Conventional Management					
ISLab: Management by Information System of Laboratory					

The feasibility test results show that all aspects meet the standards, and four elements are particularly feasible in meeting user needs— accuracy meets 96 %, data entry 95 %, security system 94 %, and reliability 94%. The other six aspects meet 86 % of the user needs. The ISLab operates in accordance with laboratory standards and achieves a performance of 90.3% while Conventional Management only 41.1% according to user needs. These results show that ISLab is suitable for use in an educational laboratory management information system, following academic laboratory standards (**Yusof; Arifin**, 2016; **Panhwar *et al.***, 2020). Furthermore, especially in the Report aspect, the built system has significant advantages compared to the previous management approach, as shown in Table 2.

Table 2: Summary of the ISLab Feasibility Test for Aspect Report.

No	Feasibilities Aspect	Conv. Man*	ISLab*	ð-Score*	Grade of Feasibility
1.	R-Variance of inventory	6.20	9.80	3.60	Highly Feasible
2.	R-Group of inventories	6.50	9.40	2.90	Highly Feasible
3.	R-Inventory name	6.20	8.70	2.50	Feasible
4.	R-Production time	4.20	9.80	5.60	Highly Feasible
5.	R-Corporate	4.50	9.60	5.10	Highly Feasible
6.	R-Specification	2.40	8.50	6.10	Feasible
7.	R-Numbering	2.40	8.60	6.20	Feasible
8.	R-Detail profile	2.70	8.20	5.50	Feasible
9.	R-Time used	1.60	9.80	8.20	Highly Feasible
10.	R-Work resource	1.40	7.80	6.40	Feasible
11.	R-Accurate of data	4.20	9.70	5.50	Highly Feasible
12.	R-Documentation	4.60	9.50	4.90	Highly Feasible
13.	R-Record	2.40	9.80	7.40	Highly Feasible
14.	R-Rent transaction	5.30	8.80	3.50	Feasible
15.	R-Return transaction.	4.60	8.60	4.00	Feasible
16.	R-Circulation transaction	3.40	7.90	4.50	Feasible
17.	R-Check/re transaction	4.20	7.80	3.60	Feasible
18.	R-Verification transaction	4.50	7.90	3.40	Feasible
19.	R-Action time	3.20	8.40	5.20	Feasible
20.	R-Spec Accuracy	6.50	9.80	3.30	Highly Feasible
21.	R-Allocation	4.30	9.60	5.30	Highly Feasible
22.	R-Reschedule	3.50	8.70	5.20	Feasible
23.	R-Maintenance	4.80	7.80	3.00	Feasible
24.	R-Planning (used)	4.60	7.80	3.20	Feasible
25.	R-Finance report	3.20	7.60	4.40	Feasible
26.	R-Function of inventory	5.70	9.70	4.00	Highly Feasible
27.	R-Histories of inventory	3.40	9.60	6.20	Highly Feasible
28.	R-Error protection	6.50	9.80	3.30	Highly Feasible
	Mean	4.18	8.89	4.71	
**Score range: 0 – 10*					
Conv. Man: Conventional Management					
ISLab: Management by Information System of Laboratory					

Of the 28 indicators that are reported as outputs in Table 2, all have significant positive results in improving the performance of the laboratory management system. The details of the mean score relating to the growth of the performance aspect of the reporting system are shown in Figure 5.

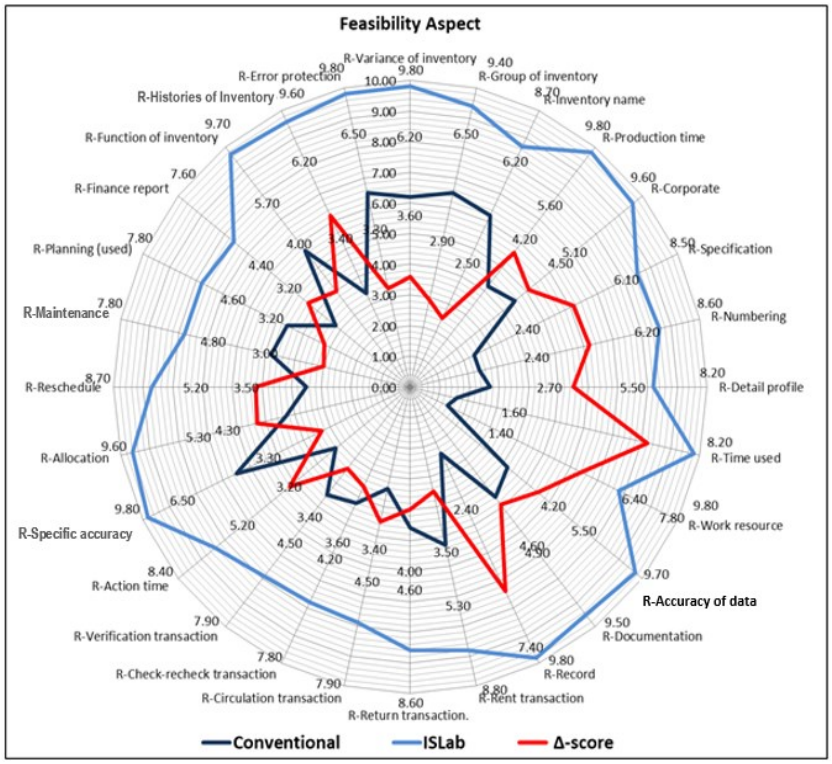

Figure 5: Mean-Score of the ISLab Performance System.

The feasibility test results of the program for reporting aspects showed that all sub-indicators experienced a significant increase. The highest growth in the feasibility level of laboratory management system performance was in the time-used sub-indicator, with a rise of 82%, followed by the record system at 76 %, work-resource at 64 %, numbering at 62 %, history/track of inventory at 62 %, specification at 61%, and several sub-indicators that have a growth of 50–60%, such as data of production, accuracy, detail profile, corporate data, schedule, allocation, and work time. The magnitude of the increase in scores from the system tests strengthens the feasibility of the ISLab, showing that it is capable in meeting the standard criteria for the role and function of the laboratory in supporting educational activities, training, and research experiments at TVE institutions (**Sun *et al.***, 2021; **Yusof; Arifin**, 2016; **Panhwar *et al.***, 2020). Thus, this information system proved to be definitely feasible for use.

4.3 Performance of System

System performance is based on the fulfillment of work indicators that are based on the specific needs of laboratory users in supporting experimental, educational, training, and research activities. Four main aspects were measured in the performance assessment with several derivative indicators referring to the management function, namely SOP and scheduling (planning), equipment management (organizing), equipment accuracy (actuating), and security system (controlling). The results of the laboratory performance data analysis are presented in Table 3.

Table 3: Fulfillment of Laboratory Performance Aspects.

Performance Aspect	Conventional				:	ISLab			
	LStaff* n=20	Lect* n=40	Stud* n=80	Total (n=140)	:	LStaff* n=20	Lect* n=40	Stud* n=80	Total (n=140)
SOP and scheduling (P)	3.69	3.41	4.44	4.05	:	4.23	4.02	4.49	4.32
Equipment management (O)	3.74	3.35	4.38	3.99	:	4.45	3.96	4.39	4.28
Equipment accuracy (A)	3.80	3.31	4.42	4.01	:	4.49	4.11	4.31	4.28
Security system (C)	2.50	3.01	4.24	3.64	:	4.30	4.08	4.52	4.36
Total (mean)	3.43	3.27	4.37	**3.92**	:	4.37	4.04	4.43	**4.31**
Note: Mean score range: 1 – 5; LStaff: Laboratory staff; Lect: Lecturers; Stud: Students									

Table 3 shows that laboratory management using conventional methods can only meet 78.4 % (Total mean= 3.92) of user needs, while laboratory management using the ISLab application can meet 86.2 % (Total mean= 4.31) of user needs. The lowest performance was found with regards to the security system, which only meets 50% of the user needs under conventional management.

However, this outcome varies considerably from the control methods adopted within ISLab application, which can fulfill 86.2 % of user needs. Analysis using the gain score technique, with the formula N-gain (**Hake**, 1999), obtained an N-gain index of 0.38, which was significantly high. This means that laboratory management using the ISLab can improve laboratory performance, to relatively large extent, compared to conventional control methods used previously. The findings of this study are in line with the research of **Prita *et al.*** (2019) and **Yusof and Arifin** (2016), which showed that laboratory performance can be improved through the use of an information system for the assessment of student laboratory practice. **Makarova and Pavlicheva** (2021), showed that the effectiveness of laboratory management can be enhanced, through the use of information technology, for students' laboratory practice work. The results of this study are also in line with those of **Cadavid and Zuluaga** (2011), **Qurbasari *et al.*** (2019), and **Boyar *et al.*** (2021).

4.4 Effectiveness of System

The effectiveness of the system was analyzed based on the significance of the effect of the independent variables, namely the user group and laboratory management, and their interaction with laboratory performance as the dependent variable. Therefore, the first step that must be met was testing the analysis requirements, including the normality and homogeneity of the data. The results of the calculation of Levene's Test of Equality of Error Variance for Performance of Laboratory, as the dependent variable, obtained F (5:274)= 0.227 with a significance greater than the coefficient (0.227 > 0.05). This result is a sufficient reason to state that the variance between groups is identical (homogeneous). Furthermore, data processing results obtained the mean score for the factorial design, using two-way ANOVA, as shown in Table 4.

Table 4: Factorial Design for Fulfillment of Laboratory Performance.

Lab Management	Laboratory staff*	Lecturer*	Student*	Total*
Conventional	3.43	3.27	4.37	3.92
ISLab	4.37	4.04	4.43	4.30
Total	3.89	3.65	4.39	4.12
*Mean score, range: 1 – 5				

Table 4 shows that the difference in the mean-score of laboratory performance is quite significant, namely ISLab-based management score is much higher than that of conventional methods, especially in laboratory staff and lecturers. The certainty of the substantial difference is proven from the results of data analysis with Two-way ANOVA, as shown in Table 5.

Table 5: Tests of Between-Subjects Effects.

Dependent Variable: Performance of Lab					
Source/ aspects	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	52.474[a]	5	10.495	255.229	.000
Intercept	3267.592	1	3267.592	7.947E4	.000
Lab.Man	31.611	1	15.805	384.381	.000
User	17.825	2	17.825	433.501	.016
Lab.Man * User	10.393	2	5.196	126.375	.000
Error	11.267	274	.041		
Total	4807.719	280			
Corrected Total	63.741	279			
a. R Squared = .823 (Adjusted R Squared = .820)					

Table 5 shows the significant coefficients for all aspects. The model that was built (corrected model), based on the test results, was declared significant and as a result declared valid.

All test results stated that laboratory management had a positive and significant effect on performance achievement in meeting user needs. Thus, the test results can be summarized as:

1. There is a significant difference in laboratory performance between conventional management using the ISLab application. Control using ISLab achieves higher performance, with a mean score of 4.30, than traditional management, with a mean score of 3.92, in meeting user needs.
2. There is a significant difference in laboratory performance based on user groups, with a mean score of 3.89, 3.65 and 4.39 for groups of laboratory staff, lecturers, and students.
3. There is a significant difference in laboratory performance in meeting user needs based on user groups and laboratory management interactions. Laboratory management using the ISLab can achieve higher performance than conventional management, especially in the laboratory staff group (4.37 and 3.43) and lecturer group (4.04 and 3.27). Regarding the student group, there was only a slight difference (4.43 and 4.37).

The post hoc test analysis results showed that all options for interaction between user groups and laboratory management showed a significant effect at the 5% alpha level. Therefore, it can be said that laboratory management using the ISLab application system has a very large influence on improving laboratory performance in fulfilling user needs, for laboratory staff, lecturers, and student groups. This finding supports the results of previous relevant studies, such as those by **Mishra; Kendhe, and Bhalerao** (2015), **Sembajwe *et al.*** (2018), **Qurbasari *et al.*** (2019), and **Paszko** (2019).

The success of the ISLab application in improving laboratory performance is supported by several unique systems that are deliberately built, based on the specific needs of users. This innovation is novel and has not been previously obtained in other information system applications. Some of the unique features of the ISLab application are as follows.

1. The system can provide output in text, graphics, and 3D images (multimedia-based).
2. The system can access and manage information, both top-down and bottom-up.
3. The system can accommodate the specific needs of users, provide text and image information, scan barcodes, and online access for multiple users in an integrated networking system.
4. The application is built in an open-source system that the general public can use. Thus, free software, applicable, usable, and friendly can be developed for workshops, studios, inventory, libraries, and other relevant needs.
5. Data input/device identification can be made manually or with the barcode system.

The advantages of the ISLab application system, with several innovative features, can provide solutions to the problem of low laboratory performance. Therefore, the ISLab application is the right solution to improve laboratory performance in meeting user needs to support experimental, educational, training, and research activities in technology and vocational education institutions, ultimately improving TVE graduates' competencies. The urgency and excellence of ISLab will continue to be developed through further research because the system built will be disseminated in open source form. Thus, the development and improvement of the ISLab application will continue as needed to meet user needs.

5. Conclusion

The results of this study prove that the proposed hypothesis can be tested and eventually yield positive results, as supported by previous relevant theories and research. The research findings conclude the following:

1. The ISLab application is built based on laboratory management standards and criteria that accommodate the specific needs of users and has been proven to meet the requirements for use.
2. The effectiveness of laboratory management using the ISLab application is proven to significantly improve laboratory performance to meet the user needs.
3. Laboratory management using the ISLab is proven to perform significantly better than conventional management in supporting user needs. The traditional management of laboratories can only fulfill 78.4 % of user needs, while ISLab meets 86 %.
4. There is a significant difference in laboratory performance based on user groups with an attainment of 77.8 %, 73 %, and 87.8 % for the laboratory staff, lecturers, and student groups, respectively.
5. The interaction between user groups and laboratory management has a significant positive effect on laboratory performance. Laboratory management using the ISLab can achieve considerably higher performance than conventional management in meeting user needs by 87.4 % for the laboratory staff group, 80.8 % for the lecturer group, and 88.6 % for the student group. Meanwhile, the performance of conventional laboratory management only reached 68.6 %, 63.4 %, and 87.4 % for the laboratory staff, lecturer, and student groups, respectively.

The results of this study have proven the success of laboratory management using the ISLab application system in improving laboratory performance to support learning, training, experimentation, and research activities on TVE. Furthermore, the uniqueness of the ISLab application, which is a novelty in a multimedia-based laboratory management information system, is a solution to the low performance of educational laboratories. Therefore, the use of a multimedia-based integrated information system is highly recommended to ensure the quality of service and the convenience of laboratory users to achieve optimal performance.

Competing interests

The authors declare no competing interests.

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