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IoT-Based Air Quality Monitoring in Electronics Engineering Study Program Laboratories and Workshops

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Abstract: Comfortable laboratory and workshop rooms with good air quality are important factors in maximizing the learning process. The level of user density in laboratories and workshops used by D3 Telecommunication Engineering and D4 Telecommunication Network Engineering Technology This study aims to monitor air quality in the laboratories and workshops of the Electronics Engineering study program. This study uses a direct monitoring method by measuring O2 and CO2 levels, dust, and humidity in the laboratory and workshop rooms of the electronics engineering study program. From the results of the measurements that have been taken, it has been determined that the workshop room and the electronics laboratory room 2 do not meet the threshold limit value (NBA) for CO2 levels and temperature. The measured CO2 levels in the Electronics Engineering Study Workshop are 4,221 ppm–8,721 ppm and 3,965 ppm–7,296 ppm in the Electronics Engineering Study Laboratory. The highest temperature measured in the Electronics Engineering Laboratory Workshop is 34.20 °C and 32.80 °C in the Electronics Laboratory-2 room.

Keywords: O2, CO2, Temperature, Dust

1. Introduction

Air is a mixture of gases found in the layers surrounding the earth. The composition of the gas mixture is not always constant. The air that enters the body contains various gases, such as oxygen, carbon dioxide, argon, nitrogen, and water vapor. Air quality that meets health standards is an important factor in supporting a healthy environment. Indoor and outdoor oxygen can be contaminated with substances that are harmful to health. Within certain limits, the levels of these substances can still be neutralized, but if they exceed normal limits, they can interfere with health (Waworundeng & Lengkong, 2018).

The Electronics Engineering study program has complete and adequate facilities and infrastructure. One of the available infrastructures is laboratory space and workshop space. The laboratory rooms in the Electronics Engineering study program are four laboratory practice rooms, each with a capacity of 25 people. In the workshop room, there are two classrooms, each with a capacity of 25 people. Activities in the workshop include filing, lathing, drilling, and grinding. Laboratory space facilities in the Electronics Engineering study program are not only used by D3 Electronics Engineering but also by students of D3 Telecommunication Engineering, D4 Telecommunication Network Engineering Technology, and later D4 Electronics Engineering, which is currently in the process of getting feasible from LLDikti. As a result, the condition of the

laboratory space is crowded and has exceeded the maximum limit. This can result in excess CO2 and a lack of O2, which is needed by the community.

Practical activities in laboratories and workshops demand high concentration and focus so as not to cause work accidents when using machines and laboratory work equipment. In addition, factors that support maximum learning are room cleanliness and room humidity. Air humidity must be maintained in the range of 45%–60% (RH). If the humidity in the room is above 65% (RH), then viruses, molds, mites, mildew, and bacteria that trigger allergies for asthmatics will grow rapidly. Conversely, if the humidity is below 45% (RH), the skin, throat, and eyes become dry and itchy, and the airways and mucous membranes that function as natural barriers to disease also become dry, so our bodies are more susceptible to disease. In addition, in places with low humidity, influenza viruses can survive longer. Based on these factors, the author conducted research on air quality monitoring in workshops and laboratories to maximize learning in laboratories and workshops.

2. Research Methods

This research was conducted using experimental methods and research development conducted in the laboratory of Electronics Engineering at Medan State Polytechnic. The initial step of this research method is to identify, analyze, and determine the objectives. The second step is making tool specifications and determining the components used in system design. Furthermore, the system is in the form of tools and software. The last step is testing the system as a whole. The research block diagram is shown in Figure 1.

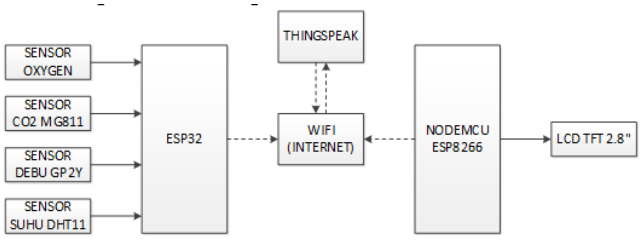

Figure 1. *Block Diagram*

This research is divided into two stages: hardware design and software design. Hardware uses ESP32 as a control center that collects data from O2, CO2, dust, and temperature sensors; DF Robot Oxygen Sensor to measure O2 content in the air; DF Robot MG811 CO2 Sensor to measure CO2 content in the air; GP2Y dust sensor for dust in the room to be measured; DHT21 temperature sensor to measure the temperature of the room to be measured; LM2596 Stepdown module, which functions to reduce the voltage from 12 V coming from the power supply to 5 V; MCU ESP8266 node module, which functions as communication between the device and computer devices using wifi; and a 2.8" TFT LCD as a display of the measurement results. 8" LCD as a display of the measurement results. The software design uses the Arduino application as an application for creating programs and the Thinkspeak application, which is used to monitor the measurement results.

The research design is depicted in Figure 2. Below is Research Design Diagram.

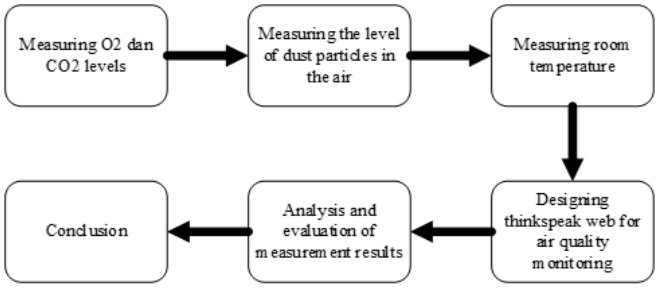

Figure 2. *Research Design*

The parameters measured were air quality monitoring assessed using four indicators, namely: CO2 and O2 content, dust particles in the air, and temperature. After that, preventive measures can be taken.

3. Results

Measurements in the Electronics Engineering Study Program workshop room. The volume of the room in the Electronics Engineering Study Program Workshop is 5m x 25m x 7m. The measurement conditions were carried out when the Workshop course was taking place with a total of 24 students. Data collection was taken from 13.55 – 16.00 WIB.

Table 1. *Test results at the Electronics Engineering Study Program Workshop*

No	Time (WIB)	T (°C)	Dust (mg/m3)	Oxygen (%Vol)	CO2 (PPM)
1	14:30:03	29,40	0.00	21,23	7.940
2	14:30:19	29,50	0.00	21,24	7.593
3	14:30:35	29,50	0.00	21,28	7.700
4	14:30:51	29,50	0.00	21,27	7.428
5	14:31:07	29,60	0.00	21,24	7.489
6	14:31:23	29,70	0.00	21,31	7.744
7	14:31:39	29,70	0.00	21,27	7.921
8	14:31:56	29,70	0.00	21,26	7.753
9	14:32:12	29,70	0.00	21,29	7.637
10	14:32:27	29,70	0.00	21,24	8.060
11	14:32:43	29,80	0.00	21,24	8.442
12	14:32:59	29,80	0.00	21,28	8.721
13	14:33:15	29,90	0.00	21,30	8.350

No	Time (WIB)	T (°C)	Dust (mg/m3)	Oxygen (%Vol)	CO2 (PPM)
14	14:33:31	29,90	0.00	21,27	8.083
15	14:33:48	30,00	0.00	21,28	7.885
16	14:34:05	30,00	0.00	21,29	8.630
17	14:34:20	30,00	0.00	21,26	8.546
18	14:34:36	30,00	0.00	21,29	8.230
19	14:34:52	30,10	0.00	21,29	8.130
20	14:35:09	30,10	0.00	21,24	7.898
21	14:35:24	30,30	0.00	21,31	7.949
22	14:35:40	30,30	0.00	21,26	8.088
23	14:35:56	30,30	0.00	21,28	8.126
24	14:36:14	30,30	0.00	21,31	8.102
25	14:36:31	30,40	0.00	21,27	8.159
26	14:38:02	30,70	0.00	21,33	7.450
27	14:38:18	30,80	0.00	21,32	7.296
28	14:38:37	30,80	0.00	21,32	7.519
29	14:38:55	30,90	0.00	21,30	7.519
30	14:39:13	30,90	0.00	21,32	7.158
31	14:39:30	31,00	0.00	21,28	6.925
32	14:39:48	31,00	0.00	21,30	6.704
33	14:40:06	31,10	0.00	21,30	6.566
34	14:40:23	31,10	0.00	21,31	6.728
35	14:40:41	31,20	0.00	21,32	6.581
36	14:41:01	31,30	0.00	21,34	6.524
37	14:41:17	31,30	0.00	21,35	6.233
38	14:41:33	31,40	0.00	21,34	6.243
39	14:41:49	31,40	0.00	21,32	6.305
40	14:42:05	31,50	0.00	21,35	6.006
41	14:42:22	31,50	0.00	21,36	6.168
42	14:42:39	31,50	0.00	21,33	6.125
43	14:42:56	31,60	0.00	21,35	6.150
44	14:43:12	31,60	0.00	21,31	6.150
45	14:43:29	31,60	0.00	21,35	6.079
46	14:43:44	31,70	0.00	21,38	5.985
47	14:44:01	31,70	0.00	21,33	5.923
48	14:44:17	31,80	0.00	21,35	6.002
49	14:44:33	31,80	0.00	21,33	5.957
50	14:44:49	31,80	0.00	21,33	5.744
51	14:45:05	31,90	0.00	21,39	5.882
52	14:45:21	32,00	0.00	21,37	5.995
53	14:45:37	32,00	0.00	21,39	5.872
54	14:45:54	32,00	0.00	21,40	6.083
55	14:46:10	32,00	0.00	21,39	5.954
56	14:46:26	32,00	0.00	21,44	5.971
57	14:46:42	32,10	0.00	21,37	5.797
58	14:46:57	32,10	0.00	21,38	5.865
59	14:47:14	32,20	0.00	21,38	5.957
60	14:47:30	32,20	0.00	21,39	5.916
61	14:47:45	32,20	0.00	21,39	5.875
62	14:48:01	32,20	0.00	21,40	5.971
63	14:48:17	32,20	0.00	21,41	5.658
64	14:48:33	32,20	0.00	21,40	5.747
65	14:48:49	32,20	0.00	21,41	5.937
66	14:49:04	32,50	0.00	21,40	5.913
67	14:49:21	32,50	0.00	21,41	5.926
68	14:49:39	32,50	0.00	21,42	5.717
69	14:49:56	32,50	0.00	21,43	5.754
70	14:50:12	32,60	0.00	21,43	5.704
71	14:50:28	32,60	0.00	21,44	5.606
72	14:50:43	32,60	0.00	21,45	5.622
73	14:50:59	32,60	0.00	21,39	5.781
74	14:51:15	32,60	0.00	21,42	5.619
75	14:51:31	32,70	0.00	21,44	5.590
76	14:51:47	32,80	0.00	21,49	5.606
77	14:52:02	32,80	0.00	21,42	5.509
78	14:52:18	32,80	0.00	21,42	5.658
79	14:52:34	32,80	0.00	21,43	5.784
80	14:52:49	32,80	0.00	21,42	5.694
81	14:53:06	32,80	0.00	21,50	5.446
82	14:53:22	32,90	0.00	21,49	5.665
83	14:53:38	32,90	0.00	21,41	5.424
84	14:53:54	33,00	0.00	21,45	5.619
85	14:54:10	33,00	0.00	21,47	5.704
86	14:54:26	33,00	0.00	21,48	5.500
87	14:54:41	33,00	0.00	21,47	5.583
88	14:54:58	33,00	0.00	21,49	5.580
89	14:55:13	33,10	0.00	21,47	5.551
90	14:55:29	33,10	0.00	21,44	5.436
91	14:55:46	33,10	0.00	21,49	5.616
92	14:56:02	33,10	0.00	21,49	5.573
93	14:56:17	33,20	0.00	21,49	5.538

No	Time (WIB)	T (°C)	Dust (mg/m3)	Oxygen (%Vol)	CO2 (PPM)
94	14:56:33	33,20	0.00	21,44	5.303
95	14:56:49	33,20	0.00	21,49	5.764
96	14:57:11	33,30	0.00	21,53	5.427
97	14:57:48	33,30	0.00	21,51	5.525
98	14:58:07	33.30	0.00	21,48	5.678
99	14:58:23	33.40	0.00	21,52	5.638
100	14:58:39	33.40	0.00	21,53	5.421
101	14:58:55	33.40	0.00	21,53	5.564
102	14:59:30	33.50	0.00	21,49	5.396
103	14:59:48	33.50	0.00	21,49	5.609
104	15:00:05	33.50	0.00	21,47	5.424
105	15:00:20	33.50	0.00	21,51	5.522
106	15:00:37	33.60	0.00	21,52	5.430
107	15:00:53	33.60	0.00	21,53	5.427
108	15:01:09	33.60	0.00	21,50	5.355
109	15:01:25	33.60	0.00	21,50	5.349
110	15:01:41	33.60	0.00	21,57	5.275
111	15:01:56	33.60	0.00	21,53	5.355
112	15:02:12	33.60	0.00	21,54	5.315
113	15:02:29	33.70	0.00	21,55	4.932
114	15:02:45	33.70	0.00	21,54	5.095
115	15:03:01	33.70	0.00	21,54	4.901
116	15:03:17	33.80	0.00	21,51	5.071
117	15:03:33	33.80	0.00	21,56	5.077
118	15:03:50	33.80	0.00	21,55	5.068
119	15:04:06	33.80	0.00	21,50	4.907
120	15:04:21	33.80	0.00	21,57	4.964
121	15:04:37	33.80	0.00	21,59	4.987
122	15:04:53	33.80	0.00	21,56	4.938
123	15:05:09	33.80	0.00	21,56	5.086
124	15:05:25	33.80	0.00	21,54	5.080
125	15:05:40	33.90	0.00	21,54	4.947
126	15:05:56	33.90	0.00	21,54	5.060
127	15:06:12	33.90	0.00	21,59	5.054
128	15:06:28	33.90	0.00	21,57	5.063
129	15:06:44	33.90	0.00	21,58	5.130
130	15:06:59	33.90	0.00	21,56	5.089
131	15:07:15	33.90	0.00	21,55	4.847
132	15:07:33	33.90	0.00	21,55	4.981
133	15:07:51	33.90	0.00	21,57	5.119
134	15:08:08	33.90	0.00	21,56	5.086
135	15:08:25	33.90	0.00	21,57	5.095
136	15:08:41	33.90	0.00	21,56	4.970
137	15:08:57	33.90	0.00	21,59	5.172
138	15:09:13	33.90	0.00	21,58	5.104
139	15:09:29	34.00	0.00	21,54	4.981
140	15:09:45	34.00	0.00	21,59	4.941
141	15:10:01	34.00	0.00	21,60	4.932
142	15:10:18	34.00	0.00	21,60	4.918
143	15:10:36	34.00	0.00	21,59	4.904
144	15:10:54	34.00	0.00	21,61	4.859
145	15:11:10	34.00	0.00	21,61	5.022
146	15:11:26	34.00	0.00	21,58	4.898
147	15:11:42	34.00	0.00	21,60	4.941
148	15:11:57	34.00	0.00	21,61	4.599
149	15:12:13	34.00	0.00	21,61	4.728
150	15:12:29	34.00	0.00	21,57	4.783
151	15:12:46	34.00	0.00	21,56	5.022
152	15:13:01	34.00	0.00	21,59	4.921
153	15:13:17	34.00	0.00	21,59	4.676
154	15:13:33	34.00	0.00	21,60	4.893
155	15:13:50	34.00	0.00	21,64	4.753
156	15:14:06	34.00	0.00	21,58	4.660
157	15:14:22	34.00	0.00	21,57	4.981
158	15:14:37	34.00	0.00	21,59	4.939
159	15:14:53	34.00	0.00	21,58	5.016
160	15:15:09	34.00	0.00	21,59	5.083
161	15:15:25	34.10	0.00	21,62	4.901
162	15:15:41	34.10	0.00	21,58	5.001
163	15:15:57	34.10	0.00	21,60	4.891
164	15:16:13	34.10	0.00	21,58	5.010
165	15:16:29	34.10	0.00	21,54	4.978
166	15:16:45	34.10	0.00	21,62	4.805
167	15:17:01	34,20	0.00	21,58	5.022
168	15:17:18	34,20	0.00	21,60	4.805
169	15:17:35	34,20	0.00	21,60	4.901
170	15:17:54	34,20	0.00	21,56	4.987
171	15:18:10	34,20	0.00	21,56	4.990
172	15:18:26	34,20	0.00	21,59	5.083
173	15:18:42	34,20	0.00	21,60	5.077

No	Time (WIB)	T (°C)	Dust (mg/m3)	Oxygen (%Vol)	CO2 (PPM)
174	15:18:57	34,20	0.00	21,57	4.845
175	15:19:13	34,20	0.00	21,59	4.756
176	15:19:29	34,20	0.00	21,62	4.780
177	15:19:45	34,20	0.00	21,60	4.825
178	15:20:00	34,20	0.00	21,57	4.698
179	15:20:16	34,20	0.00	21,59	4.912
180	15:20:32	34,20	0.00	21,61	4.825
181	15:20:48	34,20	0.00	21,58	4.847
182	15:21:04	34,20	0.00	21,56	4.873
183	15:21:20	34,20	0.00	21,60	4.981
184	15:21:35	34,20	0.00	21,58	4.918
185	15:21:51	34,20	0.00	21,62	4.947
186	15:22:07	34,20	0.00	21,61	4.723
187	15:22:23	34,20	0.00	21,59	4.775
188	15:22:39	34,20	0.00	21,61	4.658
189	15:22:55	34,20	0.00	21,56	4.927
190	15:23:11	34,20	0.00	21,60	4.970
191	15:23:27	34,20	0.00	21,64	5.007
192	15:23:43	34,20	0.00	21,60	4.750
193	15:23:59	34,20	0.00	21,61	4.764
194	15:24:15	34,20	0.00	21,58	4.767
195	15:24:31	34,20	0.00	21,59	4.753
196	15:24:47	34,20	0.00	21,58	4.660
197	15:25:03	34,20	0.00	21,63	4.706
198	15:25:21	34,20	0.00	21,60	4.853
199	15:25:38	34,20	0.00	21,61	4.690
200	15:25:54	34,20	0.00	21,59	4.750
201	15:26:10	34,20	0.00	21,61	4.734
202	15:26:27	34,20	0.00	21,65	4.685
203	15:26:43	34,20	0.00	21,62	4.636
204	15:26:59	34,20	0.00	21,60	4.679
205	15:27:15	34,20	0.00	21,59	4.687
206	15:27:32	34,20	0.00	21,61	4.819
207	15:27:47	34,20	0.00	21,59	4.747
208	15:28:03	34,20	0.00	21,63	4.633
209	15:28:19	34,20	0.00	21,62	4.761
210	15:28:35	34,20	0.00	21,59	4.764
211	15:28:50	34,20	0.00	21,63	4.676
212	15:29:06	34,20	0.00	21,61	4.572
213	15:29:22	34,20	0.00	21,62	4.591
214	15:29:38	34,20	0.00	21,60	4.736
215	15:29:54	34,20	0.00	21,59	4.649
216	15:30:10	34,20	0.00	21,59	4.488
217	15:30:25	34,20	0.00	21,62	4.485
218	15:30:41	34,20	0.00	21,62	4.517
219	15:30:58	34,20	0.00	21,61	4.575
220	15:31:14	34,20	0.00	21,59	4.663
221	15:31:30	34,20	0.00	21,60	4.540
222	15:31:46	34,20	0.00	21,60	4.658
223	15:32:02	34,20	0.00	21,66	4.441
224	15:32:19	34,20	0.00	21,63	4.475
225	15:32:34	34,20	0.00	21,55	4.647
226	15:32:50	34,20	0.00	21,62	4.668
227	15:33:06	34,20	0.00	21,61	4.745
228	15:33:22	34,20	0.00	21,62	4.750
229	15:33:38	34,20	0.00	21,61	4.465
230	15:33:54	34,20	0.00	21,61	4.467
231	15:34:09	34,20	0.00	21,61	4.416
232	15:34:25	34,20	0.00	21,58	4.797
233	15:34:41	34,20	0.00	21,57	4.845
234	15:34:58	34,20	0.00	21,61	4.593
235	15:35:14	34,20	0.00	21,60	4.596
236	15:35:29	34,20	0.00	21,60	4.221
237	15:35:45	34,20	0.00	21,61	4.612
238	15:36:01	34,20	0.00	21,63	4.532
239	15:36:16	34,20	0.00	21,61	4.556
240	15:36:32	34,20	0.00	21,62	4.666
241	15:36:48	34,20	0.00	21,56	4.527
242	15:37:05	34,20	0.00	21,62	4.546
243	15:37:23	34,20	0.00	21,61	4.615
244	15:37:40	34,20	0.00	21,60	4.483
245	15:37:56	34,20	0.00	21,63	4.599
246	15:38:12	34,10	0.00	21,59	4.493
247	15:38:29	34,20	0.00	21,63	4.475
248	15:38:49	34,20	0.00	21,58	4.607
249	15:39:06	34,20	0.00	21,61	4.585
250	15:39:30	34,10	0.00	21,64	4.660
251	15:39:47	34,10	0.00	21,62	4.612
252	15:40:10	34,10	0.00	21,56	4.639
253	15:40:28	34,10	0.00	21,65	4.712

254	15:41:06	34,10	0.00	21,60	4.734
255	15:41:45	34,00	0.00	21,59	4.690
256	15:42:04	34,00	0.00	21,61	4.501
257	15:42:22	34,00	0.00	21,59	4.786
No	**Time (WIB)**	**T (°C)**	**Dust (mg/m3)**	**Oxygen (%Vol)**	**CO2 (PPM)**
258	15:42:40	34,00	0.00	21,60	4.511
259	15:43:16	34,00	0.00	21,58	4.717
260	15:43:33	34,00	0.00	21,62	4.569
261	15:43:51	34,00	0.00	21,65	4.591
262	15:44:07	34,00	0.00	21,60	4.682
263	15:44:23	34,00	0.00	21,61	4.532
264	15:44:39	34,00	0.00	21,63	4.509
265	15:44:55	34,00	0.00	21,59	4.607
266	15:45:11	34,00	0.00	21,61	4.527
267	15:45:27	34,00	0.00	21,64	4.509
268	15:45:43	34,00	0.00	21,60	4.460
269	15:45:59	34,00	0.00	21,63	4.340
270	15:46:15	34,00	0.00	21,59	4.506
271	15:46:30	34,00	0.00	21,58	4.572
272	15:46:46	34,00	0.00	21,58	4.631
273	15:47:02	34,00	0.00	21,59	4.580
274	15:47:18	34,00	0.00	21,63	4.583
275	15:47:34	34,00	0.00	21,64	4.491
276	15:47:50	34,00	0.00	21,59	4.559
277	15:48:06	34,00	0.00	21,62	4.636
278	15:48:21	34,00	0.00	21,62	4.738
279	15:48:37	34,00	0.00	21,65	4.786
280	15:48:53	34,00	0.00	21,61	4.543
281	15:49:09	34,00	0.00	21,61	4.478
282	15:49:26	34,00	0.00	21,60	4.447
283	15:49:42	34,00	0.00	21,58	4.647
284	15:49:58	34,00	0.00	21,59	4.485
285	15:50:14	34,00	0.00	21,65	4.388
286	15:50:29	34,00	0.00	21,62	4.475
287	15:50:45	34,00	0.00	21,58	4.413
288	15:51:01	34,00	0.00	21,60	4.567
289	15:51:17	34,00	0.00	21,60	4.548
290	15:51:32	34,00	0.00	21,60	4.655
291	15:51:49	34,00	0.00	21,58	4.472
292	15:52:05	34,00	0.00	21,61	4.527
293	15:52:21	34,00	0.00	21,64	4.625
294	15:52:37	34,00	0.00	21,62	4.472
295	15:52:54	34,00	0.00	21,55	4.575
296	15:53:10	34,00	0.00	21,62	4.612
297	15:53:26	34,00	0.00	21,56	4.580
No	**Time (WIB)**	**T (°C)**	**Dust (mg/m3)**	**Oxygen (%Vol)**	**CO2 (PPM)**
298	15:53:43	34,10	0.00	21,55	4.580
299	15:53:59	34,00	0.00	21,60	4.548
300	15:54:15	34,00	0.00	21,59	4.467
301	15:54:30	34,00	0.00	21,60	4.532
302	15:54:47	34,00	0.00	21,59	4.585
303	15:55:02	34,00	0.00	21,63	4.577
304	15:55:19	34,00	0.00	21,60	4.406
305	15:55:35	34,00	0.00	21,59	4.527
306	15:55:51	34,00	0.00	21,64	4.535
307	15:56:07	34,10	0.00	21,62	4.434
308	15:56:23	34,10	0.00	21,66	4.525
309	15:56:39	34,10	0.00	21,61	4.585
310	15:56:55	34,10	0.00	21,64	4.501
311	15:57:11	34,10	0.00	21,63	4.575
312	15:57:27	34,10	0.00	21,57	4.352
313	15:57:43	34,10	0.00	21,61	4.347
314	15:57:59	34,10	0.00	21,61	4.480
315	15:58:14	34,15	0.00	21,65	4.355
316	15:58:29	34,15	0.00	21,65	4.370
317	15:58:44	34,15	0.00	21,65	4.343
318	15:59:59	34,15	0.00	21,63	4.369
319	16:00:14	34,15	0.00	21,63	4.365

Measurements in the Electronics Engineering Study Laboratory room. Measurements were carried out in the Electronics Laboratory 2 of the Electronics Engineering Study Program with a room area of 7.35 m x 5.48 m. The number of students in the room is 23 people plus 1 teacher. Data collection was taken from 15.40 – 16.20 with the fan off.

Table 2. *Data from measurements in the Electronics Engineering Study Program laboratory*

No	**Time (WIB)**	**T (°C)**	**Dust (mg/m3)**	**Oxygen (%Vol)**	**CO2 (PPM)**
1	15:40:13	29,20	0,00	21,22	7.296
2	15:40:29	29,30	0,00	21,23	7.092
3	15:40:44	29,30	0,00	21,24	6.763
4	15:41:00	29,40	0,00	21,20	7.002

5	15:41:16	29,40	0,00	21,25	7.047
6	15:41:32	29,40	0,00	21,21	6.581
7	15:41:48	29,40	0,00	21,26	6.558
8	15:42:04	29,50	0,00	21,23	6.498
No	**Time (WIB)**	**T (°C)**	**Dust (mg/m3)**	**Oxygen (%Vol)**	**CO2 (PPM)**
9	15:42:20	29,50	0,00	21,19	6.419
10	15:42:36	29,50	0,00	21,27	6.604
11	15:42:52	29,50	0,00	21,22	6.312
12	15:43:08	29,60	0,00	21,27	6.405
13	15:43:24	29,60	0,00	21,25	6.197
14	15:43:40	29,70	0,00	21,22	5.940
15	15:43:56	29,70	0,00	21,26	6.027
16	15:44:12	29,70	0,00	21,23	5.767
17	15:44:29	29,70	0,00	21,25	5.791
18	15:44:45	29,80	0,00	21,30	5.858
19	15:45:00	29,90	0,00	21,22	5.975
20	15:45:16	29,90	0,00	21,32	6.090
21	15:45:32	29,90	0,00	21,29	6.143
22	15:45:48	30,00	0,00	21,29	6.129
23	15:46:05	30,00	0,00	21,30	5.902
24	15:46:21	30,00	0,00	21,27	6.129
25	15:46:37	30,10	0,00	21,30	5.906
26	15:46:53	30,10	0,00	21,27	5.724
27	15:47:09	30,10	0,00	21,33	5.794
28	15:47:27	30,20	0,00	21,28	5.688
29	15:47:45	30,30	0,00	21,30	5.933
30	15:48:02	30,30	0,00	21,28	5.831
31	15:48:18	30,30	0,00	21,32	5.834
32	15:48:34	30,30	0,00	21,30	5.975
33	15:48:50	30,40	0,00	21,33	5.985
34	15:49:06	30,50	0,00	21,31	5.678
35	15:49:22	30,50	0,00	21,31	5.771
36	15:49:38	30,50	0,00	21,30	5.484
37	15:49:54	30,50	0,00	21,31	5.541
38	15:50:11	30,60	0,00	21,34	5.187
39	15:50:27	30,60	0,00	21,29	5.266
40	15:50:43	30,60	0,00	21,30	5.275
41	15:50:59	30,70	0,00	21,29	5.208
42	15:51:15	30,70	0,00	21,32	5.223
43	15:51:31	30,80	0,00	21,34	4.970
44	15:51:47	30,80	0,00	21,33	5.080

45	15:52:03	30,80	0,00	21,33	4.845
46	15:52:19	30,90	0,00	21,32	4.987
47	15:53:50	31,10	0,00	21,34	5.550
48	15:54:06	31,10	0,00	21,32	5.399
No	**Time (WIB)**	**T (°C)**	**Dust (mg/m3)**	**Oxygen (%Vol)**	**CO2 (PPM)**
49	15:54:23	31,10	0,00	21,33	4.690
50	15:54:38	31,20	0,00	21,33	4.833
51	15:54:54	31,20	0,00	21,31	4.839
52	15:55:10	31,20	0,00	21,38	4.728
53	15:55:26	31,30	0,00	21,32	4.526
54	15:55:42	31,30	0,00	21,37	4.462
55	15:55:59	31,30	0,00	21,35	4.522
56	15:56:14	31,30	0,00	21,39	4.483
57	15:56:31	31,30	0,00	21,38	4.623
58	15:56:47	31,40	0,00	21,35	4.599
59	15:57:03	31,40	0,00	21,35	4.599
60	15:57:18	31,40	0,00	21,34	4.599
61	15:57:35	31,40	0,00	21,38	4.540
62	15:57:50	31,40	0,00	21,37	4.285
63	15:58:06	31,40	0,00	21,40	4.596
64	15:58:22	31,40	0,00	21,41	4.360
65	15:58:38	31,50	0,00	21,39	4.655
66	15:58:54	31,50	0,00	21,39	4.575
67	15:59:10	31,50	0,00	21,38	4.493
68	16:00:01	31,50	0,00	21,39	4.978
69	16:00:17	31,50	0,00	21,40	4.775
70	16:00:34	31,60	0,00	21,38	4.921
71	16:00:49	31,60	0,00	21,40	4.819
72	16:01:05	31,60	0,00	21,37	4.833
73	16:01:21	31,70	0,00	21,40	4.532
74	16:01:37	31,70	0,00	21,39	4.196
75	16:01:53	31,70	0,00	21,41	4.141
76	16:02:09	31,70	0,00	21,38	4.213
77	16:02:25	31,70	0,00	21,40	4.226
78	16:02:41	31,80	0,00	21,40	4.378
79	16:02:57	31,80	0,00	21,41	4.426
80	16:03:13	31,80	0,00	21,45	4.609
81	16:03:30	31,80	0,00	21,43	4.538
82	16:03:46	31,90	0,00	21,39	4.725
83	16:04:02	31,90	0,00	21,42	4.870
84	16:04:19	31,90	0,00	21,41	4.803

85	16:04:35	31,90	0,00	21,41	4.352
86	16:04:51	32,00	0,00	21,41	4.385
87	16:05:07	32,00	0,00	21,43	4.522
88	16:05:23	32,00	0,00	21,38	4.601
No	**Time (WIB)**	**T (°C)**	**Dust (mg/m3)**	**Oxygen (%Vol)**	**CO2 (PPM)**
89	16:05:40	32,00	0,00	21,43	4.465
90	16:05:56	32,00	0,00	21,41	4.307
91	16:06:12	32,10	0,00	21,47	4.248
92	16:06:27	32,10	0,00	21,45	4.352
93	16:06:43	32,10	0,00	21,37	4.572
94	16:06:59	32,20	0,00	21,46	4.350
95	16:07:15	32,20	0,00	21,45	4.357
96	16:07:31	32,20	0,00	21,42	4.511
97	16:07:47	32,20	0,00	21,47	4.567
98	16:08:02	32,20	0,00	21,41	4.460
99	16:08:18	32,20	0,00	21,46	4.601
100	16:08:34	32,20	0,00	21,43	4.275
101	16:08:50	32,30	0,00	21,42	4.393
102	16:09:06	32,30	0,00	21,45	4.086
103	16:09:22	32,30	0,00	21,43	4.365
104	16:09:38	32,40	0,00	21,47	4.170
105	16:09:54	32,40	0,00	21,47	3.965
106	16:10:09	32,40	0,00	21,45	4.347
107	16:10:25	32,40	0,00	21,47	4.434
108	16:10:41	32,40	0,00	21,46	4.764
109	16:10:57	32,40	0,00	21,38	4.660
110	16:11:12	32,40	0,00	21,43	4.663
111	16:11:29	32,50	0,00	21,43	4.444
112	16:11:45	32,50	0,00	21,49	4.577
113	16:12:01	32,50	0,00	21,46	4.993
114	16:12:17	32,50	0,00	21,49	4.873
115	16:12:33	32,50	0,00	21,46	5.013
116	16:12:49	32,50	0,00	21,45	4.853
117	16:13:05	32,50	0,00	21,48	4.467
118	16:13:20	32,50	0,00	21,43	4.609
119	16:13:36	32,60	0,00	21,46	4.867
120	16:13:52	32,60	0,00	21,50	4.850
121	16:14:08	32,60	0,00	21,47	4.467
122	16:14:23	32,60	0,00	21,47	4.393
123	16:14:39	32,60	0,00	21,45	4.421
124	16:14:55	32,60	0,00	21,47	4.553
125	16:15:11	32,60	0,00	21,44	4.580
126	16:15:27	32,70	0,00	21,53	4.641
127	16:15:43	32,70	0,00	21,48	4.189
128	16:15:58	32,70	0,00	21,47	4.360
No	**Time (WIB)**	**T (°C)**	**Dust (mg/m3)**	**Oxygen (%Vol)**	**CO2 (PPM)**
129	16:16:14	32,80	0,00	21,46	4.601
130	16:16:30	32,80	0,00	21,48	4.842
131	16:16:46	32,80	0,00	21,44	5.025
132	16:17:02	32,80	0,00	21,47	4.864
133	16:17:18	32,80	0,00	21,50	4.620
134	16:17:33	32,80	0,00	21,50	4.431
135	16:17:49	32,80	0,00	21,47	4.535
136	16:18:05	32,80	0,00	21,48	4.355
137	16:18:21	32,80	0,00	21,49	4.362
138	16:18:37	32,80	0,00	21,50	4.449
139	16:18:53	32,80	0,00	21,48	4.297
140	16:19:09	32,80	0,00	21,49	4.413
141	16:19:25	32,80	0,00	21,49	4.478
142	16:19:41	32,80	0,00	21,48	4.522
143	16:19:56	32,80	0,00	21,49	4.470
144	16:20:12	32,80	0,00	21,49	4.457
145	16:20:28	32,80	0,00	21,50	4.231
146	16:20:44	32,60	0,00	21,55	4.496

Measurement data is recorded in the Thinkspeak application every 15 seconds. In the temperature measurement graph in the Electronics Engineering Workshop (Figure 3a), the highest temperature measured is 34.20°C. In the temperature measurement in the Laboratory of the Electronics Engineering Study Program (Figure 3b), the highest temperature is 32.80 °C.

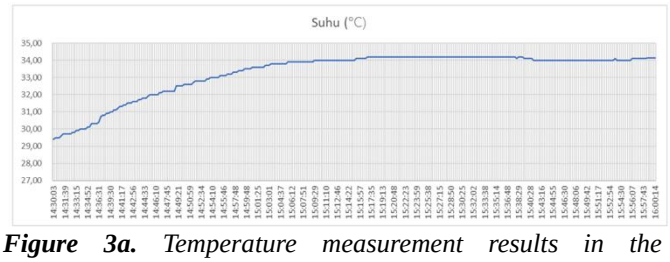

Figure 3a. *Temperature measurement results in the Electronics Engineering Study Program Workshop*

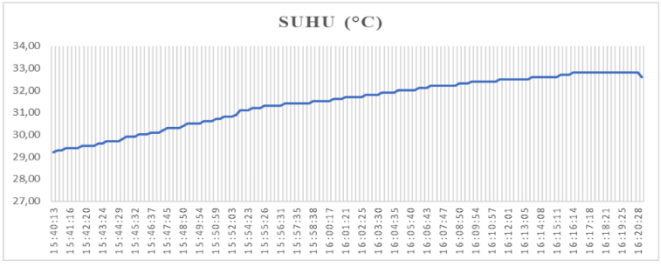

Figure 3b. *Temperature measurement results in Laboratory-2 Electronics Engineering Study Program*

Measurements for dust (Figure 4a and Figure 4b) depict no dust detected by the device in either room.

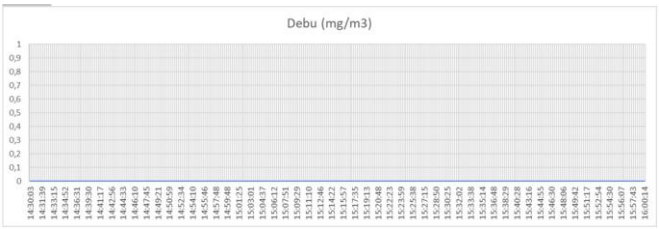

Figure 4a. *Dust measurement results in the Electronics Engineering Study Program Workshop*

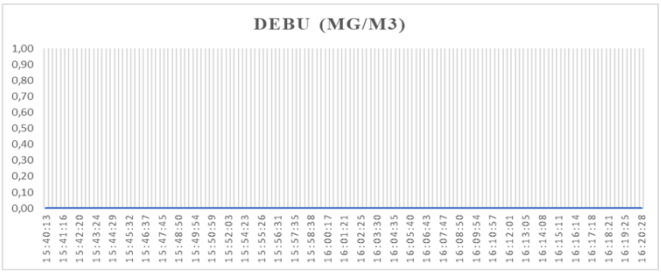

Figure 4b. *Dust measurement results in Laboratory-2 Electronics Engineering Study Program*

From the results of measuring oxygen levels in the Electronics Engineering Workshop (Figure 5a), the lowest measured oxygen level is 21.19%Vol and the highest measured oxygen level is 21.65%Vol. The results of measuring oxygen levels in the Electronics Engineering Laboratory (Figure 5b) depict that the lowest measured oxygen level is 21.19%Vol and the highest measured oxygen level is 21.55%Vol.

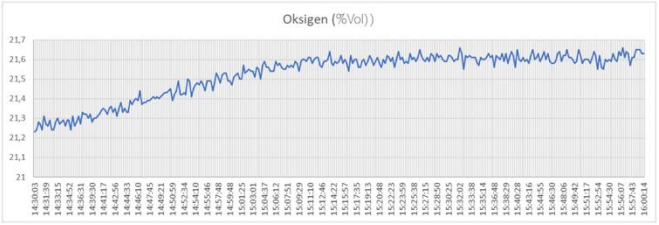

Figure 5a. *Oxygen measurement results in the Electronics Engineering Study Program Workshop*

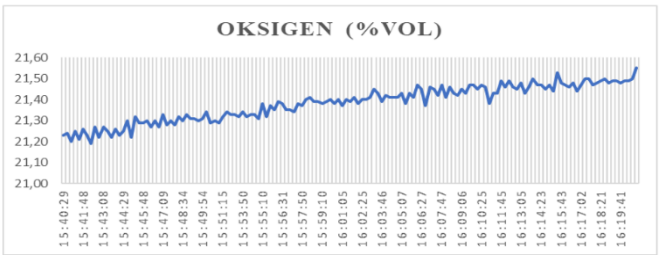

Figure 5b. *Oxygen measurement results in Laboratory-2 Electronics Engineering Study Program*

From the measurement of CO2 levels in the Electronics Engineering Workshop (Figure 6a), the lowest measured CO2 level is 4,221 PPM, and the highest measured CO2 level is 8,721 PPM. The lowest CO2 level measured in the Electronic Engineering Study Program Laboratory (Figure 6b) is 3,965 PPM, and the highest CO2 level is 7,296 PPM.

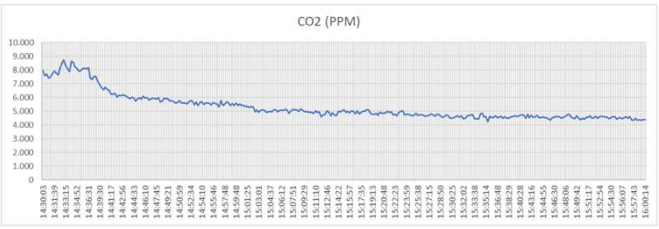

Figure 6a. *CO2 measurement results in the Electronics Engineering Study Program Workshop.*

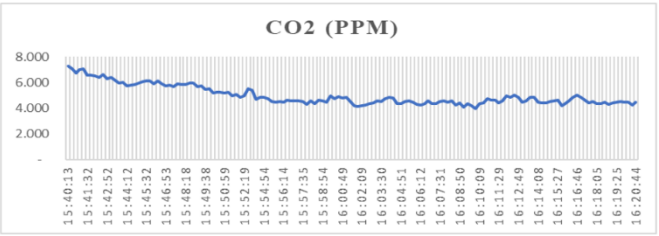

Figure 6b. *CO2 measurement results in Laboratory-2 Electronics Engineering Study Program.*

According to the Directorate of Occupational Safety Norms Supervision (2006), low oxygen levels are < 19.5% Vol and high oxygen levels are > 23.5%. The maximum limit of CO2 levels is 5,000 ppm, but if CO2 levels exceed the threshold of 600 ppm in the air it can result in disruption of user comfort and health. According to the standards set by SNI 03-6572-2001, there are 3 levels of comfortable temperature for Indonesians (Putri et al., 2020), namely:

a. Comfortably cool, between effective temperatures: 20,5 °C - 22,8 °C
b. Optimally comfortable, between effective temperatures: 22,8 °C - 25,8 °C
c. Comfortably warm, between effective temperatures: 25,8 °C - 27,1 °C

From the results of air quality measurements in the Workshop and Laboratory of the Electronics Engineering

Study Program, the results show that the room temperature far exceeds the comfortable temperature for Indonesians according to SNI 03-6572-2001 (Putri et al., 2020). A hot or humid room can disrupt comfort, health, and fatigue easily. For oxygen levels still in the safe threshold range, namely 21.19% Vol - 21.65% Vol in the Electronics Engineering Study Program Workshop and 21.19% Vol - 21.55% Vol in the Electronics Engineering Study Program Laboratory, The lowest measured CO2 level is 4,221 ppm, and the highest measured CO2 level is 8,721 ppm in the Electronics Engineering Study Workshop, and 3,965 ppm is the lowest measured CO2 level and the highest is 7,296 ppm in the Electronics Engineering Study Laboratory. CO2 levels in both rooms exceeded the threshold limit value (NBA) of 600 ppm. CO2 levels in the body can cause carbon dioxide poisoning, which can cause serious health problems, namely acidosis. This condition can cause oxygen in the blood to be difficult to release into body cells, so the body lacks oxygen.

4. Conclusion

From the results of the discussion, it can be concluded as follows:

1. Temperature and CO2 levels measured in the workshop and laboratory of the Electronics Engineering Study Program exceed the Safe Limit Value (NBA).
2. The workshop facilities and EK-2 laboratory rooms are good in cleanliness, as indicated by the absence of dust in both rooms.
3. Workshop facilities and laboratory rooms have good ventilation, as evidenced by the measured O2 levels in the Safe Limit Value range (NBA).

References

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