Designing Facility Layout Using Business Intelligence Approach: A Case Study in an Amusement Arcade

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Abstract
This paper discus a facility layout design in an amusement arcade in Surabaya. In this arcade, there are many idle game machines, since the customers only play in certain games. This problem is difficult to resolve since playing patterns and game categories have not been acknowledged. Business intelligence are used to analyze play patterns so that the game machines layout could be proposed. The proposed layout of game machines also applies the concept of store's layout. The purpose of this study is to propose game machine layout considering the playing patterns and categories. The results of this study are to develop a new layout design with considering age. The new layout design is to juxtapose the game machine which has the biggest revenue in a category with game machine which has the smallest revenue from other categories. These juxtapositions do not cost any money because they are done during working hours and using manpower. The proposed layout attracts customers spend their money to play.

Keywords
Business Intelligence, Data Mining, Facility Layout, Power BI

1. Introduction
Traditionally, the main objective of facility layout problem is to minimize the total material flow cost. Facilities layout design refers to the arrangement of all equipment, machinery and furnishings within a building envelope after considering various objectives of the facility (Riedel 2011). Facility layout problems are found in several types of manufacturing systems or plants which affect to system performance (Drira et al 2006). Many researches have been done in facility layout problems. De Carlo et al (2013) doing the layout re-arrangement of fashion production lines. In this work de Carlo et al, used the value stream mapping approach, to obtain a new facility layout. Mowrey et al. (2018) constructed a model to optimize the rack layout in a retail store. They tracked the customer behaviour for designing a new layout. Some layout problems with considering adjacencies or shape irregularities in manufacturing have been solved (Wang et al 2005; Neghabi and Ghassemi 2016). Garcia et al. (2018) proposed the use of simulation based optimization to design a facility layout that has an uncertainty associated with new production processes. While a multi objective genetic algorithm for the facility layout problem is developed by Aiello et al. (2012).

The use of facility layout is spreading in many businesses. In the service industry, such as museum, theme parks, exhibition, and an amusement arcade facility layout problem become more complex when there are a lot of visitors' number among the enterprise's entities. The visitor crowding gives the negative impacts to visitor satisfaction (Rathnayake 2015). Some researches related to reducing crowding and improving satisfaction have been proposed (Jaén et al 2011; Kawamura 2004). Yu et al. (2010) tried to solve the museum visitor routing problem. Zhang et al. (2017) mentioned that visitor movement is influenced by attraction attributes (e.g., attraction type, experience value, facility capacity, floor area, and indoor feature) and spatial layout attributes (e.g., distance between attractions, path network, entrance location, and attraction distribution), the relationships between theme park visitors traffics and service facility location along with their capacities are found out. The results indicate that there is a unique relationship between the service facility placements and the amount of predicted traffic flows for each Disneyland (Hoon et al 2016). Block layout approach for attraction based enterprises such as theme parks, museums, casinos and exhibitions is proposed by Li and Smith (2018).

The use of marketing analysis in business problems are begin to develop. Dedić and Stanier (2016) stated, business intelligence consists of strategies and technologies used by enterprises for analyzing data of business information. So, by using business intelligence, we first mining the data to get the customer's behaviour. We then used the information of their habits to layout the facilities in an amusement arcade. In a Cutter Consortium Report (Herzum 2003) stated 70 percent of the respondents (142 companies) had implemented data warehousing and Business

Intelligence (BI) initiatives. A model for assessing the success of BI is identified and introduced the most important and effective factors in evaluating the success of BI tools (Rouhani and Savoji 2016). Hence, Eder and Koch (2018) stated a strong management support, a light-weight approach, user acceptance, project team, and data quality as a critical success factor during the implementation of a business intelligence system.

The relationship between various market forces and their impacts to move the goods through distribution and end customers are examined by utilizing business intelligence and analytical (Peck et al 2017). Halim et al. (2019) tried to design facility layout problem in an amusement arcade by using market basket analysis.

The use of Business Intelligence effectively is considered an essential factor in the competiveness of a company especially in rapidly changing markets (Watson and Wixon 2007). Therefore, in this study, we attempt to re-design the facility layout for an amusement arcade in Surabaya considering the business intelligence approach. The amusement arcade is a playing area for arcade games. In the arcade games, not all games are played. Some of them are favoured, and some are not. This problem leads to 42.11% game machines to be idle which is proven from three months data. The data are obtained from 1 December 2017 until 28 February 2018. Frequency of idle game machines are shown in figure 1.

Only 51% (32 out of 63) of the game machines are played less than 100 times. So far, the owner only designed it by feeling, since they never used the recorded data to find the play pattern and the game categories. Therefore, using the business intelligence approach, the play pattern which connected to the current layout design is mined. The information collected from the business intelligence is then used for constructing a new design.

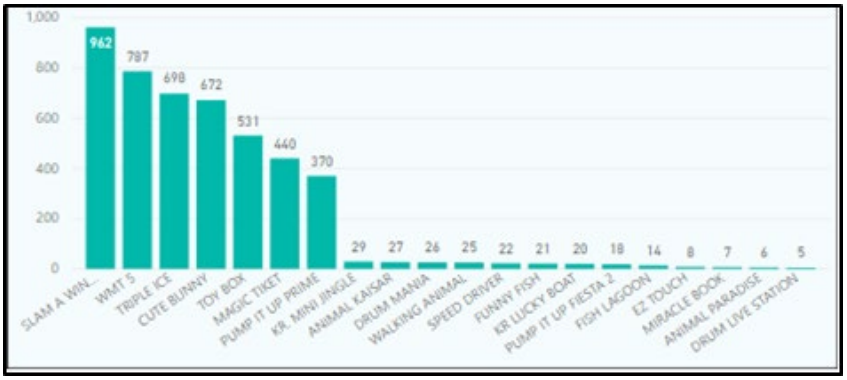

Figure 1. Frequency of idle game machines.

2. Research Method

2.1. Business Intelligence and Data Mining

Business intelligence is a set of information technology (IT) solutions which gathering and analyzing data to the right decision makers at the right time. These data then can be used for data mining. Data mining itself is the art of discovering insights and patterns from data. Data mining extracts pattern to make data more valuable (Maheshwari 2015).

Business intelligence does not tell the users what to do or what will happen, it is only a way for users to examine data, to understand trends and derive insights. Many tools can be used to extract data and presented in meaningful charts or dashboards. Excel with the power query and power pivot is one of the examples. In this study we used the Microsoft power BI for developing the business intelligence of the amusement arcade.

Power BI is a tool developed by Microsoft, it combined the Power Query and Power Pivot in a one platform. For the one who usually work with Power Query and Power Pivot we know that we must create the data table and construct the data relationship through Power Query. After that we manage the data and create the many pivot tables and pivot charts. Finally, we build the dashboard that combines all charts interactively in the Excel sheets. Using the Power BI, we can manage the data, construct the table relationship and construct the dashboard interactively at once. We also do not need to do pivoting for creating charts.

2.2. Facility Layout

Facility is the arrangement of machinery and materials from one facility to another to minimize material handling and transportation cost (Kovács and Kot 2017). In this paper, the facility layout is well focused on managing and designing facilities considering customer patterns in playing games. The facility layout planning will be developed

using Systematic layout planning (SLP). SLP is a technique to conduct layout planning that consists of a framework of phases. Three phases used in SLP are:

1. Analysing phase. The current layout is analysed by considering flow materials and activity relationship, relationship chart.
2. Searching phase. In this phase, space available and space requirement are needed to create space relationship diagram. The alternative layouts are developed by considering space relationship diagram, modifying considerations, practical limitations.
3. Selecting phase. In this step, the best layout is evaluated.

This research also considered amusement arcade principals for arranging the facility layout. There are 10 principals, namely (LAI Games Top 10 FEC & Arcade Game Room Layout Tips 2017):

1. Your entrance
   The entrance should attract customers to step inside the venue. The entrance should be large and inviting. Position of new games will encourage customers to step inside. Games like music, dance, and drum must be placed in front to attract customers and onlookers.
2. Prize redemption counter or store
   A well-designed redemption store is the heart of the amusement arcade. It will impress customers with an exciting selection of prizes and increasing the chances they will share their visit on social media. The prize shelves should made of glass with LED lighting.
3. Use free flow floor plan
   Place tall games against walls to avoid blocking the line of sight across the game room. Games like basketball, car simulation, and sports should be grouped. Small game and large game should not be adjacent because customers do not feel too comfortable with a ball fly over their head.
4. Create themed areas
   The game area should have thematic design each category. Theming the venues will give customers a pleasure to play.
5. Use square footage wisely
   Try not to pack too much in the facility because it will make customers do not have enough room to comfortably move around the area. The space between games or often called by aisle should be 3-6 feet or about 90-180 cm to allow customers walk through even they are other customers playing on both sides.
6. Boost your kiosk's potential
   The location of self-service machines like balance check machine should be placed in front to the entrance so customers can locate it from afar.
7. Put some thought into the ambience
   Create the atmosphere that will make customers remain inside and keep playing. Make sure the room is bright to attract customers. The temperature must also be comfortable to customers.
8. Mix things up every so often
   Rearrange the layout periodically which the best result is every three months. Rearrangement game machines can create awareness and get a common customer to notice game they might have missed on previous visit even the game machines are not new.
9. Trash talk
   Many customers who throw litter on the floor. Put some trash can at some points where customers can see them anywhere.
10. Think outside the box
    Invite some colleagues to mystery shop the amusement arcade. The purpose is to get some honest feedback what things should be improved.

2.3. Facility Layout Algorithm

The facility layout planning is designed using Systematic Layout Planning concept (SLP) approach. The analyzing step is applied using the result of power Business Intelligence dashboard. Searching phase is conducted the interviews with staffs of an amusement arcade included the owner in order to know the expectation of the owner and the limitations in an amusement arcade. The four alternative layouts are developed also considering the 10 principals in point 2.2, as follows:

1. Group the game machines in each category.
2. Determine the rule-combination of game played in sequence from the highest to lowest count of rule.
3. Design the layout setting in sequence based on the rule.
4. Sort the game machines in each category from the highest to lowest revenue.

3. Results and Analysis

This facility layout design uses data from an amusement arcade. The data used for this research is three-month data. The data obtained is data each card so that data recapitulation process is needed first. This recapitulation then will be aggregated to make it easier in analyzing data.

3.1. Data Aggregation

These game machines will be categorized to age (toddler, teenage and both) and type based on discussion with the owner. Most of the game machines are for teenage (35 machines), and then for the toddler or teenage (21 machines). There are only 11 game machines for the toddler. The number of each age category is used for supporting the layout design based on age. The machines can be categories as simulation, physic, card, arcade, prize, gambling and kiddy ride games. In total there are seven types of machines. To collect the information, we aggregate the recorded data in times, days, the beginning of a month and the end of a month. In the beginning of a month, Indonesia's families tend to have leisure after they get a salary. While at the end of a month they tend to spare. Additionally, we also use the store layout theory to construct the proposed layouts.

3.2. Cleaning Data

Data taken from the amusement arcade are ID card, play transactions' order, game machines' name, machine ID, price each play, date and time of transaction. Data taken is in CSV format from each ID card. These data then recapitulated and processed with R-software. This software uses some codes such as sorting date, sum the revenue, etc. The cleaning data starts with analyzing what data that will be useful then it takes only some useful data from the raw data. The process is continued with coding in R-Software and export it to Excel form. This recapitulation will be used for the next process which is making the descriptive data.

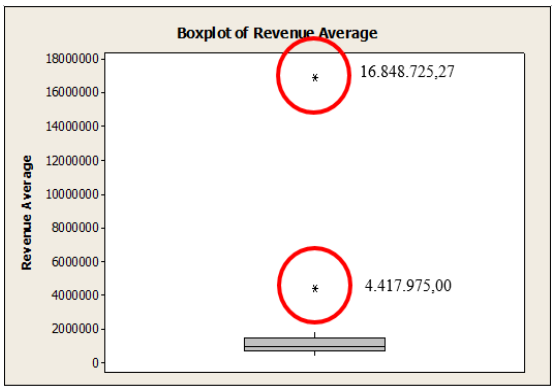

Figure 2. Outliers testing.

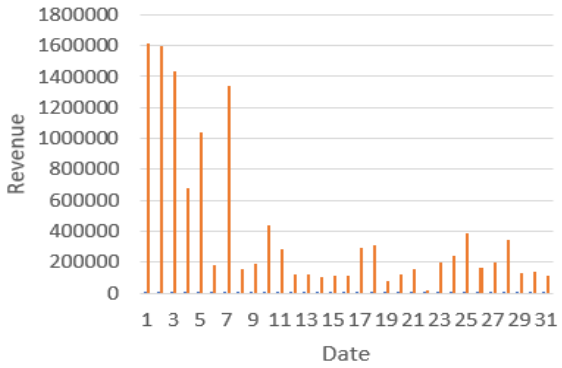

Figure 3. High and low evenues.

3.3. Descriptive Statistics

Data collection in this study was conducted using descriptive statistics to produce valuable data (data mining). The data mining process begins by categorizing based on the week from three-month data. The next step is testing whether the data contain outliers or not. The outliers testing can be seen in Figure 2.

These outliers will be deleted to see the play pattern because there were some games which are only played in those weeks. These outliers can't be used for design. These cleaned up data can be used for further processing such as showing dates with high and low revenues which can be seen in Figure 3.

The red-coloured rectangle shows high revenue only happened from the first day up to the seventh each month. It means from the 8th (besides the red-coloured rectangle) to the end of the month amusement arcade the revenue is low, i.e. the number of customers is also low. This statement is also supported by many games that have small income which can be seen in Figure 4.

There are 21 out of 63 games which have low revenue less than IDR 50.000,00 in three months. These game machines should be considered whether they need to be maintained or not. Besides, the customer behaviour should also be discovered.

3.4. Customer Description

The customers of the amusement arcade are teenagers and toddlers. Teenagers playing more frequent and contribute more revenue than toddlers. Simulation games are teenager favourite games, while kiddy ride games are the favourite of toddlers. Customers who come on weekday and weekend are dominated by teenagers and these teenagers mostly come in the evening.

3.5. Power Business Intelligence Dashboard

The contents of Power BI dashboard are transaction revenue that can be seen in some formats such as dates, weeks, months, and years. Revenue each game can also be seen in this dashboard. This dashboard also shows which game machines that are and not in demand. There is a diagram to showing transaction frequency movement each week. There are some slicers too which are used to see influence of age. These diagrams such as revenue each game will be used for layout rearrangement. This research dashboard can be seen in Figure 5.

This dashboard shows that only some games which are in demand such as WMT 5, Toy Box, and so on which are shown in picture "Percentage Game Played". This amusement arcade is only crowded at the beginning of the month from day one to the seventh. The most played game is the simulation games, followed by prize, gambling, kiddy ride, arcade, and card game. This dashboard also shows the frequency of game played movement each week. "Revenue of Transaction" shows the revenue of each game, while "Revenue" shows the revenue each week. "Total Revenue Day" shows the difference between days with high and low revenue in each day. "Average Revenue Dates" represents average revenue each date. The revenue each game categories is also shown in "Percentage Jenis Revenue", while "Percentage Game Played" shows the count of every game played in tree map form. "Game Played Movement" shows the movement for every week and "Total Revenue" shows the revenue of the data.

3.6. The Amusement Arcade Layout

The amusement arcade layout is mapped to see the initial condition. This initial condition is mapped based on real condition where each name of the game machine has a different number. Initial condition of the amusement arcade is shown in Figure 6.

Some of the same game machines have amount more than one so there is some same numbers. This layout uses a 30 cm x 30 cm scale for each tile. Game machines which are not in demand are marked with red rectangle. Game machines that are not in demand, are showed by Power BI in Figure 7.

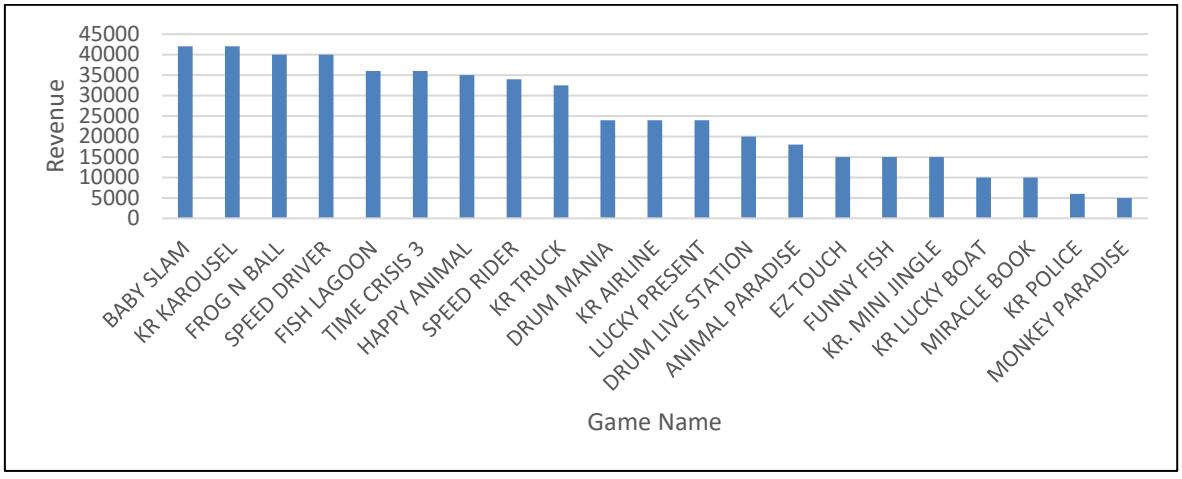

Figure 4. Bar chart with revenue less than IDR 50,000.00 in three months.

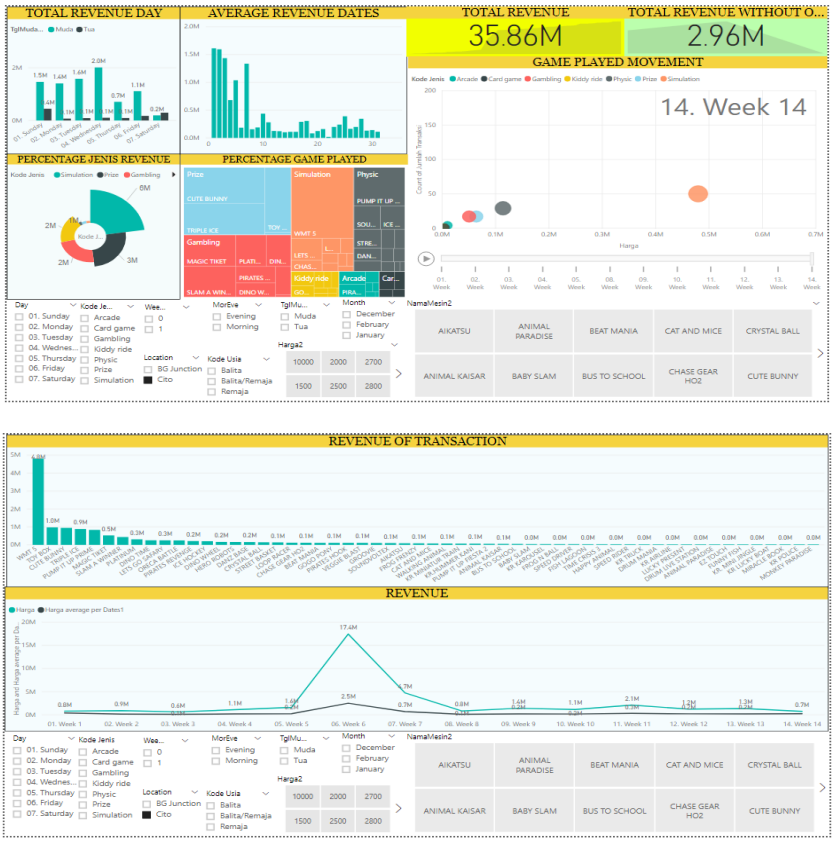

Figure 5. Amusement arcade dashboard.

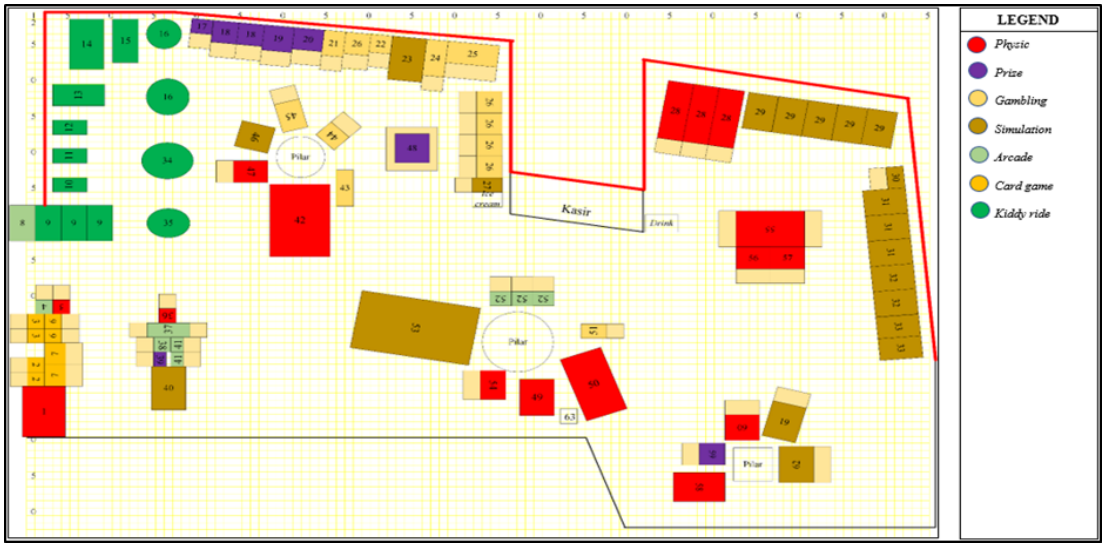

Figure 6. The amusement arcade initial layout.

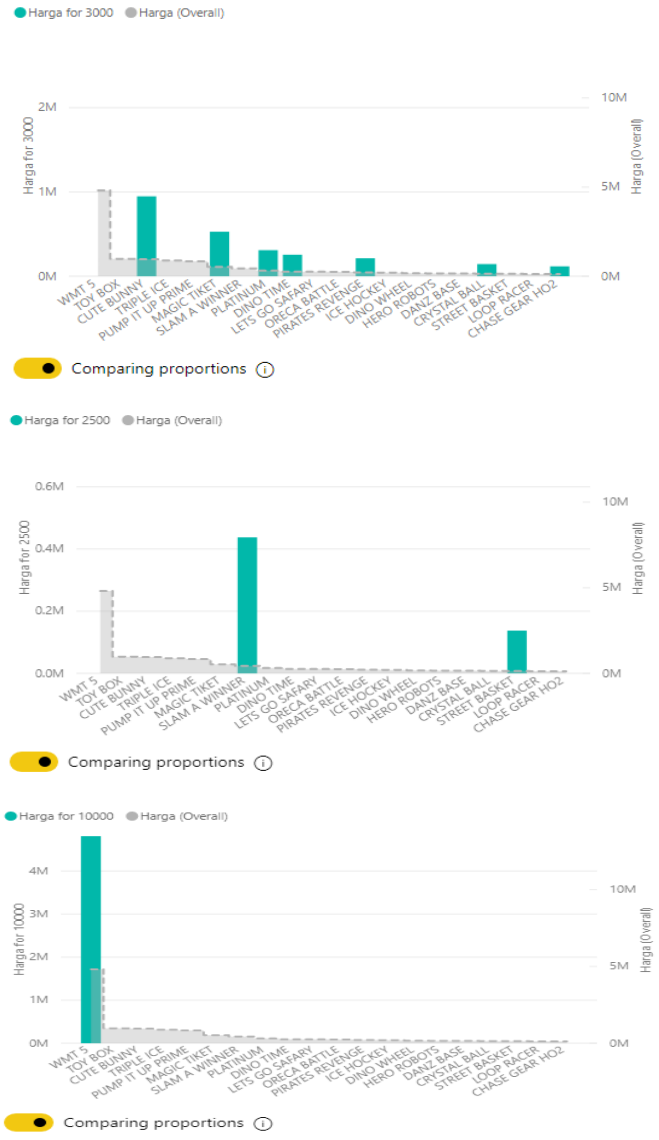

Figure 7. Games of the most affecting revenue for distribution.

Most of the customers (31.3%) played game which cost only IDR 3,000 per play, 15.7% customers played games which cost IDR 10,000, and 9.7% of them played the IDR 2,500 per play. These games are the only most affective frequency of the distribution whereas the others are not in demand because of their popularities. Popularities of games can be built with one of the ways by rearrange the layout, so these games can be seen easily by customers. This problem guides the need for this research based on this business intelligence, so it is expected to get the better layout that will lift the low sales games. Game machines' name and size can be seen in Table 1.

Teenager games are dominated by simulation game such as car simulation, toddler/teenager games by physic game like dance game, and toddler games by kiddy ride like carousel. The colours of each game category indicate the same colour in the layout. The next step is to propose the layout.

3.7. Amusement Arcade Proposed Layout

This research will propose an alternative layout considering Power BI principal. This layout has some limitations and considerations because there are some fixed facilities. Limitations and considerations of designing the layout can be seen in Table 2.

These fixed facilities can be moved if they fulfil those considerations like Pump It Up Prime (1), Pump It Up Fiesta 2 (42), Beat Mania (49), and Danz Base (50) should be placed in front based on "Your entrance" theory where the game will attract onlookers. It is expected that these onlookers will spend their money and play too. Game like KR (kiddy ride) should be placed in a large area due to area for spinning around. Speed Rider (53)

need to be put rather in rear so it will not block the view. There are also some game machines which have machines more than one for the same game must be placed adjacently. These game machines which follow that rules can be seen in Table 3.

Table 1. Machine names and category.

Cluster	Number position	Game category
Teenager	1,28,42,47,49,50,54,58,60	Physic
	17,18,18,20,39,59	Prize
	21,24,25,43,45	Gambling
	2,3,6,7	Card game
	38,41	Arcade
	23,29,30,31,32,33,46,53,61,62	Simulation
Toddler/Teenager	5,36,55,56,57	Physic
	48	Prize
	22,26,44,51	Gambling
	4,8,37,52	Arcade
	27,40	Simulation
Toddler	9,10,11,12,13,14,15,16,34,35	Kiddy ride

Table 2. Fixed facilities and considerations.

Num	Game Name	
1	Pump It Up Prime (1)	Dance to attract other customers
2	KR Karousel (16)	Need a rather large area
3	Street Basket (28)	Need to close to wall and safety of hit by ball
4	KR Miniatur Train (34)	Need a rather large area
5	KR Mini Jingle (35)	Need a rather large area
6	Pump It Up Fiesta 2 (42)	Dance to attract other customers
7	Beat Mania (49)	Music to attract other customers
8	Danz Base (50)	Dance to attract other customers
9	Speed Rider (53)	Need to be put rather in rear because motorcycle game has a large machine

Table 3. Game machines with side by side rule.

Num	Game Name	Game Number
1	Animal Kaisar	2
2	Hero Robots	3
3	Aikatsu	6
4	Oreca Battle	7
5	Gogo Pony	9
6	Toy Box	18
7	Slam a Winner	26
8	Street Basket	28
9	WMT 5	29
10	Asia Grand Prix and Fast Beat GT	30 & 31
11	Speed Driver	32
12	Chase Gear HO2	33
13	Ghost Capture	41
14	Monkey Paradise	52

Game like Animal Kaisar should be placed adjacently because they are a competition game. Game number 30 and 31 should be placed side by side because game number 30 is the card machine for game number 31. Several factors are considered in this proposed layout, as follows:

- For safety reasons, Sport game like Street Basket (28) will not be combined with other games.
- For boosting an amusement arcade, balance check machine must be placed in front of the entrance.
- For Aesthetic reasons
  Along wall pillars should be placed game machines with minimum aisle is 90 cm to prevent butt-brush effect.
- For Attracting the visitors
  Kiddy ride category must be placed in front of the entrance.

3.8. Proposed Layout

It is found that some categories such as arcade, kiddy ride, and card game are less in demand in every time and situation. It can be seen in Figure 8. It happens since those game machines are provided not based on play pattern. These categories need to be placed in a proper place. This current location of these categories like kiddy rides are located in the rear area. It has become one of the causes of lack of visitors. From the Power BI result, arcade and card game category should be placed in front area. But, since the limitation of entrance area, the owner should determine the machine games category that will be placed in front of the entrance for attracting the visitors. The owner decided that kiddy ride will be placed in front of the entrance to attract the visitors. Some attractive categories such as physic and simulation games are placed in front. The proposed layout can be seen in Figure 9. The machines in the same categories are shown in the same colours.

This layout is designed by adopting entrance sensational theory also besides Power BI. The design is done by juxtaposing the lowest revenue game machine from some category with the highest revenue game machine from other category. This design is expected to lift the low revenue game machine and create sustainable transactions. This proposal will sort game machine from the highest revenue to lowest revenue game machine in each category. The result show, Arcade and card game categories are placed behind due to limited area and the need of some attractive games to be placed in front as mentioned previously. Prize and gambling categories are placed in rear area to lure customers around passing less preferred games while looking for the preferred game. This proposal has some advantages and disadvantages, namely:

Advantages:

- Game machines which have lowest revenue each category may have more chance to be played because it is next to highest revenue game machine from other category where the initial layout game arrangement is random.
- Customers who like some category may know the other game from the same category because the game with same category are closer than the initial layout.
- Juxtaposition based on category means considering age category, so customers with the same age category will feel comfortable and will not be disturbed of age difference.
- Storefront will be more attractive because physic game is placed in front where it has the most support too, so it will attract customer to play a few games continuously.
- Butt-brush effect will not happen because the width of aisle is sufficient for customer movement.

Disadvantages:

- Some of the back of game machines like Speed Rider (53) and untidy electrical wires are visible so that reduces the aesthetics.
- There are some rules which can’t be fulfilled because there are higher supports from other rules (more important rules).

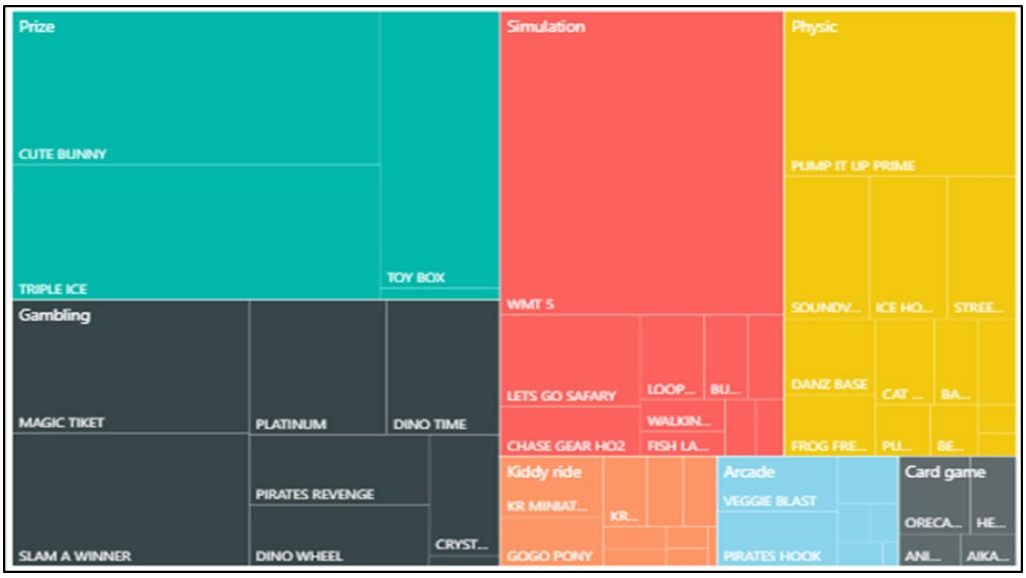

Figure 8. Game category which are not in demand.

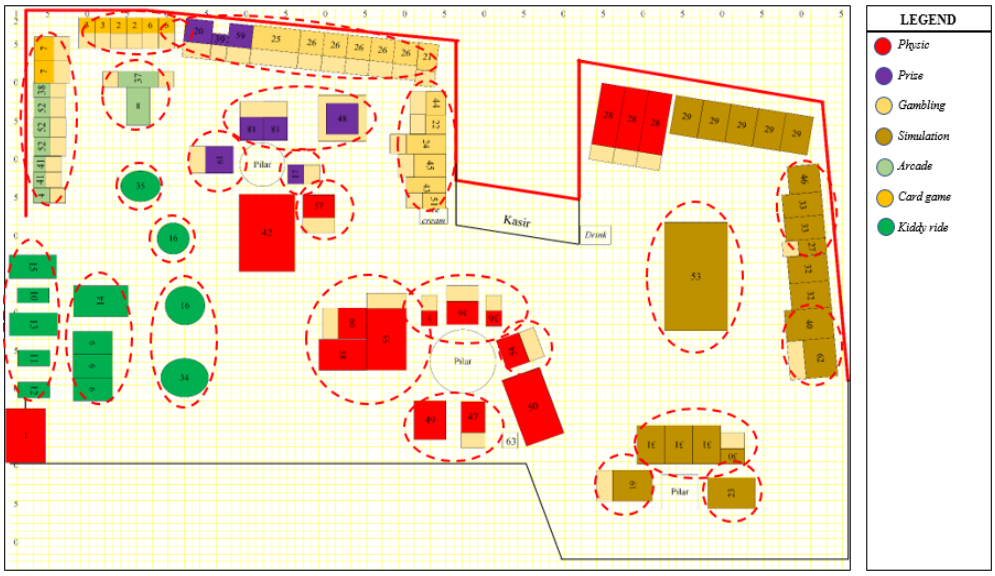

Figure 9. Proposed layout.

4. Conclusion

Designing an amusement Arcade layout is one of the important thing to increasing the customers. The associated an amusement arcade layout problem is people only tend to play in certain games. It impacts many rarely played game machines are to be idle. We present an alternative layout based on the play pattern with consideration of the store layout theory, adopting the entrance sensational theory, and the basis of Power BI. An alternative layout is designed by its category and age group. The Games are categorized into three clusters (teenagers, toddlers, both of them). The result shows 7 of 12 game categories mostly played by teenagers and only 1 game category played by toddlers. The proposed layout gives the more advantages in terms of revenues, the customer attractiveness, and safety reason.

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