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# Building a Low Cost, Good Quality and Safe Infinity Mirror Room for Suroboyo Night Carnival Amusement Park

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## ABSTRACT

Amusement parks have been growing rapidly in Indonesia in the past five years but they seem affordable only for the middle and higher classes of society. Surabaya in East Java has several amusement parks that cater for low budgets and they have good-quality equipment and are safe to use. The purpose of this research is to show the results of building a low-cost amusement park. The amusement park was built by a player in the amusement park industry in collaboration with the Computer Engineering Department of Bina Nusantara University. An infinity mirror room (IMR) was built in one of the new amusement parks in Surabaya called Suroboyo Night Carnival. The full design of the IMR is discussed in this paper including the equipment used in the design. The IMR mainly uses fibre optics, LED and a mirror. The amusement park began operation on July 28, 2013, and the amount spent on one room was around US$8,500. No safety breaches have been reported. The facility has been able to attract 500 visitors on average from 2013 to 2016. The breakeven point of this facility was achieved in the first year of operation.

*Keywords:* Amusement park, infinity mirror room, fibre optics, low-cost, Surabaya

## INTRODUCTION

According to Anand (1993), Clave (2007) and Milman (2010), entertainment is a human need. Amusement or theme parks provide pleasure for many (Nye, 1981; Lewi (2015), with many families flocking to visit them at weekends (Weinstein, 1992). This phenomenon is also true for Indonesia, a developing country. It has been observed that small amusement parks or trolley-parks that are less safe (Davis, 1996) have grown

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in number in many places especially in urban areas, where most families come from the low-income segment of society.

Understanding the need for low cost, good quality and safe amusement parks that can cater for lower-income families, one player in the amusement park industry collaborated with the Computer Engineering Department of Bina Nusantara University to study, research and build an infinity mirror room (IMR) (Applin, 2012; Cutler, 2017; Kusama, 2013) in Surabaya, East Java. The IMR is an entertainment room that uses lights, mirrors and illusion to create special effects for the entertainment of visitors. The IMR in Surabaya was built similar to the one built by Ripley in Pattaya, Thailand (R. E. Inc., 2011) and to Infinity Gold Coast, Australia (I. Ltd., 2000), but at a lower cost while maintaining high quality. Before the project was undertaken, full research was carried out to ensure that the IMR would be built based on these requirements: safe design, low cost and good effects.

A scalable IMR was developed by the Computer Engineering Department, Bina Nusantara University. The laboratory work was funded by Srimulia Indo Pertiwi Ltd. We studied the effectiveness of light propagation and its reflectivity before finally building the IMR in Surabaya. The selection of light source, fibre optics and materials for the mirror walls are discussed in this paper with the objective that any developing country may also build low-budget yet safe and high quality IMRs if so desired. The IMR, as one feature of the amusement park, which offered a science exhibition, children's playground, racing arena and wax museum, among its features, was to be a room using illusion conjured through the interplay of light, mirrors and fibre optics to provide entertainment for visitors.

Since the IMR involved the use of mirrors and fibre optics, safety was a crucial issue. Therefore, it was important to use products that were strong and durable. In addition, visitors would be asked to use gloves and socks when entering the room. Closed circuit televisions would also be mounted in key areas including the emergency exit routes.

## DESIGN AND IMPLEMENTATION

Our task was to build a dark chamber that could be used to create the illusion of infinity. We built a small mirror chamber measuring 40 cm × 40 cm × 40 cm that had holes drilled at random on one surface. Twenty strands of end-point fibre optics (Jeff, 2004) were attached in each hole and the total mirror surface covered with a vinyl sheet. The result can be seen in Figure 1. We were able to create an effect of stars sparkling in the deep space although lights were attached to only one side of the mirror as shown in Figure 2. The number of fibres to attach was a huge consideration in later implementations. The details can be seen in the block diagram of the experiment (see Figure 3).

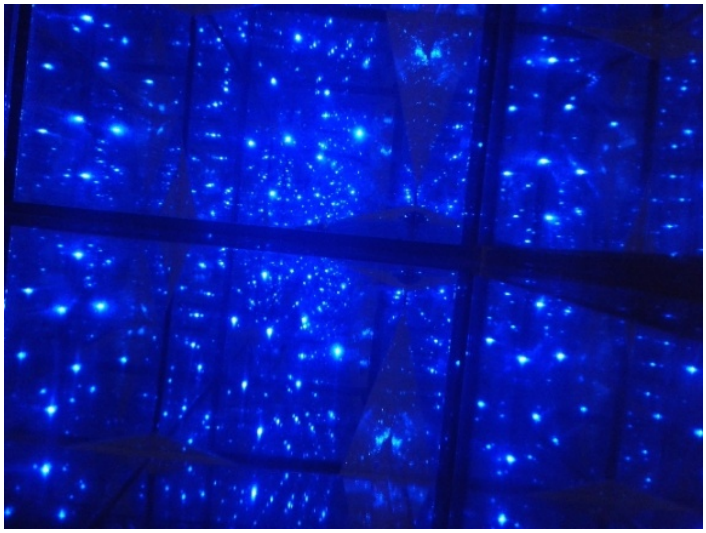


*Figure 1.* Infinity effect created in a mirror room

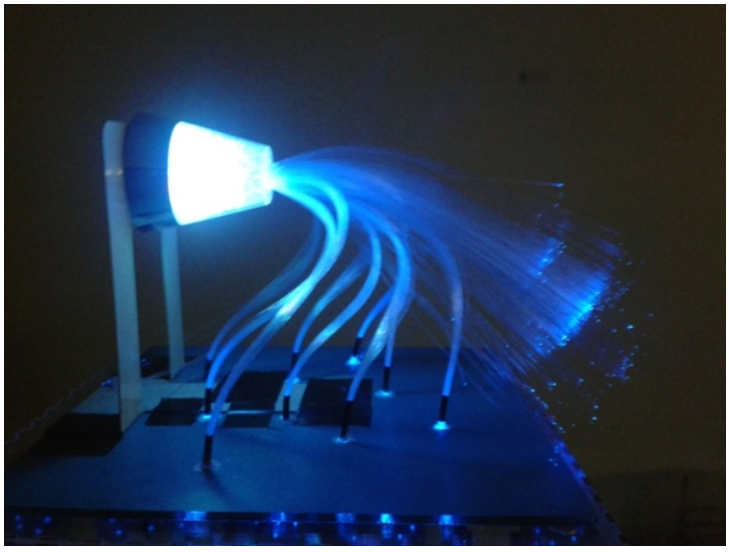


*Figure 2.* One side of the mirror chamber drilled and attached with 20 fibre optic strands per hole

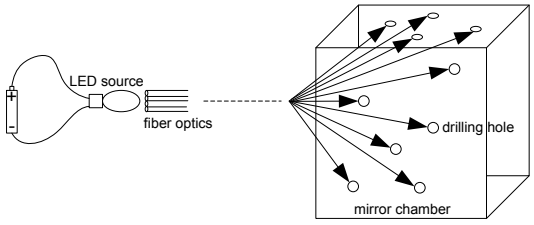



*Figure 3.* Block diagram of the experiment

In the early stage, we found that 5 mm hole was the smallest diameter that could be found in the Indonesian market. Thus, the number of fibre optic strands that should be filled in the hole had to be not less than 20 pieces. Due to this constraint, we chose a 2-mm acrylic mirror (Taylor, 1999) sheet so that we could drill holes that were 0.5 to 1 mm in diameter. The holes could be drilled in a specific pattern or in random design depending on the size of the mirror and how dense we wanted the light effect to be. Fibre optics imported from China, which came in small diameter sizes was used later in the actual chamber. The light source for the first experiment was a small LED powered by a 5-V battery, while the fibre optics were taken from children's toys and ornaments without detailed specification. Acrylic mirrors are safer than regular mirrors since they are not easily cracked in case of accidents. Its durability is due to the adhesive that holds the surface together.

Figure 4 is a map of the IMR. The infinity effect was focussed in the electron maze and star chamber room. The difference in the pattern of each room was determined by the name of the room. The electron maze room was designed to make people who entered the room feel like electrons were moving across the room, while the star chamber room was designed to show some of the constellations. However, the star chamber was only built later.

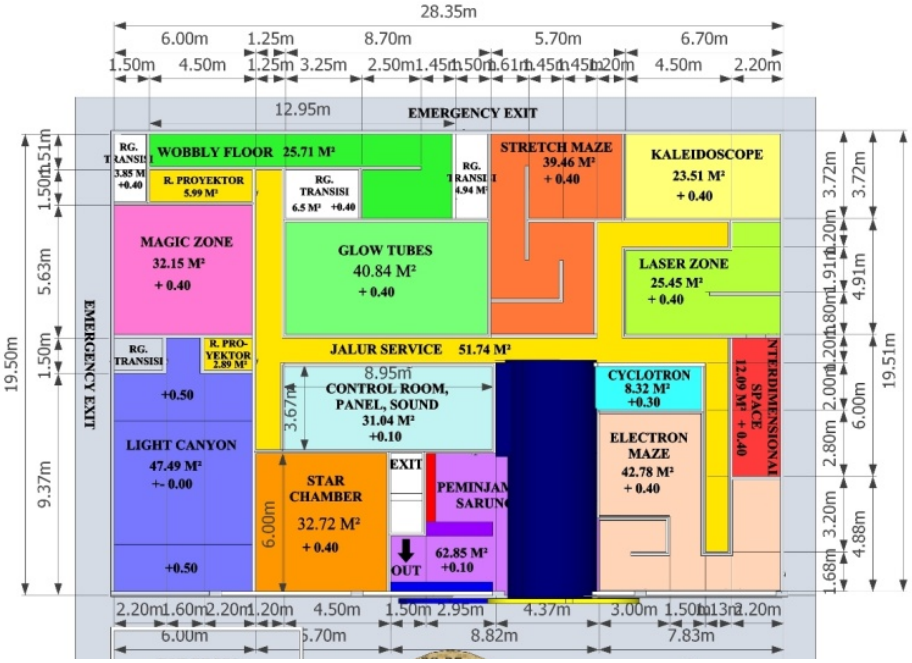



*Figure 4.* Infinity mirror room design

For additional safety, we applied tempered glass (USA Patent No. US 2177324 A, 1939) in front of the acrylic mirror so that visitors would not be in direct contact with the vinyl fibre optics or any other electric circuit exposed behind the mirror. We also used a tempered glass mirror for the floor so that a dramatic optic illusion of sparkling lights could be seen all around the room. As for the ceiling, we used an acrylic mirror sheet, which is lighter and more economical than using a tempered glass mirror (see Figure 5). These safety measures proved effective as no accidents were reported in the period 2013 to 2016 when the IMR was in operation. The mirror itself did not crack until the IMR was converted into a Kids' Play Station.

For the dramatic illusion of light, we used an LED fibre optic light engine, which produced a mix of red-green-blue colours and an end-side sparkling vinyl fibre optics. The items were supplied by a company in China; the quality of each item was good and the items were available at a lower cost. Building and instalment of the IMR took 3 months to complete.

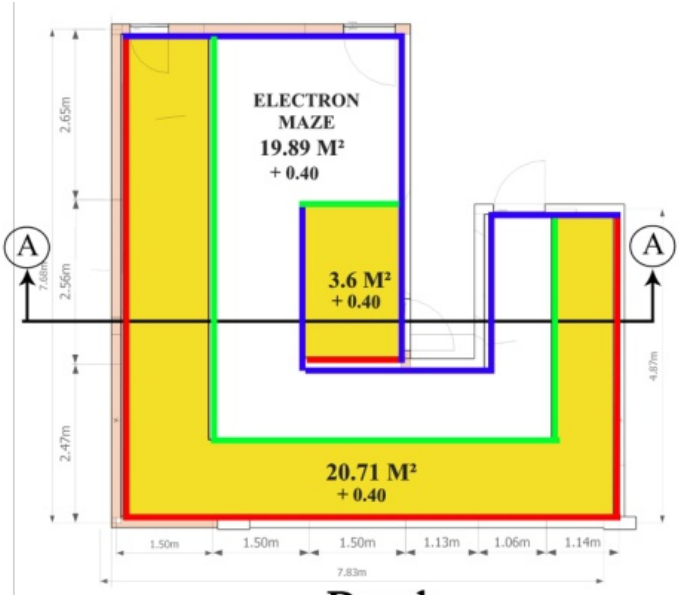



*Figure 5.* Detailed map of the electron maze chamber

## DISCUSSION

Before finally building the IMR and installing the apparatus, we ran many tests to study and fine-tune the intended effect. We expected the light that was reflected from one side of the acrylic mirror to be refracted (Crowell, 2012) due to the fact that the surface of the acrylic mirror was not exactly flat. When we first designed the fibre attachment on the back side of the mirror, we expected that the laser ray would be reflected in the possible path shown in Figure 6. However, due to the fact that the surface was not flat, we could not get a good reflection of the laser light in the electron maze chamber. This interfered with the intended optical illusion

effect of infinity. To solve this problem, the number of fibre optics placed in the mirror was increased and the distance between the holes was made to be less than 1 cm. Each hole was fit only with a single strand of the fibre optics as shown in Figure 7.

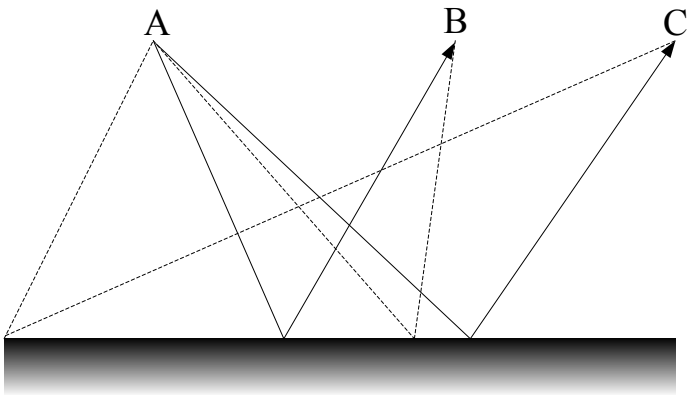
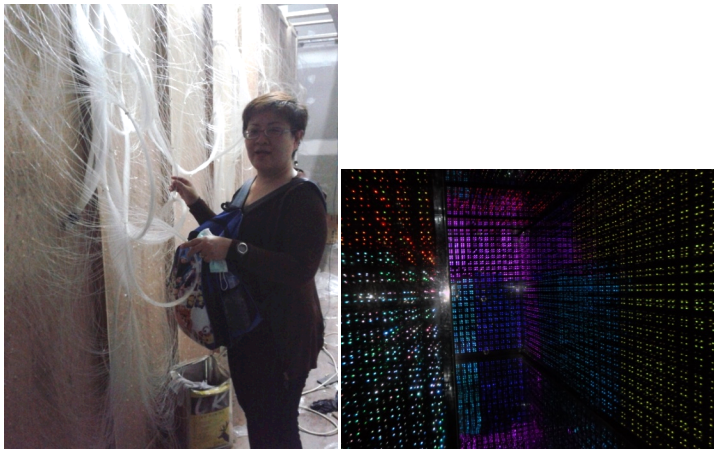



*Figure 6.* The solid lines are possible physical paths for light rays travelling from A to B or A to C (Crowell, 2012)

Although we had planted a great number of fibre optic strands in one mirror wall, numbering about 2,000 strands of fibre optics per each mirror wall of 2 m x 1 m, the reflection from the other side of the wall did not give as good an image as in our first experiment (see Figure 1). We used Side Sparking Fibre Optic, Mitsubishi fibre, 1250 pcs 4 m, 0.75 mm, 3 cm dots distance, connected by an engine connector. We also used an LED fibre optic light engine, six colours, with a remote controller, 220 V, UK plug as the light source. We found that the distance between the mirror planted with fibre optics and the two-way mirrors, which were placed parallel to one another, also played a crucial role, as shown in Table 1. Excellent reflection means that the reflection results were similar to those shown in Figure 1. The narrower the distance, the better the reflection we got. However, this condition could not be performed as the number of visitors entering the maze would have to be limited.

Table 1
*Distance between Two-Way Mirror Walls*

| No. | Distance Between Two-Way Mirror Walls | Reflection Quality |
|---|---|---|
| 1 | 2 metres | Poor/No reflection |
| 2 | 1.5 metres | Poor/No reflection |
| 3 | 1 metres | Fair |
| 4 | 0.8 metres | Good |
| 5 | 0.5 metres | Excellent |
| 6 | 0.4 metres | Excellent |
| 7 | 0.3 metres | Excellent |



(a) (b)

*Figure 7.* (a) Fibre optics instalment behind the electron maze chamber (b) front view of the instalment

From this we understood that a good reflection could be achieved by planting 10 to 20 strands of fibre optics in one hole as shown in Figure 2 and using flat mirrors for the wall instead of acrylic mirrors. The infinity effect rested on the flatness of the mirrors' surface. The distance between two mirrors was also an important consideration in generating good continual reflectivity as expected.

Air circulation also played an important role in this design. A centralised air conditioner was chosen for use but having a ceiling duct would reduce the optical illusion. A completely dark room enhances light travelling across it, making it starkly visible to the eyes. Therefore, we used a split air conditioner that was placed behind the acrylic mirror in the service area. Good air circulation would ensure long life for both the LED engine and he fibre optics. Since there was also a small space between the ceiling and the acrylic mirror sheet, air could flow easily to fill the chamber for the comfort of the visitors. The light engine produced attractive patterns of different colours.

The first budget estimation for this project was US$12,500 (US$1 = Rp. 10000,-) for the imported products we used. The price was considered high due to the purchase tax that we had to pay. We managed to source for good products at a lower price, and were able to bring the cost down to US$8,500. This was our biggest expense, due mainly to the use of tempered glass for the mirrors.

We looked forward to constructing a model of the star chamber, which would be designed to show some of the constellations on the walls of the chamber. The number of visitors who visited the IMR can be seen in Figure 8; the average number fell to 500 visitors per month in 2014. The IMR itself reached breakeven point in the first year, but the number of visitors to the amusement park started to decrease in 2015. At the beginning of 2016, the new management of Suroboyo Night Carnival decided to remodel 30% of the amusement park's facilities, including the IMR. Most of the acrylic mirrors and fibre optics were still used but the chamber was transformed into a Kids' Play Station.

Cheaper entrance tickets did play a role in attracting visitors in the beginning but perhaps the attraction of the display faded after a while. The data revealed that the IMR had visitors did not revisit the IMR more than twice; this was one of the reasons why the new management demolished the IMR and some other facilities as well. Amusement parks need to provide new attractions every three years to draw public interest. It was considered easy and economical to demolish the facilities and construct new ones because the cost was low and the attractions could reach breakeven point quick quickly.

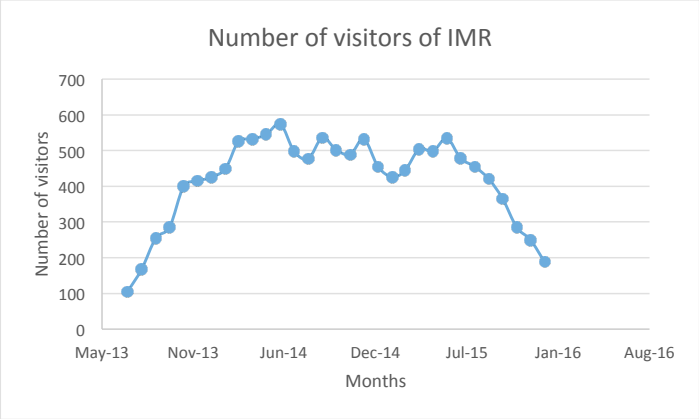



*Figure 8.* Number of visitors to the IMR

## CONCLUSION

This research was simple but its results have wide reaching implications. The prototype can be used for students of physics to study reflection of light in a mirror chamber. The IMR also provides an experience of space and light for teachers and students. It is also a useful study aid for students of art, design and architecture. We also learned that the flatness of a mirror as well as the distance between two mirrors play important roles in generating continued reflectivity. The light source and the darkness of the room are also important considerations. This qualitative research can also benefit other developing countries that might desire to build an IMR for their amusement parks as it provides an affordable model using good quality products that are also safe.

The IMR built in the Suroboyo Night Carnival Amusement Park was inside the Rumah Kinclong building, which was visited by an average of 500 visitors per week. The ticket price was only US$1, which is affordable for low-income families. The IMR was safe; no accidents were reported among visitors or workers. However, the IMR lost its appeal among the public after about three years. Visitors were not interested to visit it more than twice. To retain public interest in its offerings, the new management of the amusement park closed the IMR in 2016, converting it into a Kids' Play Station.

## ACKNOWLEDGEMENT

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