Production Scheduling System Based on Customer Orders at AsMedia Percetakan Nganjuk

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Abstract:
This research aims to identify the most effective production scheduling system at AsMedia Percetakan Nganjuk to reduce delays in order fulfillment. The proposed scheduling method is based on a priority rule system with the following criteria: First Come First Served (FCFS), Short Processing Time (SPT), Long Processing Time (LPT), and Earliest Due Date (EDD). Based on the results of data analysis and discussion, the First Come First Served (FCFS) and Earliest Due Date (EDD) methods are considered superior compared to the other methods. This is based on findings that show the effectiveness of the First Come First Served (FCFS) and Earliest Due Date (EDD) methods aligns with current criteria, including minimum average completion time, maximum utilization, minimum average number of jobs in the system, and minimum delays. Therefore, the researcher recommends that AsMedia Percetakan Nganjuk use the First Come First Served (FCFS) and Earliest Due Date (EDD) methods as alternative production scheduling methods. Given the relatively high average job delays with each method used, the company is deemed less effective in production scheduling. This is evident from the relatively high average job delays with each method used. Therefore, the solution the researcher can offer to AsMedia Percetakan Nganjuk is to increase the workforce and production machine capacity.

Keywords: *customer orders, gantt chart, priority principle, scheduling*

1. Introduction

The printing industry has recently emerged as one of the industries that is expected to endure for a long time in Indonesia. One company worth noting is the printing industry, as it continues to grow. The abundance of printed materials we encounter in daily life is proof of the printing industry's growth.

In any industry, production activities are closely interconnected. To achieve the best results from a production activity, every production process must first be meticulously planned. Scheduling is one way to do this. The goal of production scheduling is to allocate the involved resources as effectively as possible. In the industrial sector, production scheduling is a crucial tool in decision-making. To minimize overall production costs and time, companies also strive to have the most effective and efficient scheduling to enhance productivity.

According to Kiran (2019), scheduling is the process of determining the sequence, time, and resources that will be used in the production process to achieve specific goals. These goals can include maximizing machine utilization, reducing wait times, or improving resource allocation. Scheduling is essential to ensure that everything is produced according to plan and that the desired outcomes can be achieved quickly.

One company engaged in the printing industry is AsMedia Percetakan Nganjuk. Every month, AsMedia Percetakan Nganjuk experiences an excessive increase in orders. In recent months, orders have surged due to the new academic year. However, this increase in orders has not been matched with an adequate production scheduling system, resulting in frequent delivery delays. This situation highlights the need for the development of a production scheduling system. Below is the customer order data for AsMedia Percetakan Nganjuk over the past year:
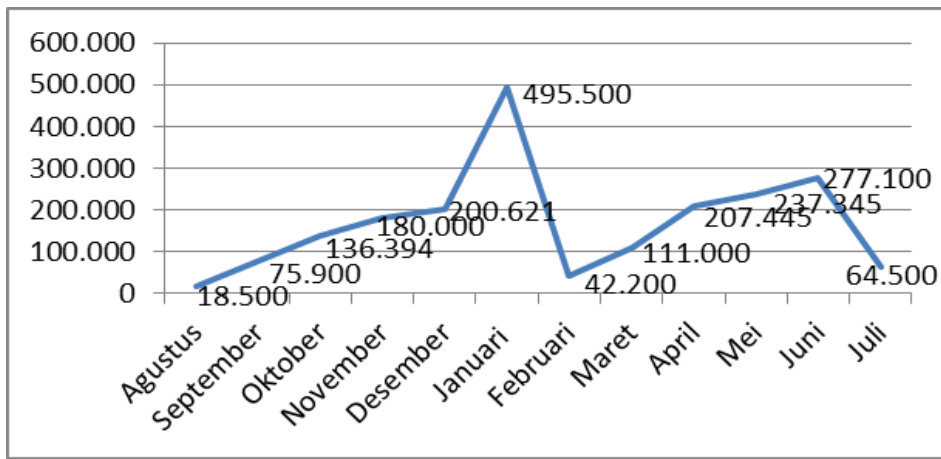
Figure 1: Customer order data for 2023-2024

Based on Figure 1: Customer order data for 2023-2024, AsMedia Percetakan Nganjuk also faces another issue, namely the accumulation of finished goods due to delays in the production process. The production process at AsMedia Percetakan Nganjuk typically takes between 1 to 2 weeks, but if there is an overload, it can take up to 3 weeks to 1 month. This accumulation of goods is not only due to the high volume of customer orders but also because of frequent machine breakdowns and inadequate storage or warehouse facilities.

The production activities at AsMedia Percetakan Nganjuk are still facing issues with delays in fulfilling customer orders. These delays are caused by suboptimal production scheduling and, at times, the need to prioritize special orders for faster processing. This situation leads to changes in the existing production scheduling system, resulting in an imbalance in the production schedule. The addition of special orders disrupts the completion time of previously scheduled orders, ultimately leading to delays in delivery to customers. Below is the data on order completion delays:

Table 1: Order completion delay data

No	Order	Total	Entry Date	Due Date	Exit Date	Delay
1	Elementary school worksheets	18.500	21/08/2023	26/08/2024	25/08/2024	-
2	Kindergarten book	75.900	04/09/2023	10/09/2023	11/09/2023	1 days
3	Elementary school worksheets	136.394	09/10/2023	21/10/2023	23/10/2023	2 days
4	Junior high school worksheets	180.000	14/11/2023	27/11/2023	30/11/2023	3 days
5	Module	96.671	01/12/2023	09/12/2023	11/12/2023	2 days
6	Junior high school worksheets	103.950	11/12/2023	21/12/2023	22/12/2023	1 days
7	Elementary school worksheets	267.000	02/01/2024	22/01/2024	25/01/2024	3 days
8	Senior high school worksheets	228.500	13/01/2024	31/01/2024	07/02/204	7 days
9	Early Childhood book	42.200	07/02/2024	13/02/2024	13/02/2024	-
10	Elementary school worksheets	36.000	04/03/2024	09/03/2024	08/03/2024	-
11	Junior high school worksheets	75.000	07/03/2024	13/03/2024	15/03/2024	2 days
12	Notebooks	93.600	01/04/2024	09/04/2024	10/04/2024	1 days
13	Elementary school worksheets	71.245	08/04/2024	15/04/2024	18/04/2024	3 days
14	Magazine	42.600	22/04/2024	27/04/2024	27/04/2024	-
15	Brochure	36.000	06/05/2024	11/05/2024	11/05/2024	-
16	Junior high school worksheets	201.345	13/05/2024	28/05/2024	31/05/2024	3 days
17	Elementary school worksheets	189.450	03/06/2024	18/06/2024	22/06/2024	4 days
18	Junior high school worksheets	87.650	19/06/2024	26/06/2024	29/06/2024	3 days
19	Senior high school worksheets	64.500	01/07/2024	08/07/2024	09/07/2024	1 days

Given these conditions, AsMedia Percetakan Nganjuk needs to improve its scheduling methods to better align with the current situation. As an alternative, several scheduling techniques can be used for comparison, including First Come First Served (FCFS), where the first order to arrive is the first to be served; Shortest Processing Time (SPT), where orders are arranged based on the shortest processing time, starting with the

fastest; Longest Processing Time (LPT), where orders with the longest processing time are prioritized and completed first; and Earliest Due Date (EDD), where orders are sorted by the shortest due date, with those having the closest deadlines being completed first. Among these four methods, the most effective one will be selected to improve productivity at AsMedia Percetakan Nganjuk.

2. Literature Review
Scheduling
The process of determining the sequence and timing of production processes to maximize resource utilization and meet consumer demand is known as scheduling. The goal is to reduce overall completion time while maximizing efficiency in the use of labor and machines. (Heizer & Render, 2021)

Production scheduling is a method of organizing and managing production schedules and resource distribution to maximize efficiency in meeting demand. This involves determining which jobs are run on which machines and in what order, setting the start and end times for each task, and maximizing the utilization of available resources. (Baker & Trietsch, 2019)

Production Scheduling
Production scheduling is a method of organizing and managing production schedules and resource distribution to maximize efficiency in meeting demand. This involves determining which tasks are performed on which machines and in what order, setting the start and end times for each task, and maximizing the utilization of available resources. (Baker & Trietsch, 2019)

Production scheduling is the process of organizing orders, schedules, and resources for production activities to achieve specific objectives. The goal of production scheduling is to ensure that each stage of the production process is completed quickly, cost-effectively, and with the best possible use of available resources. It is a crucial component of production management, ensuring that products are produced on time and in accordance with established quantity and quality standards. (Kiran, 2019)

Gantt Chart
A Gantt Chart is a diagram used as a visual tool for scheduling and task assignment (Render & Barry, 2020). Henry Gantt, who popularized the use of charts for industrial scheduling in the early 1900s, is credited with naming this diagram. The Gantt Chart is used to organize and display how resources are actually or intended to be used over a specific period. The resources that need to be scheduled are typically shown vertically, while the time scale is shown horizontally. The chart illustrates how resources are utilized and highlights any idle time.

First Come First Served
FCFS (First Come First Served) means that orders are processed in the order they arrive. Therefore, the first job to be processed at the work center is the one that arrived first. While not the most efficient, FCFS does not perform well on most criteria. Nevertheless, FCFS has the advantage of being perceived as fair by clients, which is very important in service systems.

Shortest Processing Time
SPT (Shortest Processing Time) prioritizes tasks with the shortest processing time to be completed first. In terms of reducing workflow and the average number of jobs in the system, SPT is usually the most effective method. Its main drawback is that, because tasks requiring quick completion are always prioritized, longer processes can be repeatedly overlooked.

Longest Processing Time
LPT (Longest Processing Time) prioritizes tasks with the longest processing times. Jobs that take longer are usually the most important and are processed first based on their priority.

Earliest Due Date
EDD (Earliest Due Date) prioritizes tasks based on the earliest deadline. The task with the earliest due date

is completed first. EDD reduces the maximum lateness, which may be necessary for tasks that incur penalties if completed after a certain date. EDD generally performs well when delays are a significant concern.

3. Research Method

This study uses a quantitative method and a quantitative descriptive approach. According to Sugiyono (2023), quantitative research is defined as research that uses data obtained in the form of numerical figures or quantifiable qualitative data. Meanwhile, Sarwono (2023) defines the descriptive analysis approach as depicting company actions based on known facts that can be researched through literature review to reach a conclusion.

Based on these definitions, this study presents all the collected information to propose a production scheduling system suitable for the conditions at AsMedia Percetakan Nganjuk. Among the four production scheduling methods FCFS (First Come First Served), SPT (Shortest Processing Time), LPT (Longest Processing Time), and EDD (Earliest Due Date) one will be selected that can provide effective scheduling and the fastest completion of customer orders for AsMedia Percetakan Nganjuk. Figure 2 below represents the framework of this research.
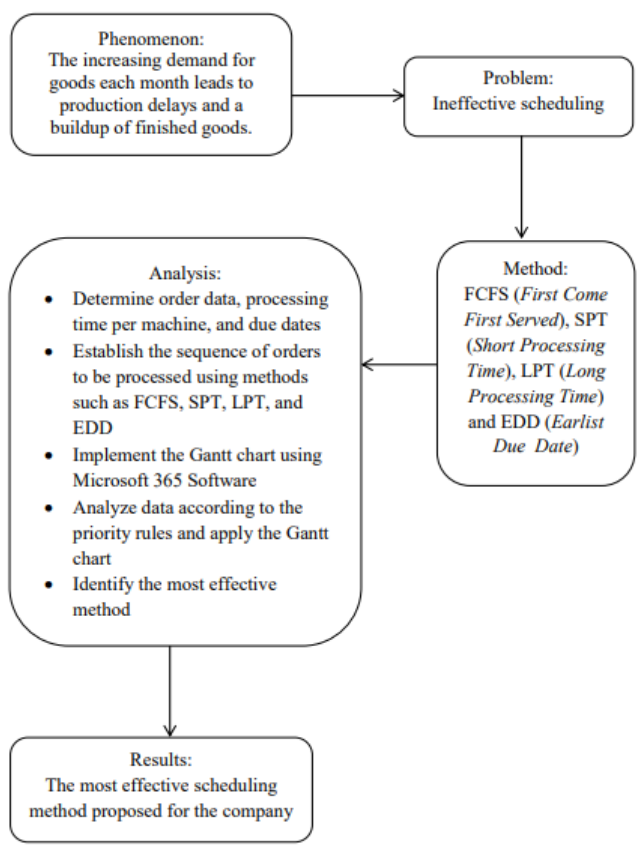

Figure 2: Framework

4. Result and Discussion
4.1. Result
First Come First Served (FCFS)

This method organizes tasks based on the order of arrival. Orders that arrive earlier are processed first. Thus, the sequence of orders to be processed by AsMedia Percetakan Nganjuk is shown in the following table:

Table 2: Sequencing using the first come first served method

No	Order	Total	Entry Date	Due Date	Exit Date	Delay
1	Elementary school worksheets	18.500	21/08/2023	26/08/2023	25/08/2023	-
2	Kindergarten book	75.900	04/09/2023	10/09/2023	11/09/2023	1 days
3	Elementary school worksheets	136.394	09/10/2023	21/10/2023	23/10/2023	2 days
4	Junior high school worksheets	180.000	14/11/2023	27/11/2023	30/11/2023	3 days
5	Module	96.671	01/12/2023	09/12/2023	11/12/2023	2 days

6	Junior high school worksheets	103.950	11/12/2023	21/12/2023	22/12/2023	1 days
7	Elementary school worksheets	267.000	02/01/2024	22/01/2024	25/01/2024	3 days
8	Senior high school worksheets	228.500	13/01/2024	31/01/2024	07/02/204	7 days
9	Early Childhood book	42.200	07/02/2024	13/02/2024	13/02/2024	-
10	Elementary school worksheets	36.000	04/03/2024	09/03/2024	08/03/2024	-
11	Junior high school worksheets	75.000	07/03/2024	13/03/2024	15/03/2024	2 days
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14	Magazine	42.600	22/04/2024	27/04/2024	27/04/2024	-
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16	Junior high school worksheets	201.345	13/05/2024	28/05/2024	31/05/2024	3 days
17	Elementary school worksheets	189.450	03/06/2024	18/06/2024	22/06/2024	4 days
18	Junior high school worksheets	87.650	19/06/2024	26/06/2024	29/06/2024	3 days
19	Senior high school worksheets	64.500	01/07/2024	08/07/2024	09/07/2024	1 days

After completing the implementation of the Gantt chart, the next step is to calculate the performance of the FCFS method based on the Gantt chart. This process involves determining the processing time, time flow, total time, as well as delays and total delays. Processing time includes total processing time (WP), machine wait time (WTM), and job wait time (WTP). Time flow is obtained by summing the the wait time of each job with its processing time. Delays occur if the time flow required exceeds the established deadline. The results of the FCFS performance calculations are shown in the following table:

Table 3: Performance calculation of first come first served

No	Order	Processing Time (Days)			Time Flow	Job Deadline	Delay
		WP	WTM	WTP			
1	Elementary school worksheets	4	-	-	4	4	-
2	Kindergarten book	6	-	-	10	5	5
3	Elementary school worksheets	12	-	-	22	10	12
4	Junior high school worksheets	13	-	-	35	10	25
5	Module	8	-	-	43	6	37
6	Junior high school worksheets	10	5	-	58	9	49
7	Elementary school worksheets	20	-	-	78	17	61
8	Senior high school worksheets	18	3	3	102	11	91
9	Early Childhood book	5	-	-	107	5	102
10	Elementary school worksheets	4	-	-	111	4	107
11	Junior high school worksheets	6	3	1	121	4	117
12	Notebooks	8	-	-	129	7	122
13	Elementary school worksheets	6	5	2	142	3	139
14	Magazine	5	4	-	151	5	146
15	Brochure	4	-	-	155	4	151
16	Junior high school worksheets	15	3	-	173	12	161
17	Elementary school worksheets	13	-	-	186	9	177
18	Junior high school worksheets	6	8	2	202	3	199
19	Senior high school worksheets	6	-	-	208	5	203
	TOTAL	**169+31+8=208**			**2.037**	**133**	**1.904**

The results of the effectiveness calculations are explained below:
a) Average Completion Time
= Total time flow = 2.037 = 107 days
    Number of jobs   19
b) Utilization
= Total processing time = 208 = 10,21%
    Total time flow   2.037
c) Average Number of Jobs

$$= \frac{\text{Total time flow}}{\text{Total processing time}} = \frac{2.037}{208} = 9,8 \text{ job}$$

d) Average Job Delay

$$= \frac{\text{Total delay days}}{\text{Number of jobs}} = \frac{1.904}{19} = 100 \text{ days}$$

Shortest Processing Time (SPT)

The Shortest Processing Time (SPT) method arranges orders based on the shortest processing time. Thus, orders that require the shortest processing time are prioritized and completed first. The sequence of orders to be processed by AsMedia Percetakan Nganjuk is shown in the following table:

Table 4: Sequencing using the shortest processing time method

No	Order	Entry Date	Total Processing Time (days)	Due Date
1	Elementary school worksheets	21/08/2023	4	26/08/2023
2	Kindergarten book	04/09/2023	6	10/09/2023
3	Elementary school worksheets	09/10/2023	12	21/10/2023
4	Junior high school worksheets	14/11/2023	13	27/11/2023
5	Module	01/12/2023	8	09/12/2023
6	Junior high school worksheets	11/12/2023	10	21/12/2023
7	Senior high school worksheets	13/01/2024	18	31/01/2024
8	Elementary school worksheets	02/01/2024	20	22/01/2024
9	Early Childhood book	07/02/2024	5	13/02/2024
10	Elementary school worksheets	04/03/2024	4	09/03/2024
11	Junior high school worksheets	07/03/2024	6	13/03/2024
12	Magazine	22/04/2024	5	27/04/2024
13	Elementary school worksheets	08/04/2024	6	15/04/2024
14	Notebooks	01/04/2024	8	09/04/2024
15	Brochure	06/05/2024	4	11/05/2024
16	Junior high school worksheets	13/05/2024	15	28/05/2024
17	Junior high school worksheets	19/06/2024	6	26/06/2024
18	Elementary school worksheets	03/06/2024	13	18/06/2024
19	Senior high school worksheets	01/07/2024	6	08/07/2024

After completing the implementation of the Gantt chart, the next step is to calculate the performance of the SPT method based on the Gantt chart. This process involves determining the processing time, time flow, total time, as well as delays and total delays. Processing time includes total processing time (WP), machine wait time (WTM), and job wait time (WTP). Time flow is obtained by summing the wait time of each job with its processing time. Delays occur if the time flow required exceeds the established deadline. The results of the SPT performance calculations are shown in the following table:

Table 5: Performance calculation of shortest processing time

No	Order	Processing Time (Days)			Time Flow	Job Deadline	Delay
		WP	WTM	WTP			
1	Elementary school worksheets	4	-	-	4	4	-
2	Kindergarten book	6	-	-	10	5	5
3	Elementary school worksheets	12	-	-	22	10	12
4	Junior high school worksheets	13	-	-	35	10	25
5	Module	8	-	-	43	6	37
6	Junior high school worksheets	10	5	-	58	9	49
7	Senior high school worksheets	18	-	-	76	11	65
8	Elementary school worksheets	20	16	-	112	17	95
9	Early Childhood book	5	-	-	117	5	112
10	Elementary school worksheets	4	-	-	121	4	117
11	Junior high school worksheets	6	3	1	131	4	127

12	Magazine	5	-	-	136	5	131
13	Elementary school worksheets	6	14	-	156	3	153
14	Notebooks	8	22	-	186	7	179
15	Brochure	4	-	-	190	4	186
16	Junior high school worksheets	15	3	-	208	12	196
17	Junior high school worksheets	6	-	-	214	3	211
18	Elementary school worksheets	13	16	-	243	9	234
19	Senior high school worksheets	6	-	-	249	5	244
TOTAL		**169+79+1=249**			**2.311**	**133**	**2.178**

The results of the effectiveness calculations are explained below:
a) Average Completion Time
$$= \frac{\text{Total time flow}}{\text{Number of jobs}} = \frac{2.311}{19} = 122 \text{ days}$$

b) Utilization
$$= \frac{\text{Total processing time}}{\text{Total time flow}} = \frac{249}{2.311} = 10{,}77\%$$

c) Average Number of Jobs
$$= \frac{\text{Total time flow}}{\text{Total processing time}} = \frac{2.311}{249} = 9{,}3 \text{ job}$$

d) Average Job Delay
$$= \frac{\text{Total delay days}}{\text{Number of jobs}} = \frac{2.178}{19} = 115 \text{ days}$$

Longest Processing Time (LPT)
The Longest Processing Time (LPT) method arranges orders based on the longest processing time. In other words, orders with the longest processing time are completed first. The sequence of orders to be processed by AsMedia Percetakan Nganjuk is shown in the following table:

Table 6: Sequencing using the longest processing time method

No	Order	Entry Date	Total Processing Time (days)	Due Date
1	Elementary school worksheets	21/08/2023	4	26/08/2023
2	Kindergarten book	04/09/2023	6	10/09/2023
3	Elementary school worksheets	09/10/2023	12	21/10/2023
4	Junior high school worksheets	14/11/2023	13	27/11/2023
5	Junior high school worksheets	11/12/2023	10	21/12/2023
6	Module	01/12/2023	8	09/12/2023
7	Senior high school worksheets	02/01/2024	20	22/01/2024
8	Elementary school worksheets	13/01/2024	18	31/01/2024
9	Early Childhood book	07/02/2024	5	13/02/2024
10	Junior high school worksheets	07/03/2024	6	13/03/2024
11	Elementary school worksheets	04/03/2024	4	09/03/2024
12	Notebooks	01/04/2024	8	09/04/2024
13	Elementary school worksheets	08/04/2024	6	15/04/2024
14	Magazine	22/04/2024	5	27/04/2024
15	Junior high school worksheets	13/05/2024	15	28/05/2024
16	Brochure	06/05/2024	4	11/05/2024
17	Elementary school worksheets	03/06/2024	13	18/06/2024
18	Junior high school worksheets	19/06/2024	6	26/06/2024
19	Senior high school worksheets	01/07/2024	6	08/07/2024

The results of the LPT performance calculations are shown in the following table:

Table 7: Performance calculation of longest processing time

No	Order	Processing Time (Days)			Time Flow	Job Deadline	Delay
		WP	WTM	WTP			
1	Elementary school worksheets	4	-	-	4	4	-
2	Kindergarten book	6	-	-	10	5	5
3	Elementary school worksheets	12	-	-	22	10	12
4	Junior high school worksheets	13	-	-	35	10	25
5	Junior high school worksheets	10	-	-	45	9	36
6	Module	8	11	3	67	6	61
7	Senior high school worksheets	20	-	-	87	17	70
8	Elementary school worksheets	18	-	-	105	11	94
9	Early Childhood book	5	-	-	110	5	105
10	Junior high school worksheets	6	-	-	116	4	112
11	Elementary school worksheets	4	3	1	124	4	120
12	Notebooks	8	-	-	132	7	125
13	Elementary school worksheets	6	5	2	145	3	142
14	Magazine	5	4	-	154	5	149
15	Junior high school worksheets	15	-	-	169	12	157
16	Brochure	4	9	2+2+3	189	4	185
17	Elementary school worksheets	13	-	-	202	9	193
18	Junior high school worksheets	6	8	2	218	3	215
19	Senior high school worksheets	6	-	-	224	5	219
	TOTAL	169+8=177			2.158	133	2.025

The results of the effectiveness calculations are explained below:

a) Average Completion Time

$$= \frac{\text{Total time flow}}{\text{Number of jobs}} = \frac{2.158}{19} = 114 \text{ days}$$

b) Utilization

$$= \frac{\text{Total processing time}}{\text{Total time flow}} = \frac{177}{2.158} = 8,20\%$$

c) Average Number of Jobs

$$= \frac{\text{Total time flow}}{\text{Total processing time}} = \frac{2.158}{177} = 12,2 \text{ job}$$

d) Average Job Delay

$$= \frac{\text{Total delay days}}{\text{Number of jobs}} = \frac{2.025}{19} = 107 \text{ days}$$

Earliest Due Date (EDD)

The EDD (Earliest Due Date) method arranges tasks based on the earliest due date. In other words, orders with the closest deadlines are prioritized and processed first. The sequence of orders to be processed by AsMedia Percetakan Nganjuk is shown in the following table:

Table 8: Sequencing using the earliest due date method

No	Order	Entry Date	Total Processing Time (days)	Due Date
1	Elementary school worksheets	21/08/2023	4	26/08/2023
2	Kindergarten book	04/09/2023	6	10/09/2023
3	Elementary school worksheets	09/10/2023	12	21/10/2023
4	Junior high school worksheets	14/11/2023	13	27/11/2023
5	Module	01/12/2023	8	09/12/2023
6	Junior high school worksheets	11/12/2023	10	21/12/2023
7	Elementary school worksheets	02/01/2024	20	22/01/2024
8	Senior high school worksheets	13/01/2024	18	31/01/2024
9	Early Childhood book	07/02/2024	5	13/02/2024
10	Elementary school worksheets	04/03/2024	4	09/03/2024

11	Junior high school worksheets	07/03/2024	6	13/03/2024
12	Notebooks	01/04/2024	8	09/04/2024
13	Elementary school worksheets	08/04/2024	6	15/04/2024
14	Magazine	22/04/2024	5	27/04/2024
15	Brochure	06/05/2024	4	11/05/2024
16	Junior high school worksheets	13/05/2024	15	28/05/2024
17	Elementary school worksheets	03/06/2024	13	18/06/2024
18	Junior high school worksheets	19/06/2024	6	26/06/2024
19	Senior high school worksheets	01/07/2024	6	08/07/2024

After completing the implementation of the Gantt chart, the next step is to calculate the performance of the EDD method based on the Gantt chart. This process involves determining the processing time, time flow, total time, as well as delays and total delays. Processing time includes total processing time (WP), machine wait time (WTM), and job wait time (WTP). Time flow is obtained by summing the wait time of each job with its processing time. Delays occur if the time flow required exceeds the established deadline. The results of the EDD performance calculations are shown in the following table:

Table 9: Performance calculation of earliest due date

No	Order	Processing Time (Days)			Time Flow	Job Deadline	Delay
		WP	WTM	WTP			
1	Elementary school worksheets	4	-	-	4	4	-
2	Kindergarten book	6	-	-	10	5	5
3	Elementary school worksheets	12	-	-	22	10	12
4	Junior high school worksheets	13	-	-	35	10	25
5	Module	8	-	-	43	6	37
6	Junior high school worksheets	10	5	-	58	9	49
7	Elementary school worksheets	20	-	-	78	17	61
8	Senior high school worksheets	18	3	3	102	11	91
9	Early Childhood book	5	-	-	107	5	102
10	Elementary school worksheets	4	-	-	111	4	107
11	Junior high school worksheets	6	3	1	121	4	117
12	Notebooks	8	-	-	129	7	122
13	Elementary school worksheets	6	5	2	142	3	139
14	Magazine	5	4	-	151	5	146
15	Brochure	4	-	-	155	4	151
16	Junior high school worksheets	15	3	-	173	12	161
17	Elementary school worksheets	13	-	-	186	9	177
18	Junior high school worksheets	6	8	2	202	3	199
19	Senior high school worksheets	6	-	-	208	5	203
TOTAL		**169+31+8=208**			**2.037**	**133**	**1.904**

The results of the effectiveness calculations are explained below:

a) Average Completion Time

$$= \frac{\text{Total time flow}}{\text{Number of jobs}} = \frac{2.037}{19} = 107 \text{ days}$$

b) Utilization

$$= \frac{\text{Total processing time}}{\text{Total time flow}} = \frac{208}{2.037} = 10{,}21\%$$

c) Average Number of Jobs

$$= \frac{\text{Total time flow}}{\text{Total processing time}} = \frac{2.037}{208} = 9{,}8 \text{ job}$$

d) Average Job Delay

$$= \frac{\text{Total delay days}}{\text{Number of jobs}} = \frac{1.904}{19} = 100 \text{ days}$$

After performing the calculations for each priority rule used, the effectiveness measurements for each priority rule method will be compared in a table. The aim is to determine which method is the most effective and can be proposed as the scheduling method for AsMedia Percetakan Nganjuk. The following table presents the comparison of effectiveness measurement criteria:

Table 10: Comparison of effectiveness measurement criteria

Effectiveness Measure	FCFS	SPT	LPT	EDD
Average completion time	107 days	122 days	114 days	107 days
Utilization	10,21%	10,77%	8,20%	10,21%
Average Number of Jobs	9, 8 job	9, 3 job	12,2 job	9, 8 job
Average Job Delay	100 days	115 days	107 days	100 days

From the comparison results above, it is evident that the FCFS and EDD methods yield the most optimal effectiveness measurements compared to other methods. Both methods result in the same calculations. The results show an average completion time of 107 days, a utility of 10.21%, an average number of jobs of 9.8, and an average job delay of 100 days. The effectiveness measurements of the FCFS and EDD methods meet the criteria for optimal scheduling. A production scheduling is considered optimal if the effectiveness measurements show the minimum average completion time, maximum utility, minimum average number of jobs, and minimum average job delay. Therefore, the FCFS and EDD methods can be proposed as improvements for optimal production scheduling at AsMedia Percetakan Nganjuk.

4.2. Discussion

The issue of production delays at AsMedia Percetakan Nganjuk can be effectively addressed using the FCFS and EDD approaches. Therefore, it is recommended that FCFS and EDD be used as alternative production scheduling methods at AsMedia Percetakan Nganjuk. It is hoped that implementing FCFS and EDD technology at AsMedia Percetakan Nganjuk will help resolve ongoing production scheduling issues, hereby reducing the number of orders taking longer to complete than expected.

Based on the calculation of average job delays at AsMedia Percetakan Nganjuk using the four methods First Come First Served (FCFS) at 100 days, Shortest Processing Time (SPT) at 115 days, Longest Processing Time (LPT) at 107 days, and Earliest Due Date (EDD) at 100 days the company is considered less effective in production scheduling. This is evident from the relatively high average job delays across each method used. Therefore, a solution that can be proposed for AsMedia Percetakan Nganjuk is to increase labor and production machine capacity.

5. Conclusion

Based on the calculations from the four methods First Come First Served (FCFS), Shortest Processing Time (SPT), Longest Processing Time (LPT), and Earliest Due Date (EDD) it can be concluded that, compared to the other approaches, the First Come First Served (FCFS) and Earliest Due Date (EDD) methods yield effectiveness measurements that are closest to the optimal scheduling criteria.

The average job delay calculations for the four methods are as follows: First Come First Served (FCFS) at 100 days, Shortest Processing Time (SPT) at 115 days, Longest Processing Time (LPT) at 107 days, and Earliest Due Date (EDD) at 100 days. Thus, the company is considered less effective in production scheduling. To address this, AsMedia Percetakan Nganjuk should consider increasing the number of workers and production machine capacity.

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