Optimization Of The Atc Simulator Laboratory In Aerodrome Control Procedure Learning For The Air Traffic Study Program At Poltekbang Surabaya

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ABSTRACT
This study aims to analyze strategies for optimizing the use of the ATC Simulator Laboratory in teaching Aerodrome Control Procedures for D3 Air Traffic students at the Surabaya Aviation Polytechnic. Although the laboratory is equipped with hardware and software that mimic real operational conditions, its utilization is not yet optimal due to outdated hardware, limited software, a lack of instructor training, and a limited number of competent personnel for its operation. This research employs a descriptive qualitative approach with data collection through direct observation, interviews with lecturers, the head of the laboratory, and students, as well as a study of documentation such as maintenance forms and schedules. The research instruments were validated by a supervisor, and data analysis was conducted using the Miles and Huberman model with triangulation as the validation method. The results indicate that the laboratory is not yet functioning optimally, in terms of hardware, software, and SOPs, and thus does not fully support realistic air traffic control simulation scenarios. The research was conducted at the ATC Simulator Laboratory of Poltekbang Surabaya during the sixth semester of 2025.

Keywords: *Aerodrome Control, Air Traffic Controller Simulator, Learning Outcomes, ATCO Guidance.*

1. INTRODUCTION

Surabaya Aviation Polytechnic (Poltekbang) stands as a pivotal vocational education institution within Indonesia's aviation sector, tasked with cultivating the next generation of industry professionals. A cornerstone of its offerings is the D3 Air Traffic (LLU) study program, which is meticulously designed to produce highly competent and certified air traffic controllers (ATC). Within this demanding curriculum, students are required to achieve mastery over essential control skills, with a particular emphasis on Aerodrome Control (ADC), a discipline absolutely critical to maintaining the rigorous standards of flight safety. To bridge the gap between theoretical knowledge and real-world application, an effective pedagogical approach that closely approximates operational conditions is indispensable; simulation technology, therefore, emerges as the most suitable method to support and enhance student competence.

To this end, the Air Traffic Control (ATC) Simulator Laboratory at Poltekbang Surabaya serves as a vital and indispensable facility for the practical training of its D3 Air Traffic students. This advanced laboratory is specifically engineered to provide a deeply immersive and realistic simulation experience in all facets of air traffic management, thereby allowing students to diligently hone their practical skills in a controlled, safe environment before they transition into the high-stakes professional world. However, despite being equipped with a sophisticated 360° ATC Simulator facility, the institution has identified that its integration into the learning process is not yet optimal. Consequently, the full potential of this laboratory as a premier training tool that accurately mirrors real-world operational conditions remains unrealized and is in need of significant improvement to ensure graduates are fully prepared for the complexities of their future roles.

1.1. *Literature Review*

1.1.1. *Definition of Optimization*

Based on several definitions, optimization can be interpreted as the process of achieving the best or highest result from something. This term refers to the effort to

achieve a goal to the maximum extent possible according to predetermined criteria. So, simply put, optimization is the search for the best value from the available choices to achieve a goal.

1.1.2. *Definition of ATC Simulator*

A simulator is a program or tool that mimics the operation of a system or process in a virtual environment. In the field of Air Traffic Control (ATC), an ATC Simulator is a hardware and software system that simulates various air traffic scenarios, from ground movements to air control areas. This facility plays an important role as a "bridge" for students to practice their air traffic control skills. By using a simulator, training scenarios can be adapted to actual airport operational conditions, allowing students to gain practical experience before entering the field. At Surabaya Aviation Polytechnic (Poltekbang), there are two main types of simulators for the Aerodrome Control Tower, namely the ADC Manual and the 360° Simulator.

The Aerodrome Control Simulator, commonly known as a Tower Simulator, is designed to replicate the operational environment of an airport control tower. Its primary function is to train controllers in the management of aircraft and vehicles on the airport's runways and taxiways, as well as aircraft operating in the immediate vicinity of the airport.. The defining feature of a Tower Simulator is its reliance on a 3D visual system that provides a panoramic, out-the-window view of the airfield. This visual interface is critical, as tower control is heavily dependent on direct visual observation. Training tasks focus on issuing take-off and landing clearances, managing ground traffic flow to prevent conflicts, applying visual separation rules, and coordinating the movement of airport vehicles.

The development, procurement, and operation of ATC simulators do not occur in a vacuum. They are shaped by a dynamic commercial market and a stringent regulatory framework. Leading technology companies compete to offer increasingly sophisticated and flexible systems, while international and national regulatory bodies set the standards for training and certification that these systems must support. The relationship between these entities is symbiotic; regulators are not merely rule-makers but are also major customers and developers of simulation technology, creating a powerful feedback loop that drives innovation across the entire sector. The needs of regulatory R&D push the boundaries of simulation, these advanced capabilities are then commercialized by industry, and the widespread availability of this technology allows regulators to mandate more sophisticated training standards.

1.1.3. *ATC Simulator Features*

The ATC Simulator has various main features that support the learning process, including:

1. Air Traffic Simulation: This simulator is designed to create highly realistic air traffic scenarios, including departure, arrival, and overflight procedures, as well as abnormal and emergency conditions.
2. Technical and Visualization Aspects: Modern ATC Simulators are equipped with a 360° visual display using a circular screen or LCD projectors. The goal is to provide a very deep and immersive simulation experience. This system has an accurate 3D graphics database, which includes aircraft models, airport structures, lighting conditions, and the surrounding environment. In addition, this simulator uses pseudo-pilots - virtual pilots who control the movement of aircraft. This allows trainees to interact with air traffic as if they were in a real situation.
3. Training Support Facilities: The simulator is equipped with various facilities designed to improve the effectiveness of training in air traffic control. One of its main features is zoom, which allows users to enlarge the view of objects so that it can replace the use of binoculars in the observation process. In addition, the simulator also provides a terminal area display in the form of a 2D radar, which provides accurate information about the position of aircraft in the control area. To support more efficient communication, the system is equipped with a digital communication system, which allows interaction between tower controllers, approach controllers, pseudo-pilots, and instructors during training sessions.
4. System and Network Configuration: The ATC Simulator is designed with a LAN-based network system that connects various positions in the simulation, such as the tower controller, approach controller, pseudo-pilot, and instructor.
5. Equipment and Specifications and Network: To support its functionality, the simulator is equipped with various advanced hardware and software, including high-performance industrial computers, a voice communication system based on the Voice Communication Control System (VCCS), and a recording and playback system (record & replay) to evaluate the performance of trainees.

1.1.4. *360° Simulator (Computerized ADC) at Poltekbang Surabaya*

The 360° Simulator or ADC Artmacs Simulator is a computer-based practical laboratory at Poltekbang Surabaya. This facility is used by students of the D3 Air Traffic and D3 Aviation Communication study programs. As a development of the static manual system, this simulator is designed to provide a more realistic and interactive training experience. Its function includes simulating various air traffic scenarios, such as aircraft movements, weather conditions, and interaction with pilots. This simulator can be used for various purposes, such as operational training, student evaluation, emergency condition simulation, and testing of new procedures. This system has a flexible architecture, allowing students to practice as Air Traffic Controllers (ATC), pseudo-pilots, or simulation administrators. Thus, this simulator becomes an effective tool for improving students' skills in communication, decision-making, and air traffic management in a safe environment.

1.1.5. *Aerodrome Control Learning Curriculum*

The Center for Human Resources Development in Air Transportation (Pusbang SDM Perhubungan Udara) designed the Aerodrome Control curriculum to equip students with the technical skills to guide air traffic in the airport area, including during take-off and landing. The goal is to produce professional air traffic controllers who meet international standards. For example, the D3 Air Traffic study program at Poltekbang Surabaya has an "Aerodrome Control Procedure I" course with a weight of 6 credits. This course consists of theory and practice, which are given in the second semester. Learning includes various competencies, such as procedures for giving clearances, instructions, and information, as well as practice in guiding under various operational conditions such as heavy traffic and low visibility. Learning is supported by international references such as ICAO Doc 4444 and CASR. At Poltekbang Surabaya and the Indonesian Aviation Polytechnic Curug (PPIC), similar courses are taught to train students in air traffic control. At PPIC, research highlights problems in the practice of guidance in the Aerodrome Control Tower laboratory to improve the quality of simulation. Meanwhile, Poltekbang Surabaya uses a technology-based simulation system such as the ADC Artmacs Simulator for effective learning. To master the skills, students at Poltekbang Surabaya are required to complete 15 core exercises and 3 evaluation sessions. Each exercise is designed with a realistic scenario to train quick, precise, and safe decision-making according to ICAO procedures.

1.1.6. *The Importance of Using Simulation in Improving Competence*

The use of simulation, such as Artmacs, is very important to improve the competence of air traffic students. This method allows them to experience a realistic work environment without operational risks. Thus, simulation plays a crucial role in shaping the technical and cognitive skills needed in the real world of work.

2.METHODS

Figure 1. 1 Research Design Stages Diagram

2.1. *Research Design*

The research design is a comprehensive guide that covers all stages of research, from planning to report writing (Silaen, 2018). This design becomes a reference for achieving research objectives through appropriate data collection methods and techniques. The author uses a qualitative research design (Sugiyono, 2017). This method aims to gain a deep understanding of a phenomenon, especially those related to the behavior and views of the individuals who are the object of the research. The choice of this design is based on the specific problems and objectives to be achieved in this study(Moeleong, 2022).

2.2. *Data Collection Techniques*

Data collection techniques are the foundational and systematic methodologies employed by

researchers to meticulously gather relevant information from specifically chosen research subjects or samples (Sugiyono, 2019) . This procedural step is of paramount importance in any scholarly inquiry, as the quality and validity of the research findings are directly dependent on the rigor with which data is collected. Both primary and secondary data can be effectively acquired through a direct and thorough review conducted at the actual research location, allowing for firsthand insights (Setiawan & Sudjana, 2023) .

In this particular study, a multifaceted qualitative approach was adopted, utilizing a strategic combination of several techniques to ensure a comprehensive and well-rounded understanding of the subject matter. The specific methods employed were:

2.2.1. *Direct Observation*

Observation is a data collection technique that involves direct, systematic, and objective observation of phenomena in the field (Kristanto, 2018) . In this study, the authors used observation to obtain supporting evidence related to the optimization of the ATC Simulator laboratory at Surabaya Aviation Polytechnic. This observation was conducted directly for two months to study and observe the practice of Aerodrome Control Procedure learning in depth.

2.2.2. *Interview*

An interview is a data collection technique through a question and answer process with respondents, either directly (face-to-face) or indirectly (through other parties)(Rahmawati et al., 2024).

In this study, the author used a guided free interview. This approach allows for flexibility in asking questions, including additional open-ended questions, according to the information provided by the source. Intensive interviews will be conducted with a sample of relevant sources, namely, three D3 Air Traffic (LLU) students, the Head of the Laboratory Unit (Kanit Lab), the Head of the LLU Study Program (Kaprodi), and one lecturer for the Aerodrome Control Procedure course. The selection of these sources aims to obtain in-depth information about the utilization and constraints of the ATC Simulator at Poltekbang Surabaya, as they have a direct role in the learning and operational aspects of the laboratory.

2.2.3. *Documentation*

Documentation is a data collection technique by collecting information from various written and visual sources, such as books, notes, transcripts, and photos. This method can include documents such as maintenance forms, damage reports, photos of laboratory conditions, and training certificates. In this study, the author used a documentation technique by taking photos using a mobile device. The aim is to record and analyze the condition and utilization of the ATC Simulator laboratory in the learning of Aerodrome Control Procedure at Surabaya Aviation Polytechnic.

The use of these three techniques aims to make the research results more accurate and in accordance with field conditions.

2.3. *Research Instruments*

FAARFIELD (Federal Aviation Administration Rigid and Flexible Iterative Elastic Layered Design) is a computer program for calculating and designing the thickness of flexible and rigid pavements on runways, taxiways, aprons, and heliports. The calculations in this program refer to FAA Advisory Circular AC 150/5320-6G.

2.4. *Data Analysis Techniques*

This study uses a qualitative approach with a model data analysis technique(Miles, M., Huberman, A. M., & Saldaña, 2014). This model consists of three main stages:

2.4.1. *Data Reduction*

Data reduction is the initial stage in qualitative analysis to simplify the raw data that has been collected. At this stage, the researcher filters data from interviews, observations, and documentation. The goal is to retain only information that is relevant to the research focus, namely the utilization of the ATC Simulator laboratory in learning the Aerodrome Control Procedure. This reduction process takes place continuously and becomes the foundation for the next stage of analysis.

2.4.2. *Data Display*

This crucial stage of the research process involves the meticulous organization and structuring of the condensed data into a format that is both accessible and easy to interpret. The primary goal is to present the information in a clear and coherent manner, utilizing various methods such as compelling narratives to tell the story within the data, well-defined tables or

matrices for systematic comparison, or the inclusion of direct and powerful quotes from interviews to provide authentic context.

This methodical arrangement is what allows the researcher to delve deeper into the dataset, enabling them to identify and analyze recurring patterns, significant themes, and critical issues that emerge from the teaching and learning activities under investigation. By presenting the data systematically, the researcher can more effectively discover and understand the intricate relationships and connections between different variables, which ultimately facilitates a more robust and insightful process for making analytical decisions and drawing well-supported, credible conclusions from the study.

2.4.3. *Conclusion Drawing and Verification*

The final stage of analysis is to draw conclusions from the presented data. This conclusion is the researcher's interpretation of the patterns and relationships between the information found. The goal is to answer the research problem about the utilization of the ATC Simulator laboratory in learning, the obstacles faced, and the optimization strategies that can be implemented. To ensure the validity of the findings, verification is carried out through data triangulation. This process is carried out continuously by comparing the results from various sources and data collection methods, such as observation, interviews, and documentation.

3.RESULTS AND DISCUSSION

3.1. *Research Results*

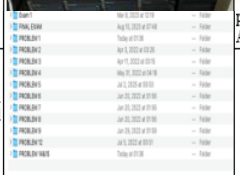
The author conducted direct observations at the ATC Simulator Laboratory of Poltekbang Surabaya, accompanied by interviews with the Head of the Study Program, the Head of the Laboratory Unit, instructors, and students, as well as an analysis of learning documents for five months in the sixth semester as part of the Final Project.

In order to gather comprehensive and multi-faceted data for this Final Project, the author implemented a detailed research methodology over an extended period of five months, coinciding with the sixth academic semester. This process began with immersive, direct observations conducted on-site at the Air Traffic Control (ATC) Simulator Laboratory located at the Surabaya Aviation Polytechnic (Poltekbang Surabaya).

To supplement these observational findings and gain deeper insights, this fieldwork was accompanied by a series of in-depth interviews with a wide range of key stakeholders. These included high-level academic administrators like the Head of the Study Program and the Head of the Laboratory Unit, as well as the instructors who facilitate the training and the students who are the direct participants. Additionally, the research was further enriched by a systematic analysis of pertinent learning documents to provide a complete understanding of the curriculum and its practical application within the laboratory setting.

3.2. *Observation Results*

Figure 3. 1 observation results

No	Indikator	Aspek yang Diamati	Dokumentasi	Keterangan
1	Perangkat Keras	Kondisi Perangkat Keras, Ketersediaan Perangkat, Performa Komponen PC		Terjadi Kerusakan monitor di lab atc simulator yang menghambat pembelajaran di lab atc simulator.
2	Perangkat Lunak	Fitur software pada Admin, VDS, Controller, dan Pilot		Software yang sudah terlalu jadul
		Sistem tidak berjalan lancar dan sering crash atau delay saat digunakan.		Tidak optimal dalam penggunaan nya
		Dengan skenario bervariasi		pembelajaran ADC.
		Exam 1 hingga 3 tersedia dan sesuai standar kompetensi Aerodrome Control		
4	SOP	Belum adanya SOP untuk penggunaan lab atc simulator.	-	-

This research was conducted at the ATC Simulator Laboratory of Poltekbang Surabaya on July 10, 2025, as the main training facility for the Aerodrome Control procedure. Through interviews with instructors, technicians, and students, a comprehensive picture of the use and optimization of the simulator was obtained. The results showed that although it plays an important role in simulation-based learning, the condition of the laboratory is not yet optimal, thus hindering the development of student skills. Observations found that about 80% of the laboratory facilities were not functioning, including damaged PCs and monitors. Some equipment was even severely damaged due to a roof leak that caused water to enter and damage the equipment, making the laboratory appear neglected.

3.3. *Interview Results*

To obtain accurate and relevant data, the researcher conducted interviews and direct documentation with six sources related to the use of the ATC Simulator Laboratory, namely:

Three students from the Air Traffic Study Program (LLU)

1. One Head of the LLU Study Program (Kaprodi)
2. One Head of the ATC Simulator Laboratory Unit (Kanit Lab)
3. One instructor lecturer involved in learning activities in the laboratory

This research was limited to the topic "Optimization of the Use of the ATC Simulator Laboratory in Aerodrome Control Procedure Learning" with the aim of knowing the perceptions, experiences, and challenges of both users and managers of the simulator in supporting the quality of student learning. Data from the six sources were analyzed to assess the condition of the equipment, the readiness of the software, the implementation of SOPs, and the effectiveness of the simulator, which were then deepened through observation and in-depth interviews.

Figure 3. 2 Interview Results

No.	Pertanyaan	Kaprodi	Dosen LLU
1.	Bagaimana Anda menilai kondisi perangkat keras (PC, monitor, *headset*, *joystick*) di laboratorium ATC Simulator saat ini?	"Menurut Kaprodi, secara umum, kondisinya sudah tidak optimal. Beberapa PC lemot, monitor sering mati, headset juga banyak yang tidak berfungsi dengan baik."	"Menurut Dosen LLU, Penilaian saya sangat kurang baik, include monitor, headaset, maupun PC nya sudah jadul dan masih menggunakan Pentium"
2.	Seberapa sering *hardware* mengalami kendala?	"Cukup sering, apalagi saat intensitas pemakaian tinggi. Taruna sering lapor kalau alatnya bermasalah pas praktik."	"Menurut Dosen LLU, Kalau dulu, hampirr setiap ngelab pasti rusak, headset juga nggapernah dipake, pc nya ngelag. Dan PTT nya tidak pernah dipakai lagi.
3.	Apakah Bapak/Ibu pernah menerima laporan kendala teknis dari taruna terkait perangkat keras?	"Menurut Kaprodi, Sering juga, terutama kalau software dipakai terus-menerus. Kadang muncul delay atau crash ringan.	"Menurut Dosen LLU, Sering, apalagi jika sudah cukup lama dipakai oleh taruna pada saat ngelab"
4.	Apakah *software* yang digunakan sudah Memenuhi standar industri?	"Ya, beberapa kali dapat laporan dari taruna dan dosen. Biasanya langsung diteruskan ke Kanit Lab untuk ditindaklanjuti."	"Iya, saya pernah beberapa kali menerima laporan dari taruna."
5.	Apakah terdapat fitur pembelajaran yang Anda harapkan namun belum tersedia pada *software*?	"Fungsionalitas dasarnya cukup memenuhi standar industri, tapi tidak support fitur lanjutan atau update terbaru."	"Kalau software nya menurut aku udah, lumayan bisa nyeimbangi lah..kita bisa memodifikasi exercise nya, Cuma dia ngga support untuk upgrade."
6.	Seberapa sering terjadi kendala teknis *software* berdasarkan pengamatan Bapak/Ibu?	"Beberapa fitur memang belum tersedia seperti, E-FPS contohnya.	"Sepertinya ada fitur yang tidak tersedia, mungkin fitur koordinasi nya yang kurang. Dan fitur E-Fps nya masih belum ada."
7.	Apakah SOP penggunaan laboratorium ATC Simulator tersedia?	"SOP hanya untuk peminjaman lab saja, untuk SOP penggunaan lab atc simulator masih belum ada"	"Masih belum tersedia."
8.	Apakah SOP tersebut sudah terdokumentasi dan disosialisasikan ke semua dosen dan taruna?	"Belum semuanya. Hanya sebagian dosen dan taruna yang sudah paham penggunaan secara menyeluruh"	"*I don't think so*, jika ke semua dosen dan taruna seperti nya belum"
9.	Menurut Anda, jika ada, di bagian manakah dari SOP yang masih bisa dikembangkan?	"Banyak yang bisa dikembangkan, terutama soal penanganan kendala teknis dan alur pemakaian lab."	"Seharusnya semuanya, terutama problem solving jika terjadi kendala pada saat pengoperasian. Tidak tersosialisasikan ke semua taruna dikarenakan lab atc simulator lab riskan yang tidak boleh dioperasikan oleh semua taruna.
10.	Bagaimana efektivitas simulator ATC dalam meningkatkan pemahaman taruna terhadap prosedur ADC?	"Efektif, kalau semua alat berjalan normal. Sangat membantu taruna memahami kondisi lapangan secara realistis."	"Seharusnya semuanya, terutama problem solving jika terjadi kendala pada saat pengoperasian. Tidak tersosialisasikan ke semua taruna dikarenakan lab atc simulator lab riskan yang tidak boleh dioperasikan oleh semua taruna."
11.	Apakah ada masukan atau saran untuk optimalisasi pemanfaatan simulator kedepannya?	"Perlu upgrade perangkat, penyusunan SOP final, dan pelatihan untuk semua pihak supaya lab bisa dimanfaatkan maksimal."	"Segera di upgrade atau segera di adakan, kalauu rusak segera di perbaiki. Karena sudah sangat ketinggalan jaman jika menggunakan lab ADC Manual."

Figure 3. 3 Interview Results

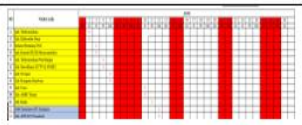
No.	Pertanyaan	Kanit Lab
1.	Bagaimana kondisi keseluruhan perangkat keras dan perangkat lunak simulator saat ini menurut penilaian Anda?	"Menurut Kanit Lab, secara umum, kondisinya sudah tidak optimal. Beberapa PC lemot, monitor sering mati, headset juga banyak yang tidak berfungsi dengan baik."
2.	Apakah laboratorium memiliki jadwal perawatan (*maintenance*) rutin untuk perangkat keras dan perangkat lunak?	"Ada. Jadwal Perawatan Rutin dilakukan oleh Teknisi dan PLP (Pranata Laboran Pendidikan) setiap sebulan sekali baik Hardware maupun Software."
3.	Bagaimana proses pengadaan *spare part* atau pembaruan *software* ketika terdapat kerusakan atau kebutuhan peningkatan fitur?	"Untuk pembaruan Software dalam rangka peningkatan fitur tidak dapat dilakukan karena alasan teknis. Untuk Pengadaan spare part saat ada kerusakan dapat dilakukan sesuai dengan kerusakan tersebut."
4.	Apakah jumlah SDM (laboran atau teknisi) yang tersedia sudah mencukupi untuk mendukung operasional simulator? Dan apakah ada rencana untuk menambah diklat untuk SDM?	"SDM yang tersedia sudah cukup memenuhi dengan komposisi yang saat ini terdapat 3 (tiga teknisi) dan 2 (dua) PLP."
5.	Apakah ada rencana untuk menambah pelatihan (diklat) atau pengembangan kapasitas SDM laboratorium?	"Ada yaitu diklat teknis seperti refreshment maintenance dan operation ADC Simulator 360"
6.	Apa saja kendala utama yang dihadapi dalam hal teknis atau dukungan operasional simulator sejauh ini?	"Kurangnya Awarness (Kesadaran) pengguna lab dalam hal Prosedur teknis mematikan system setelah menggunakan lab. Hal itu menyebabkan potensi kerusakan pada sistem simulator tersebut. Software yang tersedia saat ini hanya dapat dijalankan dengan Spesifikasi perangkat pendukung / Graphic dengan spesifikasi yang tidak dapat di upgrade, sehingga jika terjadi kerusakan sangat susah untuk mengganti perangkat pendukung spesifikasi yang sama.
7.	Bagaimana prosedur pelaporan apabila terjadi kerusakan atau gangguan pada perangkat simulator??	"Pengguna melaporkan terjadinya kerusakan alat atau simulator dengan FORM TERJADINYA KERUSAKAN kepada Kepala
		Unit. Lalu Teknisi / PLP Laboratorim mengecek ke alat / simulator, jika kondisi alat / simulator tersebut, dalam kategori perlu adannya tindak lanjut maintenance maka kepala unit mengusulkan adanya perbaikan sesuai dengan ketentuan SOP LAPORAN KERUSAKAN LABORAOTIUM."
8.	Apakah sudah ada sistem dokumentasi atau *logbook* untuk mencatat kejadian kerusakan atau *maintenance*?	"Ada, yang tertuang dalam FORM MONITORING dan PERAWATAN."
9.	Apakah laboratorium telah menyediakan user guide atau panduan penggunaan simulator untuk taruna dan dosen?	"Terdapat Dokumen manual book dan Dokumen INSTRUKSI KERJA ALAT sebagai panduan penggunaan simulator."
10.	Apakah terdapat SOP internal terkait peminjaman, penggunaan, serta penjadwalan laboratorium ATC Simulator?	"Terdapat SOP PEMINJAMAN dan PENGGUNAAN LAB" Untuk Penjadwalan Laboratorium, yang pertama pihak Pengguna / User mengusulkan Rencana Penggunaan Laboarotorium per Semester dalam bentuk Nota Dinas kepada Unit Laboratorium dan Simulator. Unit laboratorium dan Simulator memastikan usulan tersebut dapat memasukan ke Jadwal Penggunaan Laborotium dan berkoordinasi Kembali kepada seluruh user pengguna dalam hal ini ke Unit Prodi masing masing
11.	Bagaimana alur koordinasi antara pihak laboratorium dengan dosen pengampu dan manajemen kampus dalam hal ATC Simulator?	"Berdasarkan kondisi saat ini yang tertuang dalam pertanyaan nomer 1 dan 6 maka rencana pengembangan atau modernisasi fasilitas laboratorium ATC Simulator akan dilaksanakan dalam waktu dekat."

Figure 3. 4 Interview Results

No.	Pertanyaan	Azara	Cemal	Ershanda
1.	Bagaimana kondisi perangkat keras (PC, monitor, *headset*, *joystick*) saat Anda menggunakan laboratorium ATC simulator?	Menurut saya, perangkat kerasnya secara umum sudah baik, tetapi masih banyak yang perlu diperbaiki. Misalnya, headset masih sering mengalami error, dan monitor juga sering mati-mati sendiri saat digunakan.	Menurut saya, kondisi PC dan monitor di Lab 360 masih banyak yang perlu diperbaiki. PC yang digunakan juga sudah cukup lama, sehingga perlu pembaruan agar bisa lebih optimal mendukung kegiatan nge-lab dan menunjang proses pembelajaran.	Berdasarkan pengalaman saya, perangkat keras seperti PC dan monitor di laboratorium Simulator 360 sering mengalami error. Misalnya, saat praktik, PC bisa tiba-tiba mati sendiri dan butuh waktu lama untuk dinyalakan kembali. Hal ini sangat mengganggu proses latihan. Untuk headset, sebagian bisa digunakan, tapi banyak juga yang tidak berfungsi. Jadi jumlah headset yang layak pakai masih sangat sedikit.
2.	Apakah Anda pernah mengalami kendala saat menggunakan perangkat tersebut? Jika ya, jelaskan.	Pernah. Waktu itu saat kami sedang kegiatan di laboratorium, tiba-tiba layar monitor saya mati sendiri tanpa sebab yang jelas.	Ya, saya pernah mengalami kendala terutama pada headset. Suara yang dihasilkan dari headset tidak jelas, sehingga koordinasi antara unit pilot dan ATC menjadi kurang efektif. Hal ini cukup mengganggu selama latihan.	Tentu saja pernah. Saat praktik, terutama ketika saya bertugas sebagai pilot dan harus melakukan manuver melalui PC, sering terjadi error. Jika PC sudah terlalu lama digunakan atau terlalu panas, biasanya tiba-tiba mati sendiri. Ini sangat mengganggu jalannya praktik.

3.4. *Documentation Study Results*

Figure 3. 5 Documentation Study Results

No	Jenis Studi Dokumentasi	Gambar	Keterangan
1.	DOKUMENTASI LABORATORIUM		Kerusakan lab atc simulator yang parah.
2.	FORM MAINTENANCE/ JADWAL PERAWATAN LAB		Kegiatan maintenance dilaksanakan setiap 1 bulan sekali
			Masing masing lab dalam 1 bulan dilaksanakan perawatan 1x dalam 1 bulan.c
3.	SOP PENGGUNAAN LAB	-	Belum adanya SOP terkait penggunaan lab atc Simulator

The documentation study revealed several important findings related to the ATC Simulator Laboratory at Poltekbang Surabaya. First, the physical condition of the laboratory has suffered considerable damage to the roof and cable installations, thus disrupting practical work. Second, although there is a regular monthly maintenance schedule, the effectiveness of its implementation still needs to be evaluated. Third, there are no specific SOPs governing the use of the laboratory, which has the potential to cause operational irregularities and difficulties in handling technical problems. These findings form the basis for formulating a laboratory optimization strategy to improve the quality of learning.

3.5. *Validation Results*

Before data collection, the researcher validated the interview and observation instruments with the supervising lecturer and the Head of the Study Program to ensure their suitability with the research objectives. After revising the wording and content of the questions to make them more relevant and easier to understand, the instruments were declared feasible and used in interviews with the Head of the Study Program, LLU lecturers, the head of the laboratory, and students using the ATC Simulator Laboratory.

3.6. *Problem Discussion*

The ATC Simulator Laboratory should be the main facility for learning the practice of the Aerodrome Control Procedure, but the results of observations, documentation, and interviews with the Head of the Study Program, lecturers, the Head of the Laboratory Unit, and students show that its utilization is not yet optimal. The main obstacle lies in the outdated hardware, such as slow PCs, monitors that often turn off, broken headsets, and unresponsive joysticks. Some computers even still use Pentium processors, so almost every practical session is hampered by equipment. This condition disrupts the smooth running of learning and reduces the students' practical experience. This is in line with the fact that the effectiveness of the simulator is highly dependent on the readiness of the hardware, especially input/output devices such as headsets and joysticks. Without it, the transfer of learning is hampered. In addition, the software used is also limited-although it still supports basic functions, its performance often lags and is not yet able to run advanced scenarios, making it less than optimal for modern learning needs.

This confirms that simulator software that does not keep up with technological developments and industry SOPs will reduce the effectiveness of learning. Therefore, modernizing the software is an urgent need. Another obstacle is the suboptimal socialization of laboratory SOPs; although the documents are available, only some lecturers and students truly understand them. The lack of socialization of SOPs leads to irregularities, weak coordination, and a slow response when technical problems occur. In fact, clear and consistent SOPs are very important for creating efficient and standardized practices. In addition, the physical condition of the laboratory is also problematic: the room is poorly maintained, the lighting is minimal, the air conditioning is often broken, the layout is not ergonomic, the ceiling is damaged, and there are exposed cables that pose a risk to users. The inadequate physical condition of the laboratory not only reduces the comfort of the students' practical work but also poses a safety risk and reduces the effectiveness of learning. It is emphasized that a laboratory that is not ergonomic and poorly maintained can reduce learning focus and increase the risk of accidents due to physical hazards and improper work posture.

Another important obstacle is the limitation of support staff, especially lab assistants and instructors. There is no special lab assistant with the technical competence to fully manage the simulator, so operations are often assisted by lecturers or senior students. The existing technical support, although there are 3 technicians and 2 PLP, is not enough to ensure smooth operation. As a result, training scenarios are limited to basic functions, the risk of equipment damage increases, and the quality of learning the Aerodrome Control procedure is low. It is emphasized that the effectiveness of the laboratory is highly dependent on trained technical personnel who maintain operations, support instruction, and prevent damage. Without it, the quality of simulator-based practical learning will stagnate. Overall, technical constraints, software limitations, weak SOPs, and the physical condition of the laboratory make the ATC Simulator not yet optimal as a learning medium for Aerodrome Control. Therefore, a comprehensive improvement strategy is needed, including the procurement of adequate hardware and software, updating SOPs and user training, and revitalizing physical facilities so that simulations are effective and graduates are ready for use in the air navigation industry.

3.7. *Problem Solving*

Based on the results of observations and interviews, the function of the ATC Simulator Laboratory in learning Aerodrome Control is still not optimal. Systematic and sustainable optimization efforts are needed so that the laboratory can support the student learning process to the maximum. The strategies that can be implemented include:

3.7.1. *Cloning the Hard Disk on All Computer Units*

The strategic process of cloning a system, which involves creating an exact replica of a master computer that has been meticulously and optimally configured, offers substantial benefits for deploying multiple machines. This method not only drastically accelerates the overall installation and setup time by eliminating repetitive manual tasks, but it also enforces a crucial standard of software uniformity across all units. This consistency is vital for simplifying future maintenance and troubleshooting, while also significantly minimizing the risk of configuration errors or security vulnerabilities that could potentially lead to system instability and subsequent data loss when transferring information between computers.

3.7.2. *Updating the ATC Simulator or Replacing it with a Newer, More User-Friendly Version*

When the currently implemented system is found to be inadequate or obsolete, lacking the capacity to support the latest, most relevant features essential for effective instruction, undertaking an update or a complete replacement of the simulator becomes a critically important step forward. The goal of such an initiative is to introduce a more modern and highly interactive version that is precisely aligned with the specific requirements and learning objectives of the training program. Beyond just enhanced functionality, this new or upgraded simulator is also expected to offer a significantly more stable and reliable platform, which would, in turn, provide a more user-friendly experience, making it substantially easier and more intuitive for both students and instructors to operate and engage with during training sessions.

3.7.3. *Training for Lab Assistants and Laboratory Managers*

To significantly enhance the laboratory's operational efficiency and build internal technical capacity, it is strongly recommended to implement a structured and comprehensive training program for the lab assistants. This initiative is designed to elevate their role beyond basic duties, empowering them to competently act as skilled operators and first-line technicians for the equipment. The curriculum for this training should thoroughly cover a range of essential skills, including not only proficiency in routine software operation but also the development of diagnostic abilities for basic troubleshooting to resolve common errors. Furthermore, it should include practical instruction on performing essential hardware and software maintenance, such as installing updates, conducting system checks, and managing peripherals, thereby ensuring the lab's technical self-sufficiency and minimizing potential downtime.

3.7.4. *Preparation of SOPs and User Guides*

To guarantee the simulator's optimal and seamless integration into the curriculum, it's crucial to develop and distribute comprehensive documentation tailored for all users. This should include a set of clear Standard Operating Procedures (SOPs) that provide step-by-step instructions for routine tasks, alongside a detailed user guide specifically created for both students and lecturers.

Having these materials readily available is fundamental to ensuring that all practical work and simulation-based activities are conducted in a structured, consistent, and effective manner. This approach helps to eliminate ambiguity, reduce operational errors, and ensure that all participants can confidently and competently utilize the simulator to achieve the desired learning outcomes without unnecessary technical hurdles.

3.7.5. *Periodic Maintenance and Care*

It is imperative to establish and consistently follow a proactive schedule for conducting routine inspections and preventative maintenance that covers both the physical hardware and the integral software components of the simulator. This comprehensive approach involves systematically checking for signs of wear, ensuring all connections are secure, cleaning components to prevent overheating, as well as regularly updating software, applying security patches, and verifying data integrity.

By diligently performing these tasks, the primary goal is to identify and rectify minor issues before they can escalate into sudden, critical damage, which could lead to significant operational disruptions and expensive repairs. This strategy is not only crucial for preventing unexpected failures but is also fundamental to maintaining the simulator's optimal performance and responsiveness, ultimately ensuring a reliable and effective training environment while significantly extending the functional lifespan of the valuable equipment.

3.7.6. *Hardware Upgrade*

To address the performance issues and technological limitations inherent in aging

infrastructure, it becomes imperative to systematically replace outdated equipment. This includes foundational hardware such as personal computers (PCs) that no longer possess the required processing power, as well as peripheral devices like low-resolution monitors, subpar headsets, and imprecise joysticks.

This hardware needs to be upgraded with modern counterparts that feature the latest specifications, carefully chosen to meet the demanding requirements of contemporary simulator software. Undertaking this essential modernization effort is not merely a technical refresh; it is a critical step to guarantee a fluid, responsive, and uninterrupted simulation, which in turn serves the ultimate goal of significantly improving and enriching the students' overall learning experience by providing a more immersive, realistic, and effective training environment.

3.8. *Strengths and Weaknesses of the Research*

The strength of this research lies in its qualitative approach, which allows for in-depth data collection through observations and interviews with various parties related to the use of the ATC Simulator Laboratory. This approach provides a real picture of the condition of the facilities, the obstacles faced, and contextual and applicable strategic input, as well as highlighting technical and operational aspects that are often overlooked, so that the results are useful for the evaluation and improvement of educational institutions. This research has limitations in the scope of the data due to the limited implementation time and the number of respondents who do not yet represent all laboratory users. In addition, the results are descriptive and depend on the subjective perceptions of the sources, so they cannot be generalized broadly. Nevertheless, the findings remain relevant and useful for the development of the laboratory in the context studied.

4.CLOSING

4.1. *Conclusion*

Based on in-depth observations and interviews with students, lecturers, the Head of the Study Program, and the Head of the Laboratory, several important things can be concluded regarding the optimization and constraints of using the ATC Simulator Laboratory at Surabaya Aviation Polytechnic:

1. The main obstacles to the use of the ATC Simulator in the D3 Air Traffic Study Program at Poltekbang Surabaya hinder the effectiveness of learning. Problems include damage to >70% of the hardware, software that often errors and is not up-to-date, the absence of clear SOPs, outdated training materials, and a lack of user discipline, resulting in a decrease in student readiness and the quality of the simulation experience.
2. The optimization strategy for the ATC Simulator Laboratory at Poltekbang Surabaya must be focused on modernizing the hardware and software, improving routine maintenance, preparing and socializing SOPs, and updating training scenarios to be relevant to the aviation industry, so that the laboratory can once again become an adaptive and responsive learning ecosystem.

4.2. *Suggestions*

To increase the optimization of the use of the ATC Simulator Laboratory at Poltekbang Surabaya in Aerodrome Control learning, the author provides the following suggestions:

1. Prioritize Hardware and Software Modernization: Damaged hardware such as PCs, monitors, and headsets need to be replaced with high specifications according to the needs of modern ATC simulation, to ensure smooth simulation and realistic visualization for students. The software must also be updated or replaced with a more modern version to reduce technical problems such as lag and errors, and be supported by technicians or an internal IT team for quick problem handling.
2. Socialize Technical SOPs Thoroughly and Consistently: Comprehensive SOPs need to be prepared to explain all procedures for using the simulator, from preparation, operation, to shutdown. This document must be socialized to all students and supervising lecturers, accompanied by regular training, so that users understand and are disciplined in following the procedures, preventing equipment damage.
3. Increase the Discipline and Responsibility of Laboratory Users: Students need to understand that the use of the simulator reflects professional readiness, so a culture of discipline, responsibility, and reporting of disturbances must be instilled. The instructor or supervising lecturer is expected to monitor and be an example of the application of a professional attitude during training.

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