IJoCED

Indonesian Journal of Computing, Engineering, and Design

Journal homepage: http://ojs.sampoernauniversity.ac.id/index.php/IJOCED

Systematic Layout Planning and Analytical Hierarchy Process for Laboratory Layout Optimization: A Case Study of DESPRIN

Mergie Miranda Sihotang[1], Josua Boyke William Jawak[1]*

[1] Engineering Management, Faculty of Industrial Technology, Del Institute of Technology, Indonesia

Corresponding email: josua.jawak@del.ac.id

ABSTRACT

The Product Design and Innovation Laboratory (DESPRIN) at Institute Technology Del plays a crucial role in supporting innovation. Yet, its current layout struggles to meet its users' diverse and evolving needs. This study addresses the problem of inadequate spatial configuration, which hampers workflow efficiency, ergonomics, and the lab's overall capacity to accommodate various activities. To resolve this issue, a flexible layout is designed using the Systematic Layout Planning (SLP) method, emphasizing optimizing space utilization, workflow, and spatial adaptability. Data collected from literature reviews, interviews, statistical analyses, and anthropometric measurements inform the design process to enhance the lab's quality and spatial efficiency. The Analytical Hierarchy Process (AHP) is employed to prioritize key layout design factors, identifying capacity as the most critical element (0.4930), followed by facilities (0.1688), accessibility (0.1414), security (0.1270), and environment (0.0708). The study results in 13 new layout configurations that can accommodate various activities within DESPRIN, providing a more dynamic and responsive user environment.

ARTICLE INFO

Article History:
Received 17 Aug 2024
Revised 30 Sep 2024
Accepted 30 Sep 2024
Available online 07 Oct 2024

Keywords:
Adaptability,
Analytical hierarchy process,
Flexibility,
Laboratory layout,
Systematic layout planning.

1. INTRODUCTION

The standards for facilities and infrastructure within the context of national education standards encompass minimum criteria related to classrooms, sports areas, places of worship, libraries, laboratories, and other learning resources required to support the learning process, including the use of information and communication technology (Arifin, 2014). One of the facilities provided by the institution is a laboratory that offers practical experience to students, allowing them to apply theoretical knowledge in a real-world environment (Dwiharsanti et al., 2016). A laboratory is a workspace specifically designed for conducting experiments, research, product development, and other scientific activities (Sani, 2018).

Del Institute of Technology offers various laboratories that support students' academic and research activities. One of these laboratories is the Product Design and Innovation Laboratory (DESPRIN). The DESPRIN Laboratory plays a crucial role in fostering student creativity and supporting innovation in product design. At IT Del, the DESPRIN Laboratory is a versatile facility that serves as a space for product design and innovation and can be utilized for various other purposes (Simanjuntak et al., 2021).

The importance of examining this laboratory lies in the fact that practical work is an integral part of students' learning, enabling them to apply theoretical knowledge in real-world settings. Indicators of the laboratory's success or failure involve critical factors influencing efficiency, quality, and impact on users and educational outcomes (Anggraeni et al., 2013). Failures can be observed in the mismatch between equipment and students' needs and curriculum requirements, inadequate staff training, and a lack of responsiveness to technological advancements and financial constraints.

Data from 70 respondents, including Engineering Management students from the 2020 to 2023 cohorts, faculty, and staff involved in this laboratory, provide insights into its effectiveness. The survey included three categories of questions posed to student respondents: their experience using the DESPRIN Laboratory, the flexibility and adaptability of the DESPRIN Laboratory, and suggestions or feedback. In the first category, it was generally found that respondents often used the DESPRIN Laboratory for purposes beyond its primary function. Moreover, as reported by respondents, the types of activities conducted in the DESPRIN Laboratory included a wide range of events such as classroom sessions, tutorial classes, practical work, Despro Club activities, socialization events, seminars, meetings, exhibitions, certification exams, and workshops. This validates that the DESPRIN Laboratory is utilized for classroom activities and other purposes. The types of activities with the highest number of hours conducted in relation to the DESPRIN. **Table 1** shows the distribution of total hours spent on different types of activities conducted in the DESPRIN Laboratory per semester, highlighting its diverse utilization beyond standard classroom use.

Table 1. Usage of the DESPRIN lab based on type of activity

Type of Activity	Total Hours/Semester
Class	633.48
Practicum	272.48
Seminar	136.44
Exhibition	136.44
Despro Club	32

Due to the absence of a definitive standard for the DESPRIN laboratory, there is a need for a reference framework that can provide an overview of a layout capable of supporting the activities conducted within it. Consequently, this research will examine the users' needs concerning the laboratory's layout, identify the indicators to be used, assess the priority level of these needs, and design the required layout accordingly.

2. RESEARCH METHODOLOGY

This research employs a quantitative descriptive method, which meticulously details data to provide an in-depth overview (Utomo et al., 2022). In quantitative descriptive methods, the researcher prioritizes objective measurement of social phenomena, with the collected data being processed and analyzed using statistical tools or formulas.

In this study, a structured questionnaire was used as the primary data collection instrument, consisting of 15 items that assessed vital factors such as capacity, comfort, functionality, accessibility, space efficiency, and safety in the laboratory environment. Each item was measured on a Likert scale from 1 (strongly disagree) to 5 (strongly agree). To ensure the instrument's reliability and validity, a pilot test was conducted with 30 respondents, and the results were analyzed using Cronbach's Alpha. The final sample of 185 respondents confirmed that the Cronbach's Alpha values exceeded the acceptable threshold of 0.70, indicating good internal consistency for all constructs.

The questionnaire responses were scored by aggregating participant answers for each item, and statistical techniques were employed to analyze the relationships between variables. This allowed for a thorough evaluation of the indicators, ensuring that the questionnaire was a valid and reliable tool for assessing user needs in the laboratory. These methods provide a robust foundation for future studies and ensure the reproducibility of our findings.

2.1 Object of Study

This research was conducted at Del Institute of Technology in Sitoluama village, Laguboti district, Toba Samosir (Tobasa) regency, North Sumatra, 22381. IT Del campus is approximately 225 kilometers from the provincial capital of North Sumatra, Medan. Within Del Institute of Technology, the specific location chosen for this research is the Product Design and Innovation Laboratory (DESPRIN). This laboratory is in the Faculty of Industrial Technology, Building 9, rooms 912-913.

2.2 Population and Sample

In the context of this research, the selected population includes all students and faculty/staff members of the Faculty of Industrial Technology at Del Institute of Technology. The total population consists of 240 students and 17 faculty/staff members. For sample selection, the author employed purposive sampling techniques. Sampling was aimed at gathering samples for the Analytical Hierarchy Process (AHP) to evaluate the assessment indicators. A total of five respondents were selected for this test using purposive sampling. The criteria for selecting respondents for the AHP test were as follows:

1. Lecturers who teach design courses at the DESPRIN Laboratory
2. DESPRIN Laboratory Manager
3. Head of Club Despro (Extracurricular Laboratory DESPRIN)
4. Students who are Assistant Lecturers of Design Courses at the DESPRIN Laboratory.

2.3 Validity and Reliability Instrument

The respondent data involved in the instrument validity and reliability tests are presented in **Table 2**. The instrument, consisting of 15 questions, was assessed using 185 respondents from the students and staff/faculty of the Faculty of Industrial Technology at Del Institute of Technology. Each question item is essential in determining whether the variables or indicators of the questionnaire are valid by comparing the R_{tabel} with R. The results of the conducted tests are presented in **Table 3.**

Table 2. Respondent demographics

Gender	Frequency	Percent
Student	183	99
Staff/Lecturer	2	1
Total	185	100.0
Age	**Frequency**	**Percent**
17-18	45	24
19-20	103	56
21-22	34	18
>22	3	2
Total	185	100.0
Level of education	**Frequency**	**Percent**
Bachelor Class of 2019	2	1
Bachelor Class of 2020	42	28
Bachelor Class of 2021	47	22
Bachelor Class of 2022	47	25
Bachelor Class of 2023	45	24
Total	183	100.0
Tenure	**Frequency**	**Percent**
Engineering Management	163	88
Metallurgical Engineering	20	12
Total	183	100.0

Table 3. Validity and reliability test

Variable	Ref	Instrument	R	R table (5%)	Cronbach's Alpha	Note
Capacity and Space	(Larasati, 2017) (Toyib, 2020) (Handayani, 2018)	Number of Participation	0, 767	0,1443	0.797	Valid
		Room Lighting	0, 631	0,1443		Valid
		Space Flexibility	0, 813	0,1443		Valid
		Availability of Movement Area	0, 764	0,1443		Valid
Equipment Capacity	(Apryadi, 2017) (Toyib, 2020) (Arianto et al., 2020)	Facility Availability	0, 844	0,1443	0.825	Valid
		Technology Integration	0, 859	0,1443		Valid
		Equipment Layout	0, 816	0,1443		Valid
		Storage Facility	0, 822	0,1443		Valid
Safety and Security	(Rohimah et al., 2023) (Hanom et al., 2020) (Bordoloi et al., 2013)	Emergency Evacuation	0, 895	0,1443	0.888	Valid
		First Aid Kit Availability	0, 884	0,1443		Valid
Accessibility and Circulation	(Siadari et al., 2023) (Wicaksono, 2020) (Morandi, 2011)	Movement Circulation	0, 917	0,1443	0.899	Valid
		User Ability	0, 906	0,1443		Valid
Zoning and Item Separation	(Christina & Suprobo, 2017) (Toyib, 2020) (Comber et al., 2020)	Work Zone	0, 867	0,1443	0.853	Valid
		Discussion Room	0, 872	0,1443		Valid
		Special Room	0, 867	0,1443		Valid

In **Table 3**, with an r product moment value for N (df = 185 - 2 = 183) and α = 0.05, the R table value is 0.1443, indicating that each questionnaire item is valid.

2.4 AHP Test

Figure 1 presents a hierarchy that explains the interrelation and workflow in the Analytical Hierarchy Process (AHP) testing process. The global weighting for sub-criteria and criteria from the test is presented in **Table 4**. The criterion weights are derived by multiplying the priority scores of the criteria by their respective sub-criteria, as detailed in **Table 4.** The result of the weights specified in **Table 4** are multiplied by the priority score of each alternative of each sub-criterion. The highest alternative score will be selected as the selected alternative, which is the top priority (Jawak & Sinaga, 2020). The results of the AHP test are shown in **Table 5**

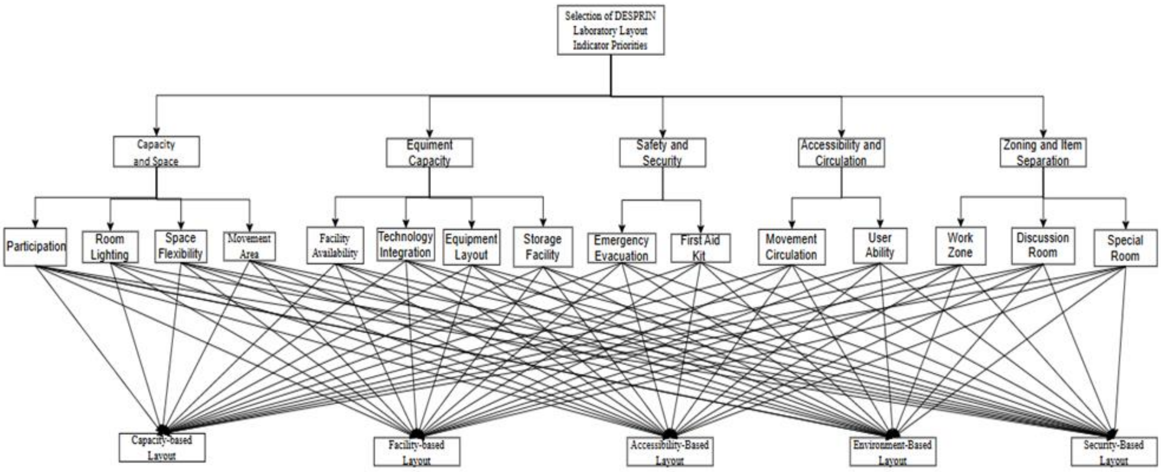

Figure 1. Hierarchical structure between criteria and alternatives

Table 4. Weighting of sub-criteria with criteria

Sub Criteria	Weight
Number of Participants	0.039
Room Lighting	0.035
Space Flexibility	0.111
Availability of Movement Area	0.115
Facility Availability	0.035
Technology Integration	0.058
Equipment Layout	0.036
Storage Facility	0.017
Emergency Evacuation	0.110
First Aid Kit Availability	0.058
Movement Circulation	0.080
User Ability	0.199
Work Zone	0.066
Discussion Room	0.035
Special Room	0.007

Table 5. Final results of the AHP test

Alt.	Overall Weight Alternative
Capacity-based Layout	0.4930
Facility-based Layout	0.1688
Accessibility-Based Layout	0.1414
Environment-Based Layout	0.0708
Security-Based Layout	0.0708

The Capacity-based Layout, Facility-based Layout, Accessibility-Based Layout, Environment-Based Layout, and Security-Based Layout are chosen to optimize the lab's functionality and flexibility. The Capacity-based Layout ensures efficient space for different user numbers, while the Facility-based Layout improves equipment arrangement. Accessibility-Based Layout enhances movement, Environment-Based Layout ensures comfort and Security-Based Layout focuses on safety. These alternatives support a flexible and safe lab environment for various activities.

In **Table 5**, it can be seen that Alternative 1, which is the Capacity-Based Layout, has the highest test score of 0.4930. Alternative 2, Facility Equipment, is ranked second with a score of 0.1688. Alternative 3, the Security-Based Layout, has a score of 0.1414, making it the third priority. The fourth and fifth priorities are the Zone-Based Layout and the Accessibility and Circulation-Based Layout, with each score of 0.0708.

3. RESULTS AND DISCUSSION

By understanding the available capacity, we can design a laboratory layout that adapts to the evolving needs of users and the continuously advancing technology.

3.1 Layout of Theory Class Activities

The layout was designed for proximity and has been adjusted. This level of proximity is described in the Activity Relationship Chart (ARC) as shown in **Figure 2**.

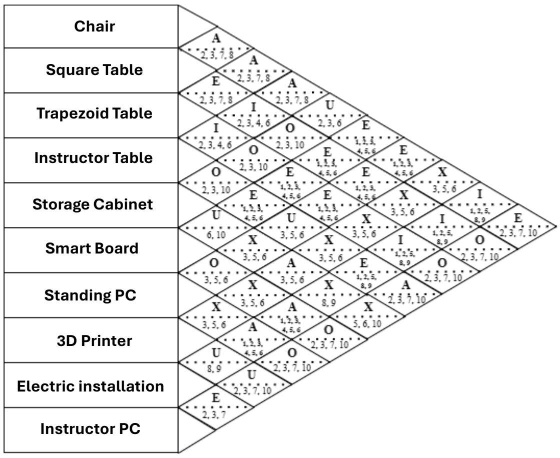

Figure 2. ARC of theory class activities

Figure 3 is a display of the proposed layout that supports classroom activities with a capacity of 34 to 44 people. This layout is designed based on proximity considerations that have been adjusted accordingly.

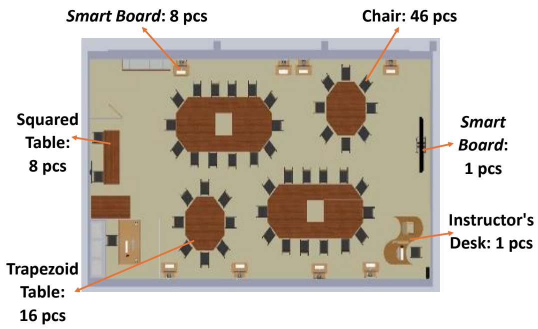

Figure 3. Final class (34-44) layout display and facilities

Figure 4 presents the layout according to the capacity of 45-52 people. The design of this layout takes into account proximity factors that have been modified as needed.

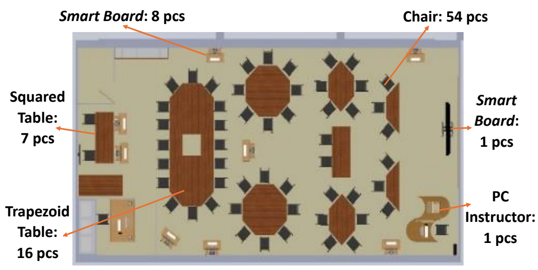

Figure 4. Final class (43-52) layout display and facilities

Figure 5 is the layout according to room capacity for 53-60 People. Proximity considerations, which have been adjusted, form the basis of this layout's design.

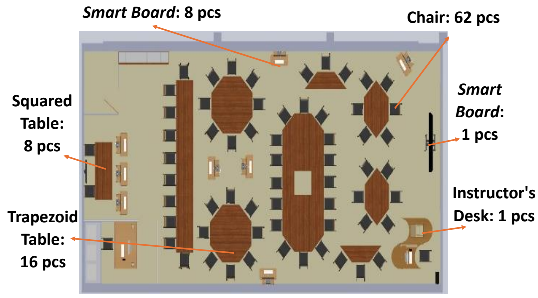

Figure 5. Final class (53-60) layout display and facility

3.2 Layout of Practicum Activities

This level of proximity is described in the Activity Relationship Chart (ARC) as described in **Figure 6**. The following is a display of the layout that supports practicum activity.

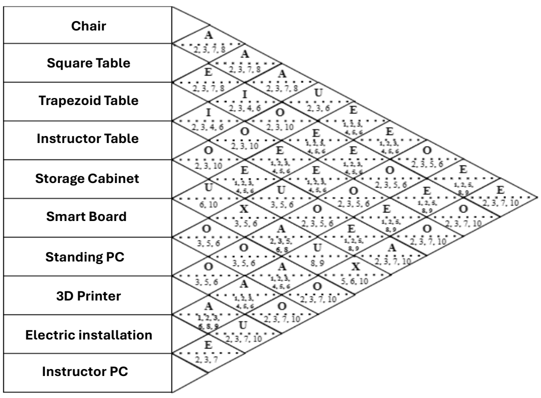

Figure 6. ARC of practicum Activities

Figure 7 displays the proposed layout that supports practicum activities that accommodate a capacity of 34 to 44 people. This layout is developed with proximity factors that have been adapted as necessary.

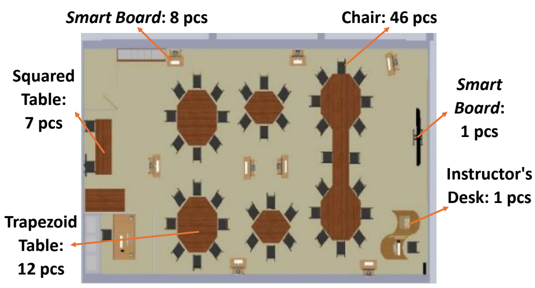

Figure 7. Final practicum (34-44) layout display and facility

Figure 8 displays the layout which supports classroom activities and can accommodate 45 to 52 people. The layout is structured with proximity factors that have been revised accordingly.

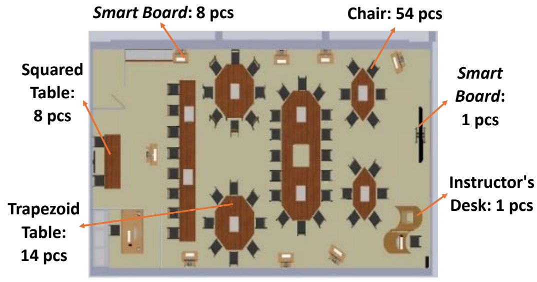

Figure 8. Final practicum (45-52) layout display and facility

Figure 9 displays the layout which supports classroom activities and can accommodate 53 to 60 people. This layout was developed with proximity factors that were adapted as necessary.

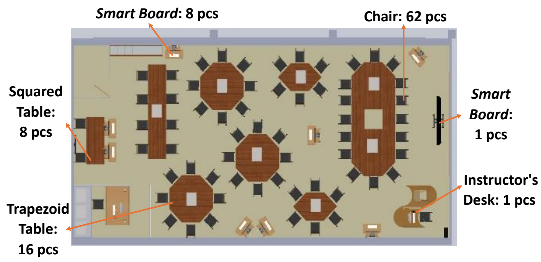

Figure 9. Final practicum (53-60) layout display and facility

3.3 Layout of Seminar Activities

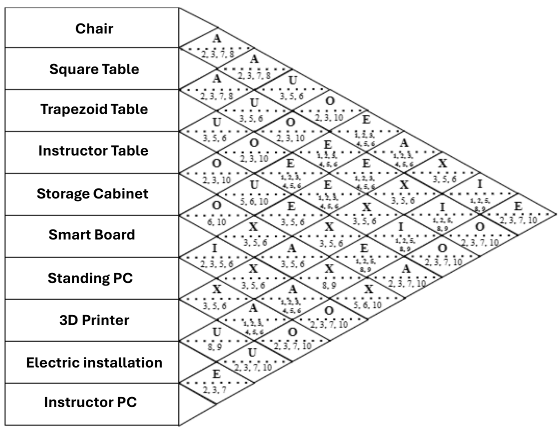

Figure 10. ARC of seminar activities

Figure 10 shows the ARC of seminar activities. **Figure 11** displays the proposed layout for classroom activities which can accommodate 7 to 9 people. The design of this layout is based on proximity considerations that have been revised.

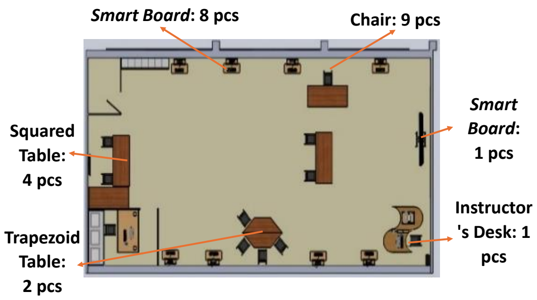

Figure 11. Final seminar (7-9) layout display and facility

Figure 12 displays the proposed layout for classroom activities which can accommodate 9 to 11 people. This layout is developed with proximity factors that have been adapted as necessary.

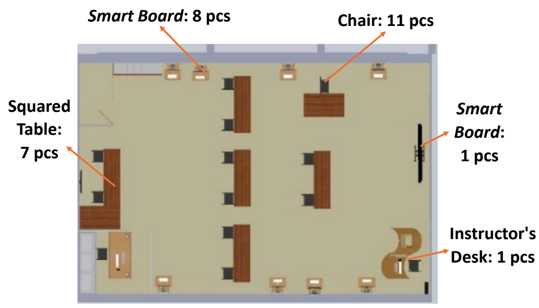

Figure 12. Final seminar (7-9) layout display and facility

Figure 13 displays the proposed layout which supports classroom activities and can accommodate 11 to 13 people. Proximity aspects have been considered and adjusted in the layout's design.

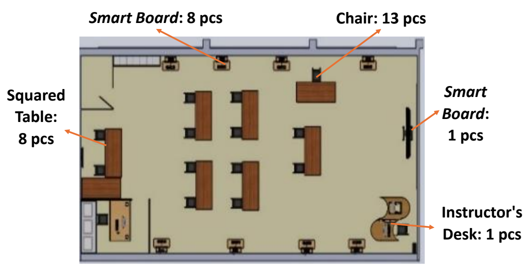

Figure 13. Final seminar (11-13) layout display and facility

3.4 Layout of Exhibition Activities

This level of proximity is described in the ARC as shown in **Figure 14. Figure 15** displays the layout that supports activity with capacity of 5 to 6 group. The layout is designed by emphasizing proximity factors that were modified as needed.

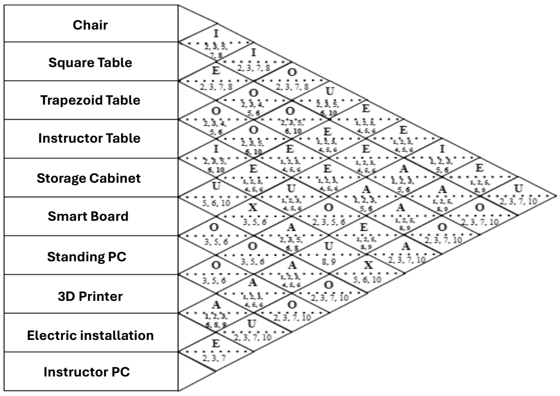

Figure 14. ARC of exhibition activities

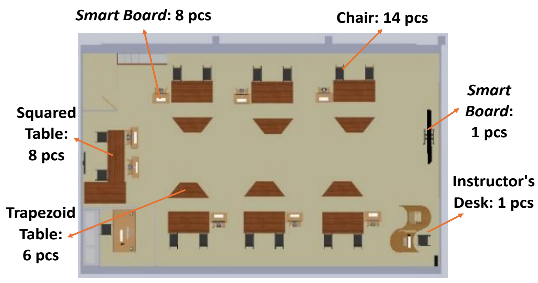

Figure 15. Final exhibition (5-6) layout display and facility

Figure 16 display of the proposed layout that supports classroom activities for 6 to 7 group. Proximity criteria were considered and adjusted in the creation of this layout.

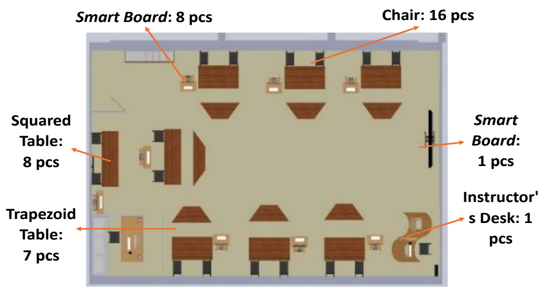

Figure 16. Final exhibition (6-7) layout display and facility

Figure 17 shows the proposed Layout, which supports classroom activities and can accommodate 8 to 10 groups. This layout has been arranged with proximity factors that have been appropriately adjusted.

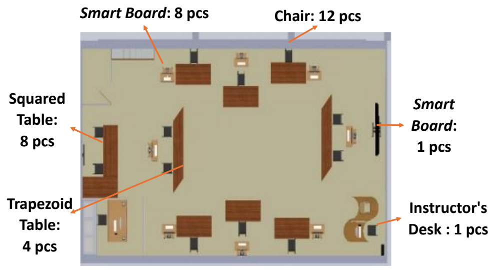

Figure 17. Final exhibition (8-10) layout display and facility

3.5 Layout of Club Despro Activities

In **Figure 18**, the layout is designed for the reason of proximity that has been adjusted. This level of proximity is described in the Activity Relationship Chart (ARC) as follows.

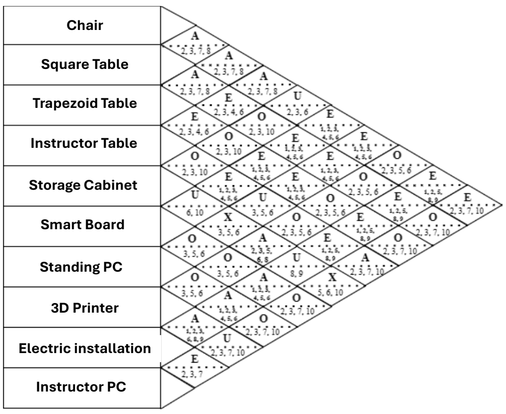

Figure 18. ARC of Club Despro activities

In **Figure 19**, The layout is configured according to proximity criteria that have been appropriately modified.

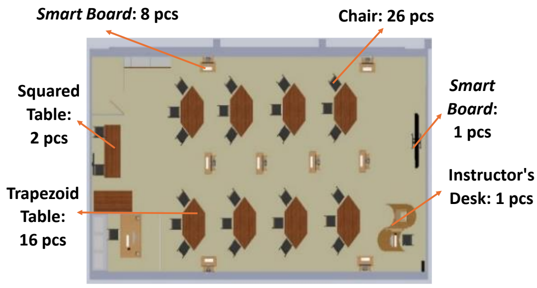

Figure 19. Final Club Despro (24) layout display and facility

4. CONCLUSION

This research identifies various user needs within the laboratory, particularly regarding layout that supports the effectiveness and efficiency of its activities. The DESPRIN Laboratory supports various activities such as classrooms, practical sessions, seminars, exhibitions, and the Despro Club. Validity and reliability tests were conducted to determine relevant assessment indicators when creating the laboratory layout. The tested indicators include capacity, comfort, functionality, accessibility, space efficiency, and safety. Using the AHP method, this research identified the highest priority alternatives in the laboratory layout design, finding that capacity, with a weight of 0.4930, is the primary consideration in layout planning. Based on this weighted data, layout changes can be determined by considering the layout history data. Through these stages and based on the most frequently used activities in the Laboratory, 13 proposed layouts were obtained: 3 classroom layouts, 3 practical layouts, 3 seminar layouts, 3 exhibition layouts, and 1 Despro Club layout.

REFERENCES

Anggraeni, A., Retnoningsih, A., & Herlina, L. (2013). Pengelolaan Laboratorium Biologi Untuk Menunjang Kinerja Pengguna Dan Pengelola Laboratorium Biologi SMA Negeri 2 Wonogiri. In *Unnes Journal of Biology Education* (Vol. 2, Issue 3). http://journal.unnes.ac.id/sju/index.php/ujeb

Apryadi, D. (2017). Analisis Pengaruh Ketepatan Waktu, Fasilitas dan Harga Tiket terhadap Kepuasan Penumpang Kereta Api di Stasiun Purwosari. *Jurnal Magistra*, *8*(2), 59. https://plj.ac.id/ojs/index.php/jrlab/article/view/292

Arianto, B., Bhirawa, W. T., Darmawan, Y., & Indramawan. (2020). Perancangan Tata Letak Fasilitas dan Aplikasinya. In *Program Studi Teknik Industri* (1st ed., Vol. 5, Issue 3). Program Studi Teknik Industri.

Arifin, Z. (2014). *Evaluasi Pembelajaran*. PT Remaja Rosdakarya.

Bordoloi, S., Nath, M., & Dutta, R. K. (2013). pH-conditioning for simultaneous removal of arsenic and iron ions from groundwater. *Process Safety and Environmental Protection*, *91*(5), 405–414. https://doi.org/10.1016/j.psep.2012.10.002

Christina, S. C., & Suprobo, F. P. (2017). Perancangan Interior Fasilitas Dolanan Edutainment untuk Anak Usia 4-12 Tahun di Surabaya. *Intra*, *5*(2), 871–889. http://publication.petra.ac.id/index.php/desain-interior/article/viewFile/5927/5414

Comber, S., Arribas-Bel, D., Singleton, A., & Dolega, L. (2020). Using convolutional autoencoders to extract visual features of leisure and retail environments. *Landscape and Urban Planning*, *202*, 103887. https://doi.org/10.1016/j.landurbplan.2020.103887

Dwiharsanti, M., Gumilar, G., Siswanto, H., Besar, B., & Perindustrian, K. (2016). Perancangan Ulang Tata Letak Fasilitas Laboratorium Pengujian Balai Besar Logam dan Mesin. *Jurnal Industri*, *38*(2), 1–15. https://doi.org/10.32423/jmi.2016.v38.55-67

Handayani, S. (2018). Analisis Tata Letak Fasilitas Produksi Pada Pabrik Tahu Ud Podotresno Di Kabupaten Kepulauan Selayar. In *Fakultas Ekonomi Dan Bisnis Universitas Muhammadiyah Makassar Makassar*. https://digilibadmin.unismuh.ac.id/upload/599-Full_Text.pdf%0Ahttps://digilibadmin.unismuh.ac.id/upload/599-Abstrak.pdf

Hanom, I., Rozefy, R. A., & Filasta, H. T. (2020). Pengaruh Ergonomi Terhadap Aktivitas Working From Home (The Influence of Ergonomic on Working From Home Activities). *Jurnal Idealog*, *5*(1), 58–66.

Jawak, J. B. W., & Sinaga, C. J. S. (2020). Aplikasi Analytical Hierarchy Process (Ahp) Dalam Memilih Pemasok Pada Ksu Pom Humbang Cooperative. *Jurnal Sains Dan Teknologi: Jurnal Keilmuan Dan Aplikasi Teknologi Industri*, *19*(2), 123. https://doi.org/10.36275/stsp.v19i2.207

Larasati, M. A. (2017). Effect of Linear Seating Arrangements on Students Seating Preferences Density in The Classroom. *ARTEKS : Jurnal Teknik Arsitektur*, *1*(2), 149–160. https://doi.org/10.30822/arteks.v1i2.34

Morandi, C. (2011). Retail and public policies supporting the attractiveness of Italian town centres: The case of the Milan central districts. *URBAN DESIGN International*, *16*(3), 227–237. https://doi.org/10.1057/udi.2010.27

Rohimah, S., Aprilia, A., Ginanjar, Y., Rofiah, R., Nuralam, D., & Anggun. (2023). Kajian Infrastruktur Keamanan, Keselamatan Dan Kesehatan Kampus Unigal Berdasarkan Indikator UI Green Metric. *Keperawatan*, *5*(2), 95–106. https://jurnal.unigal.ac.id/JKG/article/view/11857

Sani, R. A. (2018). *Pengelolaan Laboratorium IPA Sekolah* (S. B. Hastuti (ed.); 1st ed.). PT Bumi Aksara.

Siadari, W. N. A., Chairin, Y., & Erizal, E. (2023). Kajian Perbandingan Asesmen Green Building Bangunan Gedung Baru Menggunakan Sistem Greenship New Building Versi 1.2 dan Versi 2.0. *Rekayasa Sipil*, *17*(2), 153–160. https://doi.org/10.21776/ub.rekayasasipil.2023.017.02.6

Simanjuntak, D. N. R., Manik, Y., & Siboro, B. A. H. (2021). Perancangan Rak Sepatu Untuk Laboratorium Desain Produk Dan Inovasi Del Institute of Technology Dengan Metode Value Engineering Dan Quality Function Deployment (QFD). *Jurnal Ilmiah Teknologi Dan Rekayasa*, *26*(2), 122–138. https://doi.org/10.35760/tr.2021.v26i2.4469

Toyib, N. T. (2020). Upaya Meredesain Layout Store Pada Pamelia 6 Yogyakarta [Universitas Islam Indonesia]. In *Journal of the European Academy of Dermatology and Venereology* (Vol. 34, Issue 8). http://dx.doi.org/10.1016/j.jaad.2013.01.032

Utomo, D. P., Adji, S., Wahyuningsih, D. W., Manajemen, P., Ekonomi, F., & Muhammadiyah, U. (2022). Penerapan Layout Dengan Metode Systematic Layout Planning Dalam Meningkatkan Kelancaran Produksi Pada UD . Temon Raya Kabupaten. *Bussman Journal : Indonesian Journal of Business and Management*, *2*(3), 564–573.

Wicaksono, D. (2020). Kajian Elemen Aksesbilitas Ramp (Bagi Penyandang Disabilitas) pada Fasilitas Umum Fakultas Teknik UNNES. *Indonesian Journal of Conservation*, *9*(2), 106–118. https://doi.org/10.15294/ijc.v9i2.27273