IMPROVING THE INFANT'S OR TODDLER'S SAFETY HELMET USING INDUSTRIAL ENGINEERING DESIGN TECHNIQUES

SIVANANTHA S/O CHANDRASEKARA PANDIAN

A project report submitted in partial fulfilment of the requirements for the award of the degree of Bachelor of Engineering (Hons) Industrial Engineering

Faculty of Engineering and Green Technology
Universiti Tunku Abdul Rahman

June 2015

DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

Signature : _____

Name : Sivanantha s/o Chandrasekara Pandian

ID No. : 09AGB01445

Date : 1st September 2015

APPROVAL FOR SUBMISSION

I certify that this project report entitled **"IMPROVING THE INFANT'S OR TODDLER'S SAFETY HELMET USING INDUSTRIAL ENGINEERING DESIGN TECHNIQUES"** was prepared by **SIVANANTHA A/L CHANDRASEKARA PANDIAN** has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of Engineering (Hons) Industrial Engineering at Universiti Tunku Abdul Rahman.

Approved by,

Signature : _____

Supervisor : Mr. Khoo Sze Wei

Date : _____

Specially dedicated to

my beloved parents, family, friends and lecturers

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ABSTRACT

For many beings, learning to walk in a world of hard surfaces can turn a special moment into a heart rendering incident in a flash. But now toddlers have better protection with a step further to secure their head. Subsequently, the aim of this study was to assess the infant's or toddler's safety helmet and to aid redesigning the improvements on the safety helmet based on several designing techniques of industrial engineering. Further designing of the improvements made on the safety helmet was carried out using the AutoCAD and solid works where else a 3D printer was used to print out the chin guard and mouth guard. A list of vital designing methods needs to be accomplished in order to get a better perspective on what the customer really needs concerning the safety helmet for the infants or toddlers. Beginning with survey then observing the users later signifying objective tree method and last of all house of quality. Once these methods were completed, the designing processes of the improvements made on the toddler's safety helmet were started based on the requirements and results obtained from the design methods carried out. Over and done with that, the chin guard, mouth guard, a knob at the end of the chin strap and straps on top of the helmet were upgraded on the safety helmet. Above these expansions, the infant's or toddler's safety helmet can further protect the user effectively and efficiently with no further injuries.

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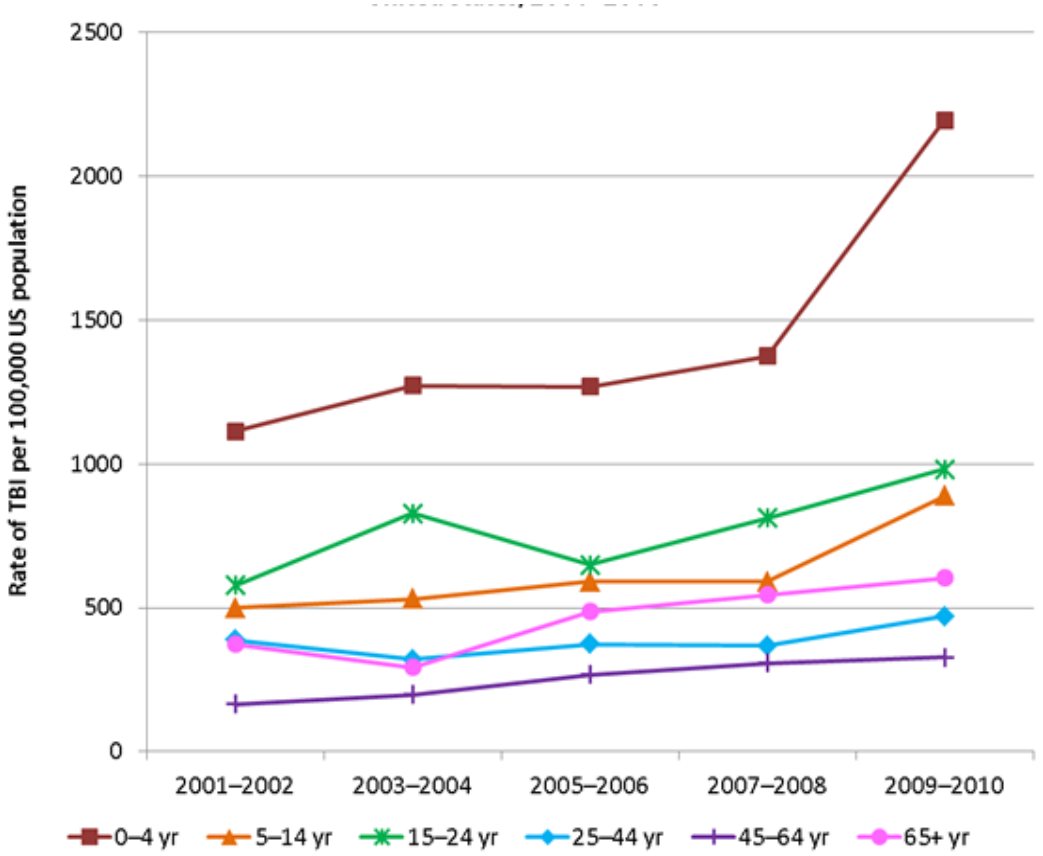
CHAPTER 1

INTRODUCTION

1.0 Introduction

In this fast developing era, it is always unpredictable when, where, to whom and how accidents might occur but the consequence of it might cause injuries of various severity or even death. According to the data collected by the U.S Centres for Disease Control and Prevention (CDC), traumatic brain injury (TBI) is one of the most suffered injuries among the people in United States. In addition, a research was carried out to study the number of visits into the emergency departments by different age group to reflect the age group that are prone to injuries in United States (U.S). The results of the research show that the recorded cases for the visits to the emergency department was the highest for kids below 4 years old, approximately twice the toll of the next highest group (CDC, 2001). This is because the kids below 4 years old are generally weak and active in this period of time and they need special attention as they will be getting used to the surroundings after getting up to their feet. The Fig. 1.1 shows the rates of TBI related emergency department visits by different age group in United States from the year 2001 until 2010.



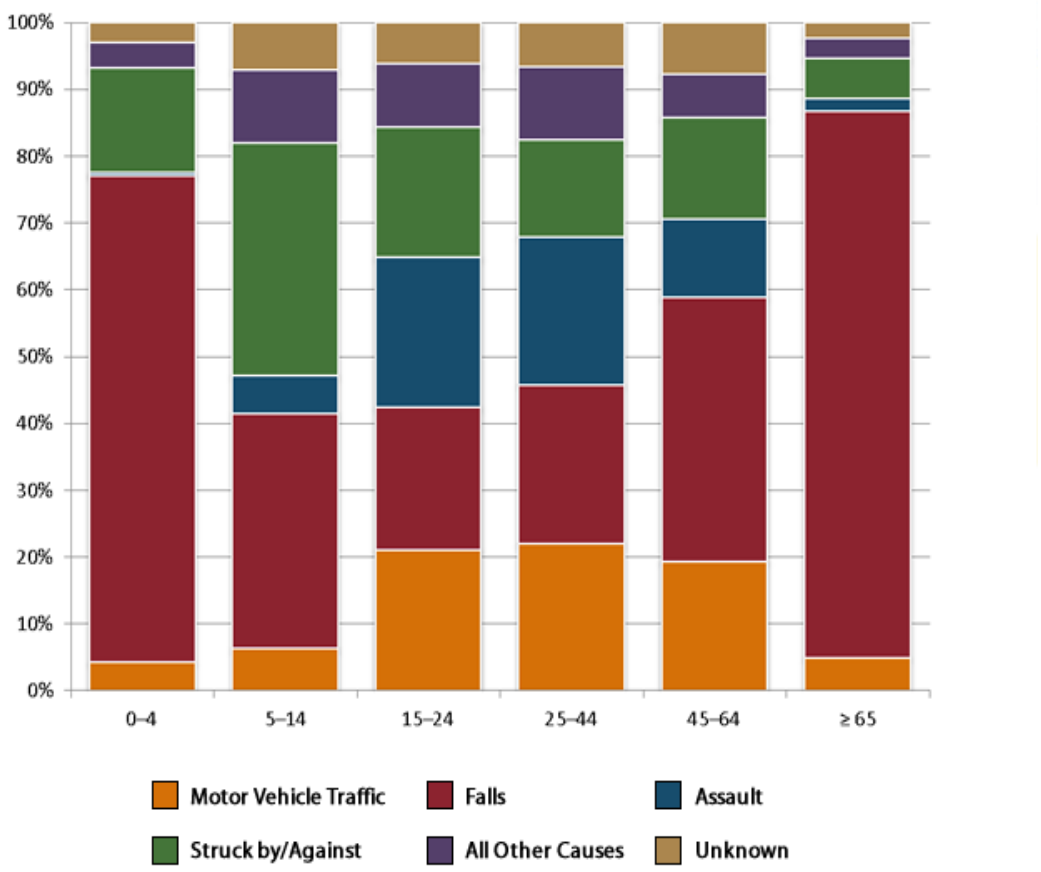
	0–4 yr	5–14 yr	15–24 yr	25–44 yr	45–64 yr	65+ yr
2001–2002	1112.6	498.8	576.9	388.3	164.8	373.1
2003–2004	1272.3	529.8	827.5	320.3	197.3	293.3
2005–2006	1268.3	591.4	648.3	373.0	267.0	485.8
2007–2008	1374.0	590.2	811.3	366.7	307.4	544.7
2009–2010	2193.8	888.7	981.9	470.0	328.2	603.3

Source: National Hospital Ambulatory Medical Care Survey

Figure 1.1: Rates of TBI related emergency department visits by different age group in United States, 2001 – 2010

CDC also conducted a study on the relationship between the number of emergency department's cases by different age group and the injury mechanism in United States (U.S). According to the data collected on the research, fall was the highest injury mechanism which has a staggering 781,389 cases (CDC, 2006). Amongst all these cases by fall, the group aged 0 to 4 years old and more than 65 years old people are mostly affected accounting for 72.8% and 81.8% respectively.

Both of these groups have something in common that is their bones tends to be soft when they are at this particular ages which contributes to this situation where they are very prone to injuries through fall. Figure 1.2 reveals the percent distribution of TBI related emergency department cases by different age group and the injury mechanism in United States from the years between 2006 until 2010.



	Motor Vehicle Traffic	Falls	Assault	Struck by/Against	All Other Causes	Unknown
0–4	14,655	250,413	1,513	53,761	13,222	10,225
5–14	18,110	101,790	16,612	101,112	31,355	20,763
15–24	76,602	77,951	81,822	71,031	34,486	22,722
25–44	75,122	80,867	75,527	49,505	36,933	22,855
45–64	46,923	95,824	28,206	36,925	15,843	18,804
≥ 65	10,359	174,544	4,068	12,815	6,285	5,216

Source: National Hospital Ambulatory Medical Care Survey

Figure 1.2: Percent Distribution of TBI related emergency department visits by different age group and the injury mechanism in United States, 2006 - 2010

From the data collected by CDC, there is a need to reduce the number of head injuries suffer by the kids below 4 years old. Currently, there is a safety helmet which satisfies the toddler's needs but there are certain elements of it can be improved so that it can fulfil the objectives of preventing head injuries to the toddlers efficiently. Safety helmet for infants or toddlers is designed to protect their head by absorbing and lessening the impact of falls, avoid bruises and bumps and minimizes the chances of serious head injuries while they learn to walk themselves. Therefore, this toddler's safety helmet is a type of lightweight head protection hat that is designed for kids to keep them safe until they are up to their feet (Emily Clark, 2008).

In this study, the industrial engineering design techniques play a very important role in improving the toddlers or infants safety helmet. The process of engineering design is a series of steps an engineer follows to come up with a solution for a particular problem. The solutions usually engage designing a product; in this case toddler's safety helmet, that meets definite criteria and completes certain task. The general steps in the engineering design process is to analyse the research background, define the problem, specify requirements, brainstorm solutions, choose the best solution, development work on the solutions must be done and redesign the existing prototype. The method of working in this designing process is called iteration where engineers normally would not always follow the steps in order, one after another (Science Buddies, 2002).

1.1 Problem Statement

Toddler's safety helmet is an efficient design in preventing the head injuries suffered by infants or toddlers. This invention has managed to reduce the number of injury cases in many hospital's accident and emergency department. However, there might be a few limitations that would contribute for a better room for improvement of the product.

There are some other body parts around the head of a toddler that are injury prone when they fall down such as their face and chin. Toddlers also suffer chocking caused by toys where they have the habit to put things that are in their hand while playing (Abraham, Gaw, Chounthirath & Smith, 2015). So, this safety helmet should also be improved to give further protection to these regions as well.

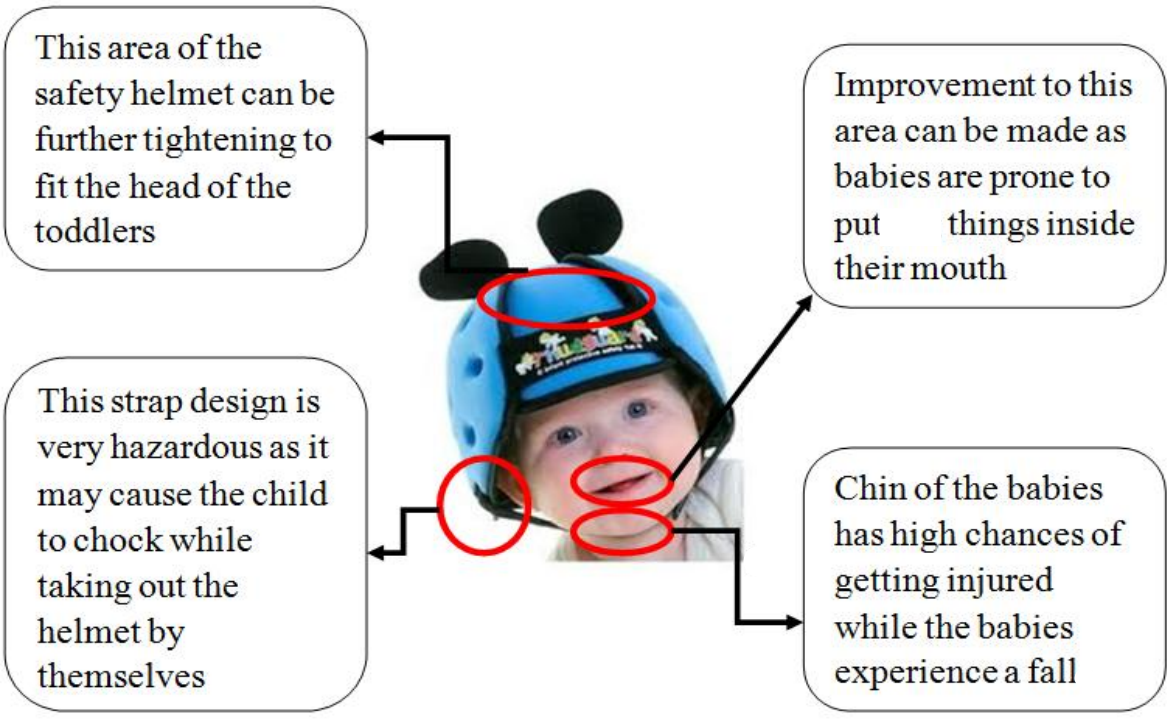


Figure 1.3: Figure showing the areas to be considered for improvement

Moreover, this safety helmet is a useful invention for toddlers for all around the world to prevent injuries but the availability of this helmet is mostly in overseas and there are none for sale in Malaysia. Even though, the product can be bought online, it is a very sad as there is a lack of urges to sell the product directly in Malaysia. It should be either due to very less awareness of the existence of this safety helmet among the people in Malaysia or there could be other factors such as price of the product that contributing to this scenario. Parents might feel that this existing safety helmet does not justify its functions fully according to its value.

Nevertheless, this safety helmet is a useful creation for toddlers and this product should be available throughout the world for the safety of the kids who are the future of the next generation. So, this study is conducted to discover the reason behind this situation and improve the safety helmet for toddlers according to their needs in order to give the protection and satisfaction that is desired by the user.

1.2 Objectives

The usage of safety helmet for children in overseas are very huge compared to people using it in Malaysia. It is not that accidents rarely happen in Malaysia, it does but there must be a reason why parents are not using the safety helmet for their toddlers which would save them from suffering serious head injuries. It is essential to study the feasibility of the infants or toddler's safety helmet in Malaysia so that the number of head injuries suffered by the toddlers in Malaysia can be reduced. Other than that, there are certain aspects of this helmet need to be improved such as mouth guard to prevent choking and chin guard to prevent injuries to the chin. Therefore, the objectives for this study are:-

a) To study the feasibility of the infants or toddlers safety helmet in Malaysia
b) To redesign the infants or toddlers safety helmet by adding additional safety precaution gadgets using the Industrial Engineering Design Techniques

1.3 Scope of study

In the previous studies, researches were concerned on the injuries suffered by the children of various age groups and the precautions that need to be taken by parents to prevent their children from getting hurt. There was also emphasis on the invention of bicycle safety helmet for outdoor activities to prevent head injuries while cycling. However, limited researches have been carried out on the study of the safety helmet for kids aged from a few months old to three years old, to prevent unintentional injuries such as fall while they were getting up on their feet. Currently, there is only one type of safety helmet for this purpose in the market and further improvement can be made to the safety helmet using the industrial engineering design techniques. Testing of the improved prototype is not covered in this research due to lack of facilities and equipments to carry out the testing processes. So, this study is focused in redesigning a safety helmet that has many functions and utilises its value to the maximum while taking into consideration all constrains and also satisfying the need of customers.

1.4 Outline of study

This part is generally to introduce the study topic and present a brief review on the study of improving the safety helmet for toddlers. The summary for outline of study contains of total five chapters which are introduction, literature review, research methodology, research results and lastly discussion and conclusion.

Chapter 1: Introduction

This chapter will illustrate on research background about the injury in general and move to a more specific injury; head injuries in general to head injuries suffered by kids below 4 years old and the invention of safety helmet to prevent it, research problem, research objectives, scope of study and the outline of the study.

Chapter 2: Literature Review

In chapter two, the history of the safety helmet and the theory of the safety helmet would be discussed. Critical review of literature would also be done in this chapter where articles are read to offer additional understanding on the field of study.

Chapter 3: Research Methodology

In this chapter, the procedures are explained more in detail. The design techniques of industrial engineering are elaborated on how they are related to this study.

Chapter 4: Research Results and Discussion

The results of the project will be discussed in this chapter where all the data including pie charts and figures will be showed. Besides that, discussions will also be explained in this chapter.

Chapter 5: Recommendation and Conclusion

In this final chapter, recommendation for future researches and the conclusion of the overall study will be explained.

CHAPTER 2

LITERATURE REVEIW

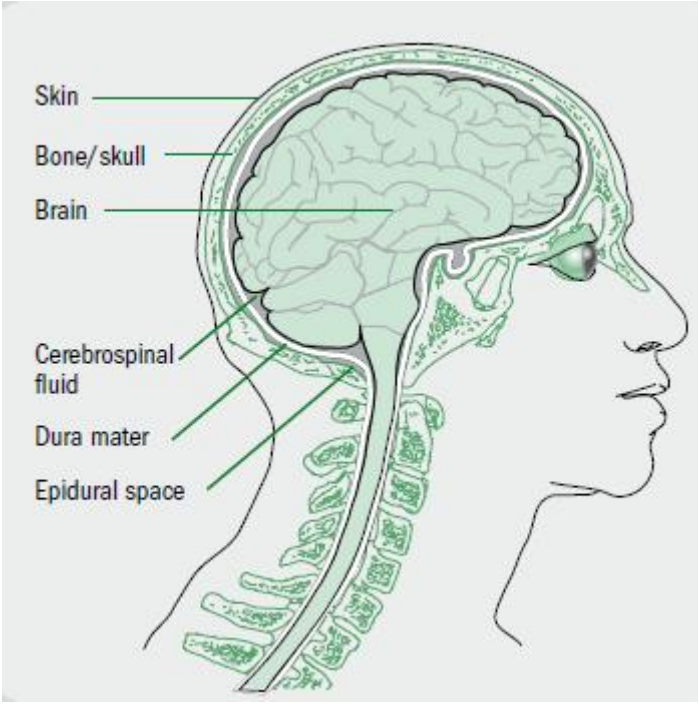
2.0 Overview

In this chapter, the literatures are separated into 4 parts in which the historical background of the safety helmet, limitations of the helmets, development of the toddler's safety helmet and finally the 3D printing and its applications are presented.

2.1 Historical Background of Safety Helmet

Nowadays, it is very common for injuries to happen especially unintentional injuries which are the chief cause of morbidity and death among kids in United States. Every year, 12,175 children aged in between 0 -19 years old in U.S die on average and approximately, estimated a total of 9.2 million children undergo emergency department visits due to this unintentional injuries. Falls were the leading cause for nonfatal injuries and injuries suffered from transportation were the most important reason of death for children (Borse, GilChrist, Dellinger, Rudd, Ballesteros & Sleet, 2008). Both these injuries have a connection indirectly to the head of a human being. In European countries, 75% of death cases among cycle and motorcycles users are contributed by the injuries to the head (World Health Organization, 2006).

The knowledge on the head's anatomy is very important in understanding the mechanism of injuries to the head and brain. A rigid skull holds the brain through the bones at the base of the skull and the spinal cord is connected to the brain through a hole underside of the brain. Adhering to the bones, Dura which is a tough tissue surrounds the brain under the skull and between the brain and dura, there is a space occupied by cerebrospinal fluid to protect the brain tissues from suffering mechanical shocks. The cerebrospinal fluid makes the brain to float but only moves in the range of 1 millimetre in any direction and finally, the skull is covered by scalp to provide extra protection (World Health Organization, 2006). Figure 2.1 shows the structure of the head and brain.



Source: World Health Organization, 2006

Figure 2.1: Structure of the head and the brain

Head injuries are classified into external and internal categories (Singh & Stock, 2006). Scalp injuries are a type of external head injuries and involve the brain, skull and the blood vessels within the skull. This external head injury is not as threatening as internal head injury as the skull operates as the shield for the brain. A hard knock to the head would hit the brain to the side of the skull or slash the blood

vessels and injure the brain even though the brain is cushioned by cerebrospinal fluid and its effects could be life threatening (Da Dalt et al., 2006). There are many types of head injuries and each type has its own level of concern. A loss of consciousness (LOC) is an indicator that the child has suffered a serious head injury. When the brain moves within dispatch of the skull due to blunt force suffered by the head is called concussion (Purcell & Carson, 2008).

Therefore, The Injury Prevention Program (TIPP) was created in 1983 especially for children from birth to the age of 4 years old by the American Academy of Pediatrics (AAP) after recognizing the importance of injury prevention. It is a program to counsel both the parents and the children regarding safety by providing a systematic approach for paediatricians (Sangvai, Cipriani, Colborn & Wald, 2007). Other than that, bicycle helmet legislation is also done to avoid head injuries. 88% of severe brain injuries could be prohibited by the usage of bicycle helmet based on an early study (Thompson, Rivara & Thompson, 1989). The first safety helmet was granted as ordinance in Howard County, Maryland following the death of two schoolmates cycling without helmets within 9 months of one another (Scheidt, Wilson & Stern, 1992).

The main aim of a helmet is to reduce the impact of the collision to the head. Its functions are to lessen the deceleration of the skull and consequently the movement of the brain by the usage of the soft material inside the helmet which will absorb the impact to the head. Other than that, the helmet spreads the forces of the impact to a greater surface area which will not allow the impact to concentrate to a particular area of the skull. Last but not least, a helmet also acts as a mechanical barrier between the head and brain to prevent direct contact between the skull and the impacting object (World Health Organization, 2006).

A deeper knowledge on the mechanism of the helmet is very vital in understanding how it actually works to protect the head from injuries. A helmet is generally designed to handle main crash energy through a layer of crushable foam. The crushable foam will crush when the helmet fall and hit a hard surface while controlling the crash energy and extending the head’s stopping time by about six thousandths of a second (6ms). This is to decrease the peak shock to the brain as well

as rotational forces and internal strains in our brain. The thickness of the foam is very important. The thicker the foam, better it is to the head giving more space and milliseconds to stop but if the foam is very thick, the helmet will probably not be optimal as the outer circumference of the head will be in effect extended. This leads to jerk the head more and contribute strain on the neck and rotational forces on the brain (Helmet Safety Institute, 2015).

Squishy fitting pads inside the helmet are for comfort of the user and not for handling impacts. The foam bottoms out immediately if the impact is very hard. A smooth plastic skin in most helmets embraces the foam together when it crashes and helps it to skid simply on the collided surface without jerking the brain to stop. The strap on the helmet holds the helmet to the head during a fall sequence. To remain covered after suffering a crash, the helmet must be fitted well and be level on the head fully. There are also helmets designed for lesser impacts which would not have foam inside it. Where else, some safety helmets are just hard shells with a suspension headband which gives some space for air circulation inside. So, diverse sort of helmets seem identical to most users and the impact protection test cannot be conducted unless the users have a lab and willing to destroy the helmet. Hence, standards are used by the industry to delegate the performance levels of the safety helmet (Helmet Safety Institute, 2015).

Standards classify laboratory test on helmets depending on the purpose of the helmet. For instance, a helmet provides impact protection if it passes the test for a sport or an activity and different type of helmet for different uses has its own test specification. A classic standard declares impact test, characteristics of material to be used, strap test, labelling, required coverage and etc. These standards are usually developed and published by various standards-setting organizations such as American Society for Testing and Materials (ASTM), National Operating Committee for Sports and Athletic Equipment (NOCSAE) and many more (Helmet Safety Institute, 2015).

In most standards, there are various types of tests being conducted. The most important testing is the impact testing. The typical equipment for this test consists of a rig which drops a helmeted head form in a freefall that is guided to an anvil on the

floor. The helmet will be strapped on the head form and it is turned upside down in order the helmet to hit the anvil first and drop it onto the anvil. To test the vulnerable area of the helmet, the change in orientation of the helmet is very important before each drop. The variables for this test are the height, shape of the anvil and how much shock the head form suffers registered by the instruments inside the head form. The unit of measurement is usually g, for gravity. A guided freefall is used due to the complete uniform nature of the gravity everywhere and therefore, the velocity of the helmet is also uniform just before impact. Some other types of test being carried out by some standards are dropping a weight on a stationary helmet for impact testing and for penetration test; a sharp object is dropped in a directed fall to strike the helmet shell. Other than that, testing involving hot, cold, wet helmets and also those at ambient room temperature is important. Foams are badly exaggerated by heat, harden in cold or even absorb water and lose their effectiveness as water does not compress. Other testing is for the strap of the helmet. The strap must not release and must not stretch when a load is applied on the strap (Helmet Safety Institute, 2015).

2.2 Limitations of the Safety Helmet

It is true that safety helmets do protect the head and reduce the numbers of head and brain injuries. However, there are certain limitations that reduce the effectiveness of the helmet to carry out its functions to its maximum capacity. For a helmet that is being used for cycling, nothing can be more relevant than the actual situation on the street which increases the risk of accidents or injuries to the cyclist. The helmet does not actually protect the cyclist given the increased risk which overestimates the effectiveness of the helmet. This is based on best possible use of the helmet in an ideal environment where all kind of foreseeable misuse and noise in reality plays a role in this case. There are some factors that support this situation such as a lot of cyclist does not wear their helmets correctly and a research in Australia shows most cyclist wear helmets that are too big and does not fit their head correctly and the helmet used might have experience impacts before which lessen their quality (Zeegers, 2011). Besides, hot and humid conditions play a role in preventing the usage of helmet due to thermal discomfort. These situations are likely faced by the

construction workers and forest workers (Davis, Edmisten, Thomas, Rummer & Pascoe, 2000). These are only some of the limitations that the helmets have that prevent it to be fully effective and this can also be related to the safety helmet for toddlers.

2.3 The Development of the Toddlers Safety Helmet

The Thud Guard predates to 1998 for its invention to take place. The inventor of this safety helmet is Kelly Forsyth-Gibson, who was born and lives in Aberdeen, Scotland. Kelly is a mother of three kids and when the inventor's youngest child was one year old and learning to walk, the toddler fell and bumped on the floor. So, the inventor went to search for a lightweight safety hat that was attractive and pleasurable for the child but it was unsuccessful. The children suffered from more bump and bruises as the toddler become more active but there was none of the safety helmet that the inventor was looking for, so Kelly invented one by herself (Emily Clark, 2008). The helmet that Kelly designed was lightweight, attractive to children, guards the head, comfortable for the children and only available in one size which covers the age group of approximately 7 months to 2 years plus of age (Thudguard, 2010).

The Thud Guard is classified as the lightest head safety helmet in the world. It weighs less than 100 grams and it has holes all around the helmet for air ventilation. Thud Guard is made by using high collision absorption foam moulded from ultra high density foam which gives a greater protection. This safety helmet provides cushion for the forehead, side and back of the head of the toddlers. This cushion is made of ultra lightweight high density foam and medium weight, soft-spun poly / lycra. The helmet is perfect for stretching and maintains the shape permitting it to be very durable and easily kept clean due to the material used. It also provides a pre-curved, supreme comfort and flexibility for a further personal fit consent to energy absorption and added comfort (Kidsafetyhats, n.d).

This safety helmet is the only baby head protector that act in accordance with a written impact test specification. It obeys the Department of Trade & Industry Directive Personal Protective Equipment (DTI PPE Category II (89/686/EEC) and also the SGS Testing (BSEN71 / 2 & 3) for flammability test, antibacterial test and chemical test. Besides, a leading international test house tested the Thud Guard on a variety of replicated impacts against anvils representing door edges, patio slabs, round corners and pavement kerbs before giving certification to the product (Thudguard, 2010). Furthermore, Thud Guard was approved due to the elimination of the necessity for small, medium and large head sizing for a pre determined age group through its designing of the safety helmet. This is due to a stretchy circumference band which allows the head growth in the range of 16 inches to 20 inches and at the same time still giving tested and certified impact protection to the head (Kidsafetyhats, n.d).

Even though parents do take a good care of their toddlers, the parents would not be there to supervise their children continuously from falling down. At least now, there would be an option for the parents to reduce the severity of the head injuries and also minimize the workload of many accident and emergency units. In fact, Kelly's invention is shrinking the national child accidents statistics; at the mean time making the toddle's learning process to walk a lot safer and fun.

2.4 3D printing technologies

3D printing is a popular additive manufacturing technique to manufacture a product according to its specifications by adding material layer by layer and it can fabricate more complex design as well (Bowden, 2014). The 3D printer applications have a very wide range of scope and one of its applications is in the modelling skill enhancement where students with the 3D printer will be able to use the software to print out the product and recognize their errors easily. Another application of this 3D printer is in the field of mechanics which will be very useful to print many types of screws, gears and other small gadgets or machines (Moorefield-Lang, 2012).

In 1980s, additive manufacturing were used directly from a digital CAD to produce 3D objects and the objects were made of polymers only. Besides that, additive manufacturing are also used to create arbitrarily geometric objects. It is also known as a rapid prototyping due to its usage of visualizing models and produce prototypes (Alaa Elwany, 2014). Industrial engineers have the skills to monitor a process and optimize the time and cost of the product which helps in improving the part being produced.

The application of 3D printing for producing physical models of paediatric orthopaedic disorders where the rationale of carrying out this research was to improve the understanding of anatomy and pathology to the orthopaedic disorders patients. Both the surgeons and patients get the benefit through this tactile and visual experience of 3D printing by complementing the images being displayed on the computer monitor. Rapid prototyping is a long process that carried out until the required object is created where a machine puts down the material layer by layer to create the object. Other than that, printer selection, printer parameters, material parameters, model orientation, software and pre-processing are some of the prominent features to be concerned in the 3D printing (Zbigniew, 2013).

This 3D application for creating physical models of paediatric orthopaedic disorders has a limitation where it is only accessible in a few revolutionary machine shops and the printers are expensive. A 3D print scale provides a tactile and visual experience on how the human's visua-haptic inputs leads to less ambiguity in the understanding of the shape of an object (Cooke, 2007). In conclusion, 3D applications do have advantages towards the patients which are over the conventional volume rendering on a 3D workstation for surgical planning and patient education.

Next, mechanism that involved in laser additive manufacturing are metal and fabricated polymer. The laser additive manufacturing (LAM) is becoming very popular among the jewellery and dental implants companies who are competing among themselves to enhance the functional coherence of more sophisticated laser additive manufacturing components (Overton, 2013). The Global Industry Analyst (GIA; San Jose, CA) assumes that 3D printing is one of the hottest manufacturing gravitate that is hopeful to reach at $4.5 billion by 2018.

Components like ceramic such as polymer and metal are significant to the LAM where it influences the additive manufacturing to develop against the subtractive manufacturing. First and for most, the trademark Laser Cusing process from Concept Laser can be used with stainless steel, aluminium and titanium alloys and others which will be described in the thickness and how well it functions based on the characteristics of each type of metal specifically (Overton, 2013).

The more sophisticated the metal components, the harsher environment will be subjected. Polymer and ceramic components have benefits such as reduce waste, customization capability and reducing the tool costs making the additive manufacturing a logical choice for cranial implant fabrications. The practice of thermal 3D printers can be forbidden by high melting point of polyetherketoneketone, (PEKK) which is 360 degree Celsius (Serra, 2014). In conclusion, all these components are prominent to the laser additive manufacturing and bring enhancement in such manufacturing.

CHAPTER 3

RESEARCH METHODOLOGY

3.0 Overview

Overall, chapter 3 is about the procedure and methods used to carry out this study which is about improving the infant's or toddler's safety helmet using the industrial engineering design techniques. There will be very well explanations on how the methods used for designing in industrial engineering related to this study and the designing of the improved prototype of the safety helmet. There were a total of four techniques used for the designing process in this study and they are identifying opportunities, clarifying objective, setting requirements and determining characteristics. Once the industrial engineering design techniques were implemented, the parts need to be improved on the safety helmet were designed using the AutoCAD and Solid Works. Next, the chin guard and mouth guard were printed out using the 3D printer before the objects printed were evaluated with the users. Fig. 3.1 illustrates the summary of the entire project's flowchart.

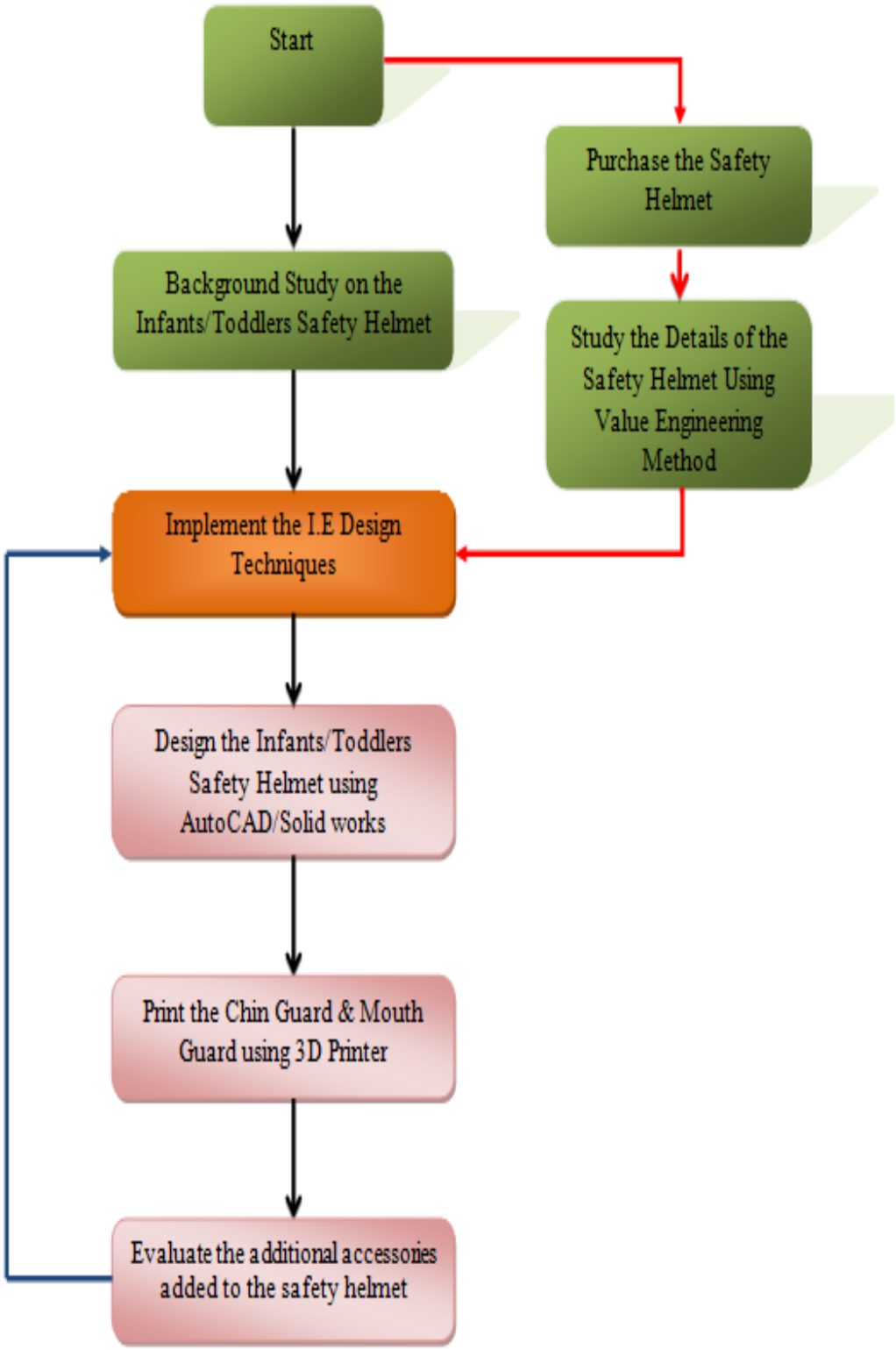


Figure 3.1: Flow Chart of the entire project

3.1 Background Study on the Infants or Toddlers Safety Helmet

At the initial stage of this study, a lot of information was gathered to carry out the background study on the infants or toddlers safety helmet. It took a while to do the background study as there were very less research done before on this topic. After searching many websites and journals, the information on the safety helmet was gathered and analysed.

3.1.1 Purchase the Toddler's Safety Helmet

While the background study was being carried out, another task was done simultaneously which was to purchase the existing product that is required to be improved. It was important to have an existing prototype of the product as it would give a clearer picture on what the product still lacking and which part needs to be redesigned. For this study, the toddler's safety helmet known as Thud Guard was ordered from U.S. Consequently, there were some difficulties faced in getting it here early. The details of the safety helmet was analysed using the value engineering method after the helmet arrived. The measurements of the safety helmet were taken using vernier calliper, micrometer screw gauge and ruler to have a nearly precise measurement of the initial prototype.

3.2 Design using the Industrial Engineering Techniques

There are up to eight design techniques in industrial engineering field but only four design techniques are used in this project. All of these techniques are very useful to produce products which satisfy the customer demands and needs. Therefore, all four design techniques will be explained in detail how they were carried out in completing this study.

3.2.1 Identifying Opportunities

The first design technique used in this study was identifying opportunities. Most of the products in the market are of various diversity and the modern products are becoming more complex which increasingly confusing to the users. This situation arises due to lack of emphasis given to the user's needs when a product is designed. In this study, the improvement on the toddler's safety helmet was more towards user centred where the designing process gave more importance to the customer's preferences. The user scenarios method has been used to carry out this technique.

3.2.1.1 User Scenarios Method

The user scenarios method was very useful in helping to identify the opportunities that were very fundamental in creating and redesigning the toddler's safety helmet. This method also provided a useful starting point and focused on the designing process by taking into consideration the point of view of the users. In this study, this user scenario method was achieved through survey and observing the users. Thus, questionnaires were set to gather the consumer's view on the head injury suffered by the toddlers and the toddler's safety helmet. Two set of questionnaires were set for thirty parents and thirty nurses, each containing twelve to thirteen questions.

The survey was carried out from 2nd May 2015 until 10th July 2015 in the Paediatric department of Hospital Raja Permaisuri Bainun in Ipoh since it would be more practical to obtain the view of the parents whose children suffer from head injuries. The survey was also conducted for the nurses of the Paediatric department as honest response would be obtained based from their experience. The survey conducted was a combination of both open-ended response and fixed type response. Table 3.1 to Table 3.15 shows some of the summarized important feedbacks from the questionnaires of the parents and nurses.

Table 3.1: Number of children of the parents

Element	Feedback			
	None	1 - 3	4 – 6	➢ 6
No. of children	5	16	8	1

Table 3.2: Parents income

Element	Feedback			
	< RM 1000	RM 1000 – RM 2000	RM 2000 – RM 3000	> RM 3000
Parents income	8	10	11	1

Table 3.3: Number of parents that agree toddlers are prone to head injuries

Element	Feedback	
	Yes	No
Agree that toddlers are prone to head injuries	26	4

Table 3.4: Mechanism of injury

Element	Feedback			
	Object fall on head	Fall down	Parents carelessness	Others
How does head injuries occur	12	14	4	-

Table 3.5: Parents awareness on the existence of the toddler's safety helmet

Element	Feedback	
	Yes	No
Awareness on the existence of the safety helmet for toddlers	4	26

Table 3.6: Recommendation for mouth guard and chin guard

Element	Feedback	
	Yes	No
No. of Parents recommend mouth guard and chin guard	25	5

Table 3.7: Number of parents willing to buy toddler's safety helmet

Element	Feedback	
	Yes	No
No. of Parents willing to buy the safety helmet	27	3

Table 3.8: Estimated price parents willing to spend on the toddler's safety helmet

Element	Feedback			
	< RM 100	RM 100 – RM 150	RM 150 – RM 200	> RM 200
Estimated budget of the safety helmet	5	13	11	1

Table 3.9: Feedback from nurses on number of head injury cases admitted into the hospital

Element	Feedback			
	None	1 - 5	6 – 10	➢ 10
No. of toddlers admitted due to head injuries	-	22	8	-

Table 3.10: Age of toddlers admitted in hospital due to head injuries

Element	Feedback			
	< 1 years old	1 – 2 years old	2 - 3 years old	➢ 3 years old
Age of toddlers admitted	1	15	10	4

Table 3.11: Severity of the head injury suffered by the toddlers admitted

Element	Feedback			
	Low	Medium	High	Critical
Severity of the head injury	3	17	10	-

Table 3.12: Nurses opinion on efficiency of the safety helmet preventing head injuries

Element	Feedback	
	Yes	No
Is safety helmet for toddlers sufficient to prevent head injuries	25	5

Table 3.13: Nurses point of view on the important factors of a safety helmet for toddlers

Element	Feedback			
	Air-flow	Accessibility	Safety Accessories	Others
Factors that are important for a safety helmet	15	3	12	-

Table 3.14: Number of nurses that would recommend the safety helmet to the parents

Element	Feedback	
	Yes	No
Recommend the safety helmet to the parents	28	2

Table 3.15: Opinion of the nurses on the willingness of the parents buying the toddler's safety helmet

Element	Feedback	
	Yes	No
Would the parents buy the safety helmet	24	6

On the other hand, the observation of the users was carried out after the toddler's safety helmet arrived from U.S. Two toddlers of the age of 1 year 5 months old and 2 years 6 months old were observed using this safety helmet. The toddler's reactions and parents reactions were observed and listed down. Table 3.16 and Table 3.17 illustrate the observations obtained from this method.

Table 3.16: Observation of the 1 years 5 months old child wearing the safety helmet

User age & gender:	1 years 5 months old (boy)
Observations:	• The parents were shocked to notice that the surface of the product was made of soft materials. They assumed the safety helmet to be made of hard material. • There is a need to supply users with a specific requirement details and also a manual on how to use the safety helmet. • Child hesitates to wear the safety helmet at the beginning. • After wear the helmet, the child was normal and never complains or cries. • The helmet was a bit loose even though the strap was tightened. • The parents left the child alone on the floor and the kid started to play with toys on the floor. • While playing the child fell down with the face facing front and hurt his chin. • The child was crying and tried to remove the helmet but failed as the strap was tight. • Even though the strap was tight, it is hazardous as it may cause the child to chock while trying to remove the safety helmet without the guidance of the parents. • The child never sweats while wearing the helmet.

Table 3.17: Observation of the 2 years 6 months old child wearing the safety helmet

User age & gender:	2 years 6 months old (girl)
Observations:	• The parents were amazed with the lightweight of the helmet. • There is a need to supply users with a specific requirement details and also a manual on how to use the safety helmet as they searched for the details about these product after opening the box. • Child never hesitates to wear the safety helmet. • The child was normal and was attracted towards the object on top of the safety helmet and was playing happily. • The helmet fit the head of the child perfectly and was not loose at all. • The child was cycling around the hall and was comfortable throughout the observation. She sweats a bit but it should not be a concern as she was cycling around the hall and porch of the house. • Then, the parent was there when removing the safety helmet and they manage to remove the helmet smoothly.

3.2.2 Clarifying Objectives

Clarifying the objectives was the second design technique used in this study. Complete and clear statements of design objectives are very helpful at all stages of designing of a product. It gives a clear picture of what actually needed and what the designed product should meet. After the user scenarios method was carried out previously in this study, the information gathered from the previous step was used again to obtain a clear statement of objectives and understood easily. The objectives tree method was used to achieve the aim of this technique.

3.2.2.1 The Objectives Tree Method

The objectives tree method gave a clear and useful format of objectives statement for this study. This method demonstrated in a diagrammatic form, shows how different objectives are related to each other in a hierarchical pattern of objectives and sub objectives. A list of design objectives for the improvement of the safety helmet for children were prepared so that all those objectives could be expanded and clarified to produce more precise objectives. Next, the list of objectives listed were ordered into sets of higher and lower level objectives which would eventually create a clear imagination on the important objectives on improving this safety helmet. Lastly, all the list of objectives and the ordered sub objectives were drawn in a diagrammatic tree form. Once this was done, a clear pattern of relationships and interconnections in between the objectives and sub objectives were obtained.

Figure 3.2: The objective tree method of the safety helmet for the toddlers

3.2.3 Setting Requirements

The third design technique used in this study was setting requirements. Design problems are always set within certain limits or requirements comprise the performance specification of the product. Therefore, the statement of design objectives obtained from the previous method are used partially and defined with precise limits using the performance specification method.

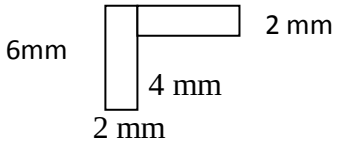
3.2.3.1 The Performance Specification Method

This method was very helpful in defining the design problem and gave a freedom to achieve a satisfactory and desired design solution by emphasizing the performance that needed to be achieved. The accurate specifications of the performance required of a design solution were obtained by considering the different levels of generality of the solution which might be applicable. Then, the generality was determined by users of the safety helmet and the required performance attributes were identified. All the requirements for the attributes were stated precisely. Table 3.18 illustrates the performance specification method clearly.

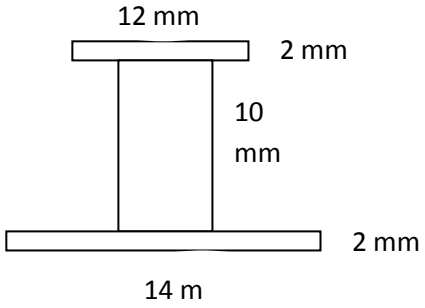
Table 3.18: The Performance Specification of the Toddler's Safety Helmet

	Specifications for Toddler's safety helmet	Page 1

Changes	D/W	Requirements	Responsible
		1. <u>Safety Helmet</u>	
	D	Diameter: 170 mm	
	D	Thickness: 10 mm	
	D	Height: 110 mm	
	W	Holes: 8.5 mm	
	D	Material: High collision absorption foam	
	D	Cushion: Ultra lightweight high density foam	
	D	Chin strap: Velcro strap	
	D	Chin strap length: 300 mm	
	W	Connection to helmet: Stitching	
		2. <u>Chin Guard</u>	
	D	Thickness: 3 mm	
		3 Parts:	
	D	Centre part: (30 x 30) mm	
	D	Chin strap holder: (20 x 20) mm	
	D	Side parts: 2 x (20 x 30) mm	
	D	Chin strap holder: 2 x (10 x 20) mm	
	W	Chin strap thickness: 5 mm	
	D	Materials: High collision absorption foam & ultra lightweight high density foam, soft spun poly/lycra	
	D	Process: Cutting technologies, post treatment Technologies & stitching	
		3. <u>Mouth Guard</u>	
	D	Dimensions: (65 x 50) mm	
	D	Thickness: 3 mm	
	W	Pacifier holder: 4 Holders	



	Specifications for Toddler's safety helmet	Page 2

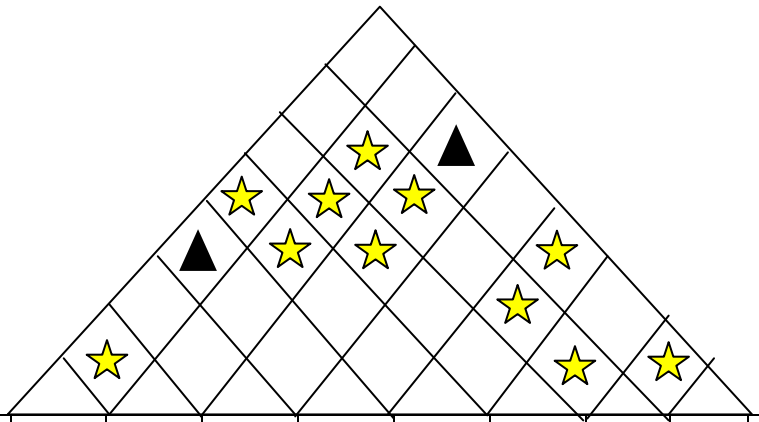
Changes	D/W	Requirements	Responsible
	D	Process: Injection molding & cutting technologies	
		4. <u>Knob</u>	
	W	Dimensions:	
			
	D	Material: High density Polyethelene	
	D	Process: Injection molding	
		5. <u>Convenience</u>	
	W	Flexible	
	W	Stretchable	
	W	Easy to clean	
	W	Easy to use	
	W	Colours: blue, purple, red, green	
	W	Ergonomically designed	
		6. <u>Costs</u>	
		Manufacturing cost: In the range of RM100 – RM200	

3.2.4 Determining Characteristics

The final design technique used in this study was the determining characteristics. This design technique was used to understand the relationships between the characteristics and attributes of the toddler's safety helmet. The quality function deployment method was used to satisfy this design technique.

3.2.4.1 The Quality Function Deployment Method

The Quality Function Deployment Method which is also known as the house of quality method was carried out to help achieve the engineering characteristics of our product as well as satisfy customer requirements. Firstly, the customer's requirements are identified and the relative importances of those attributes are determined. Then, the attributes of the competing products are evaluated. In this study, the competing products for our safety helmet are SGV motorcycle helmets and bicycle helmets. A matrix of the safety helmet attributes and engineering characteristics was also drawn and the relationships between them are identified. The interactions between the engineering characteristics are also identified and finally, target figures were set. The house of quality is shown in Fig. 3.3.



Functional Requirements / Customer Requirements	Priority	Cushion inside the helmet	Soft material component	High visual appeal	Air-flow	Flexible	High collision absorption foam	Chin guard and mouth guard	Ergonomic Design	SGV Motorcycle Helmet	Bicycle Helmet
Lightweight	3	♥	♥				♥	★		P	F
Easy to use	2					▲		♥	♥	G	G
High comfort	4	♥	★		★	♥			♥	F	F
Safety	6	♥	★				♥	♥		G	G
Reliable	5	♥	★		★		♥	♥		G	F
Appearance	1			♥					▲	P	F
Our Important Rating		90	60	5	27	22	70	92	31		
Technical Attribute		High quality	100 %	60 %	Many Holes	Stretchable	90%	75 %	Panel Ranking		
Technical Evaluation: SGV Motorcycle Helmet		Poor quality	20 %	30 %	None	Not Stretchable	40 %	30 %	F		
Technical Evaluation: Bicycle Helmet		Medium quality	40 %	50 %	Few holes	Not Stretchable	40 %	50 %	F		
Technical Evaluation: Us		High quality	100 %	60 %	Many Holes	Stretchable	90 %	75 %	G		

♥ High Rel. (5)
★ Medium Rel. (3)
▲ Low Rel. (1)

Figure 3.3: The house of quality of the safety helmet

3.3 Design Using AutoCAD

The parts need to be improved were drawn using the AutoCAD software. It took quite a while to learn the functions of the software in the beginning as the designing the 3D models were all based on try and error method. The parts that were designed are chin guard, mouth guard, knob at the end of the chin strap and straps on top of the helmet.

3.3.1 Dimensions of the Original Toddlers Safety Helmet

Firstly, the original toddler's safety helmet was drawn according to its original dimensions as it would be used as a reference for the other improved parts designed. The dimensions were measured using the vernier calliper, micrometer screw gauge, ruler and thread to have a precise measurement as the safety helmet design is complicated. Fig. 3.4 to Fig. 3.10 illustrates the dimensions of the original toddler's safety helmet.

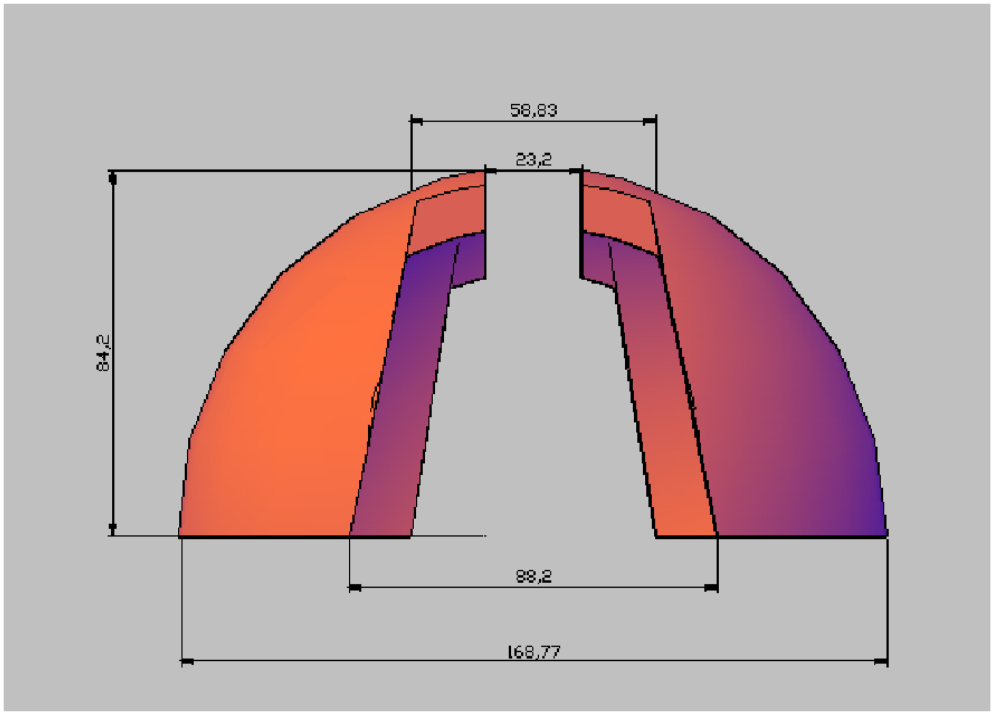


Figure 3.4: Front view dimensions of the shell of the safety helmet

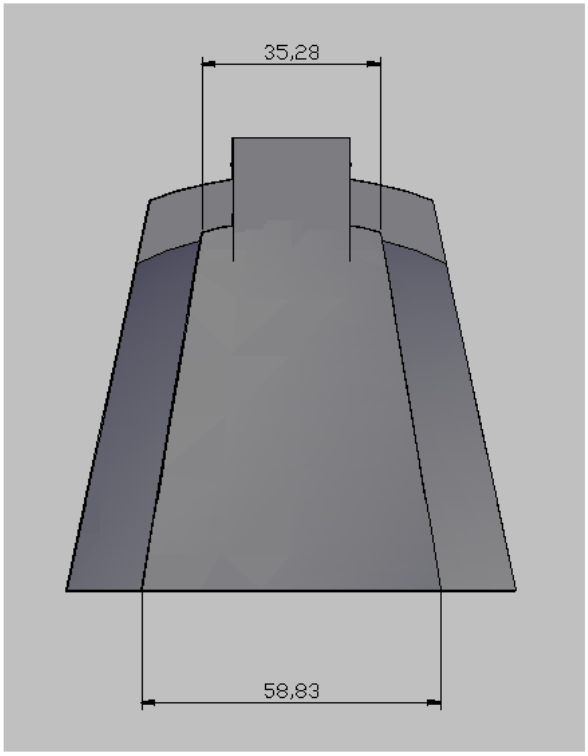


Figure 3.5: Back view dimensions of the centre part of the safety helmet

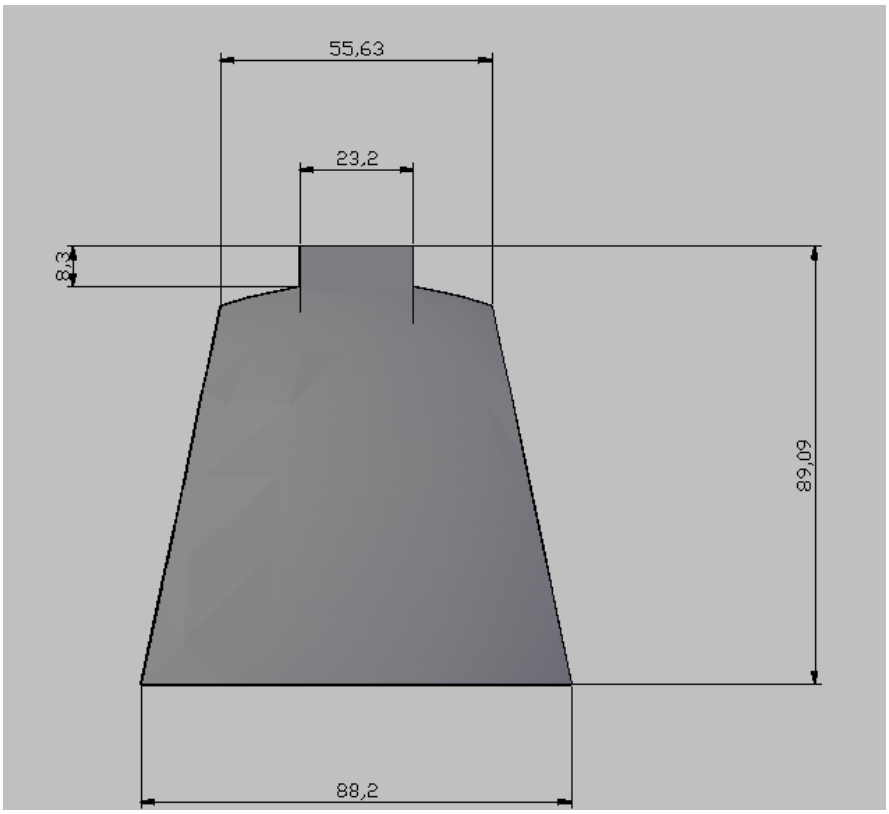


Figure 3.6: Front view dimensions of the centre part of the safety helmet

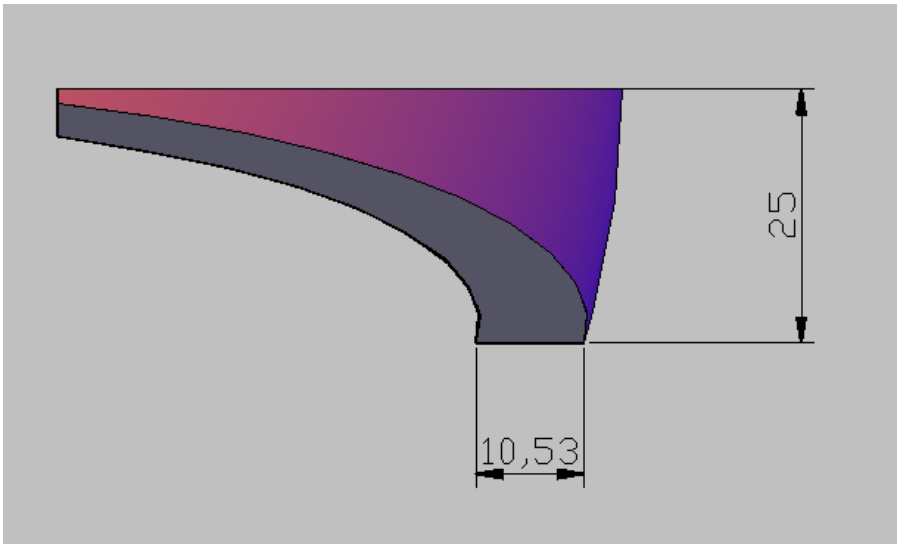


Figure 3.7: Front view dimensions of the triangle shape bottom part of the safety helmet

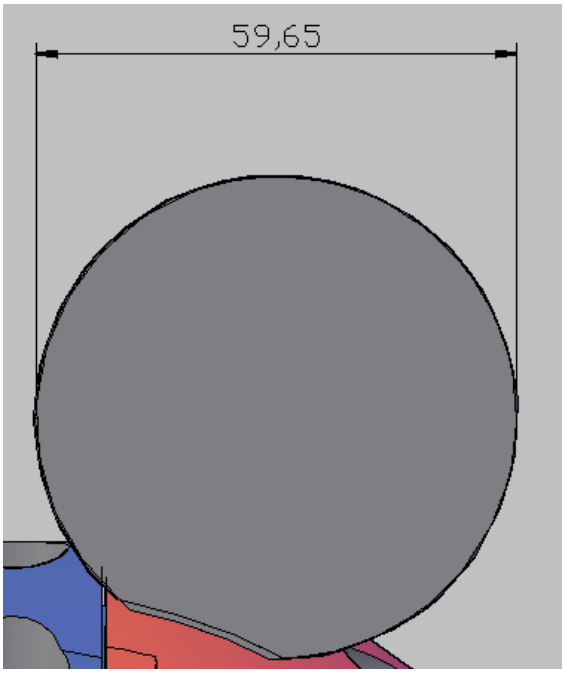


Figure 3.8: Dimensions of the object on top of the helmet

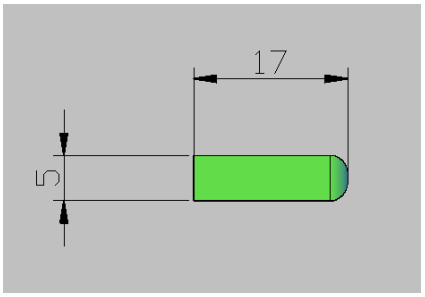


Figure 3.9: Side view dimensions of the green tab

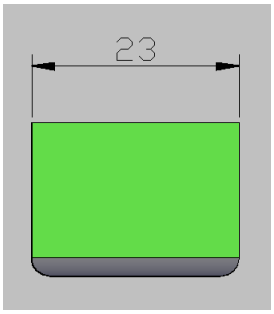
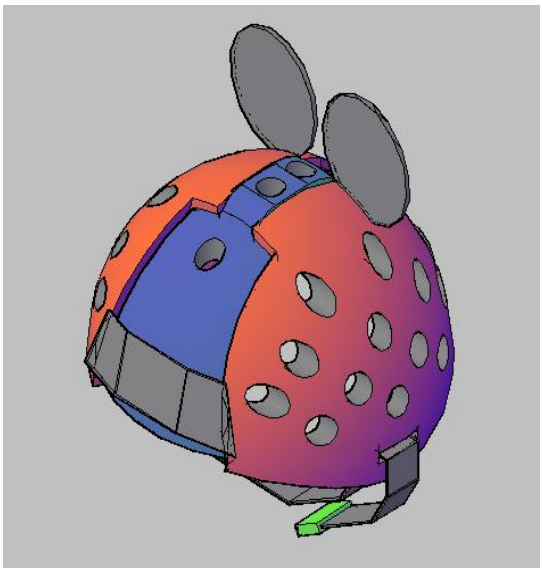
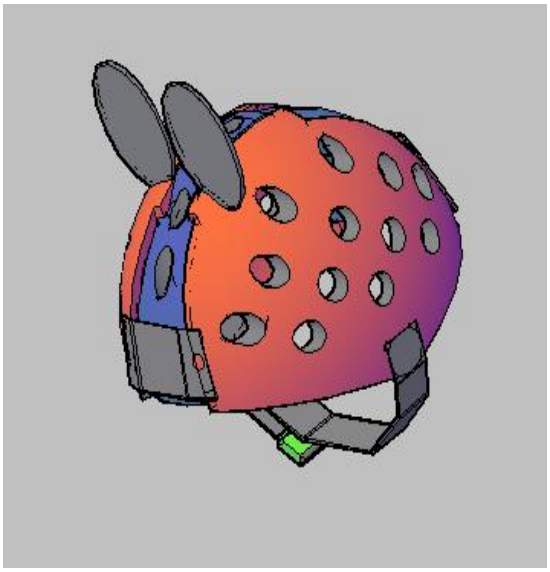


Figure 3.10: Top view dimensions of the green tab

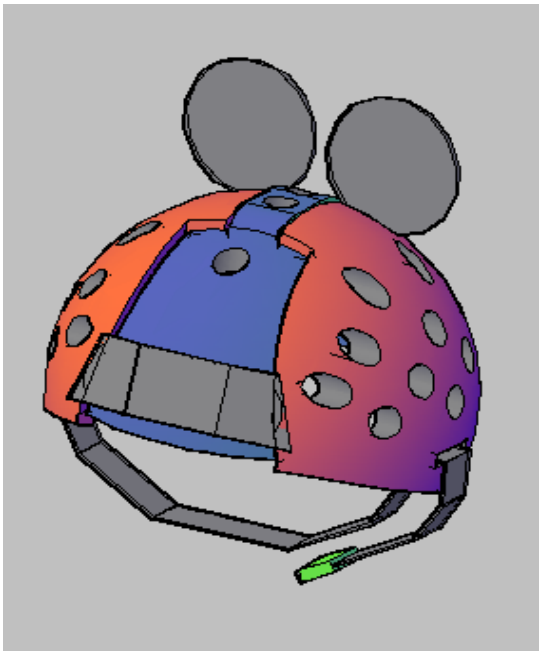
Based on the dimensions measured, the original design of the safety helmet was designed. There were few parts in designing of the safety helmet. All the parts were drawn separately before joined together. The diameter of the holes for air ventilation on the helmet was 14mm and the length of the strap was 320mm. The final designs of the original safety helmet are shown in Fig. 3.11.



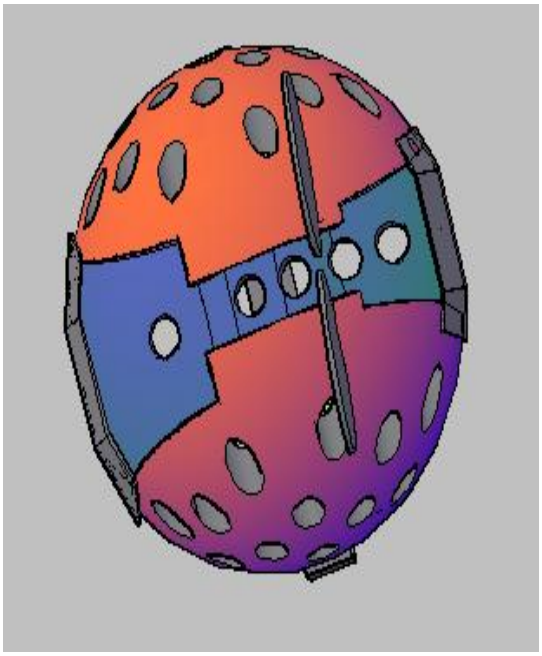
(a) 3D left side view



(b) 3D right side view



(c) 3D front view

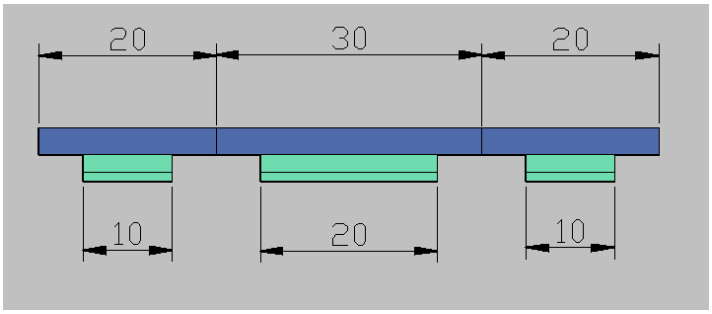


(d) 3D top view

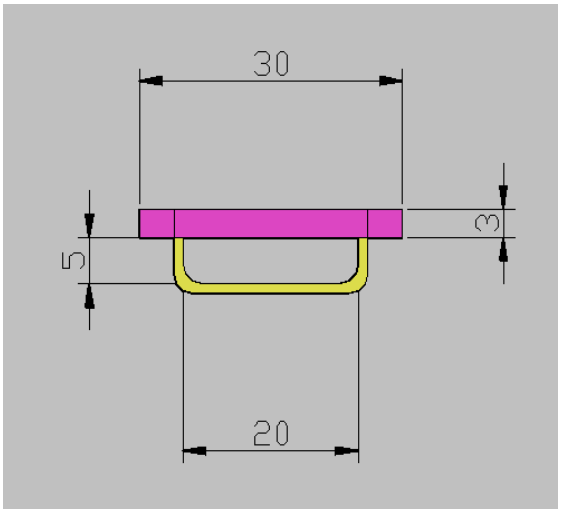
Figure 3.11: 3D designs of the original toddler's safety helmet

3.3.2 Dimensions of the Chin Guard

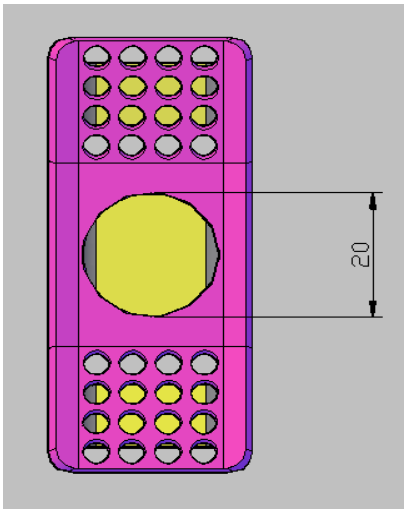
The precise chin size of the toddlers was not known due to different chin sizes of the toddlers. Therefore, the dimension for the chin guard designed was based on estimations. The chin guard designed consist of three parts. The overall dimension of the chin guard designed was 70mm by 30mm. The chin guard have holders for the chin strap of the safety helmet to enter which has dimension of 20mm in width and 5mm in height. The centre holder has a length of 20 mm where else the other two holders have length of 10mm. Fig. 3.12 shows the dimensions of the chin guard from the side view, front view and top view.



(a) Side view dimensions



(b) Front view dimensions



(c) Top view dimensions

Figure 3.12: Dimensions of the chin guard

The centre part of the chin guard was designed with a hole of 20mm in diameter, as it would help ease the placement of the toddler's chin. The other two parts beside the centre part are flexible and can be bended according to the growth of the users. Fig. 3.13 shows the 3D view of the designed chin guard.

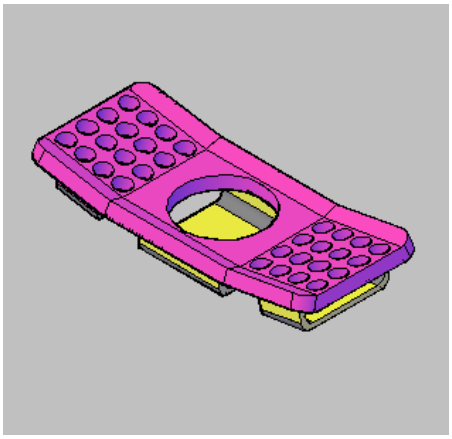
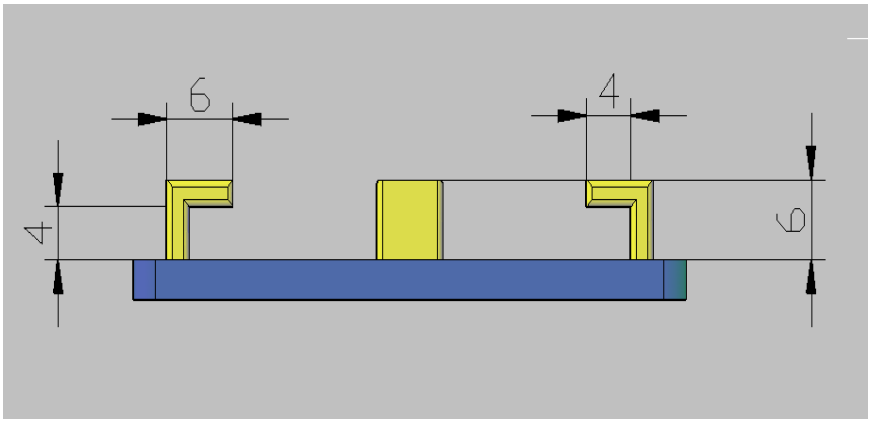


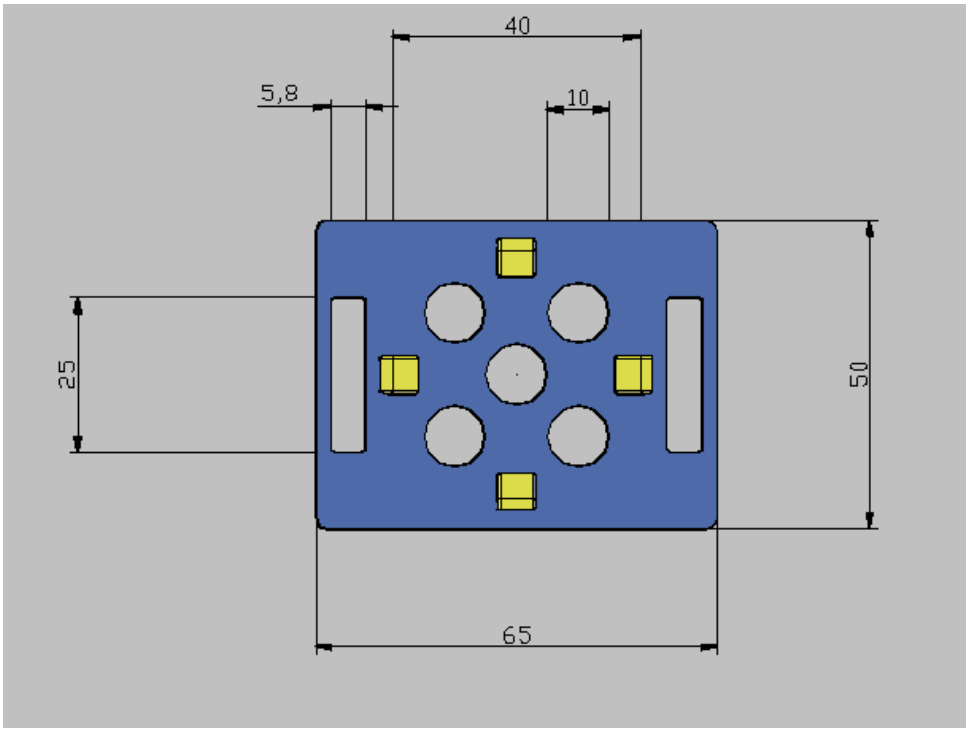
Figure 3.13: 3D view of the chin guard

3.3.3 Dimensions of the Mouth Guard

The mouth guard was designed in a cube shape with a dimension of 65mm by 50mm. It was also designed with two rectangular shaped holes at the end of each side of the mouth guard with dimensions of 5.8mm in length and 25mm in width for the strap with a green tab to enter. The base of the pacifier has a diameter of 40mm and a thickness of 4mm, so the pacifier holders are placed 40mm from each holder and has a height of 6mm to hold the base of the pacifier. Fig. 3.14 shows the dimensions of the mouth guard from the side view and top view where else Fig. 3.15 shows the 3D view of the mouth guard designed.



(a) Side view dimensions



(b) Top view dimensions

Figure 3.14: Dimensions of the mouth guard

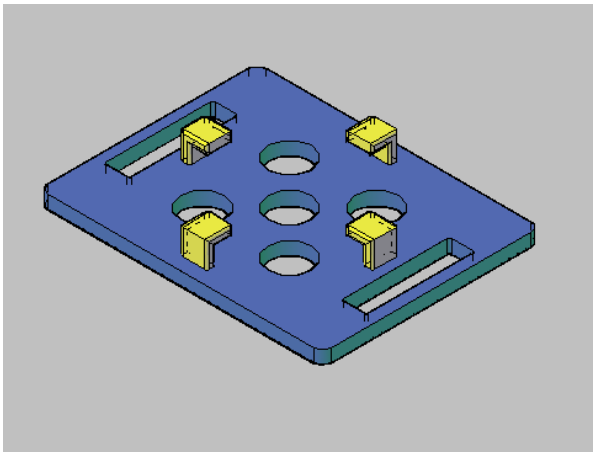


Figure 3.15: 3D view of the mouth guard

3.3.4 Dimensions of the Knob at the End of the Chin Strap

This knob designed would make the chin strap more flexible. The dimensions of the knob designed were based on the chin strap that was originally stitched to the safety helmet with a width of 20mm. The knob has an outer circular part with a diameter of 14mm and height of 2mm. This part attaches the chin strap together with the surface of the safety helmet. In addition, the hole made on the strap has a diameter of 10mm which would be the centre part dimensions of the knob that will pass through the safety helmet. The final part of the knob that holds the safety helmet from inside has a diameter of 12mm and height of 2mm. Fig. 3.16 illustrates the dimensions of the knob.

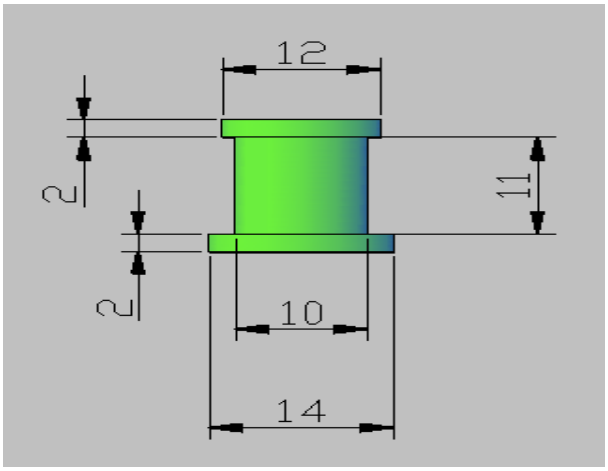


Figure 3.16: Dimensions of the knob

3.3.5 Dimensions of the Straps on Top of the Safety Helmet

The designed strap is slightly curvy due to the curve surface of the safety helmet for toddlers. The straps at the top of the safety helmet for toddlers have a total length of 80mm. The Velcro strap end will be 20mm in length and will be stitched on the surface of the safety helmet with dimensions of 16.91mm by 18mm. The red colour lines in Fig. 3.17 are represented as the stitching point. The other end of the strap will also be stitched onto the surface of the safety helmet for toddlers with dimensions of 10mm by 18mm. Fig. 3.18 shows the dimensions of the strap and Velcro end which is represented with a red colour circle

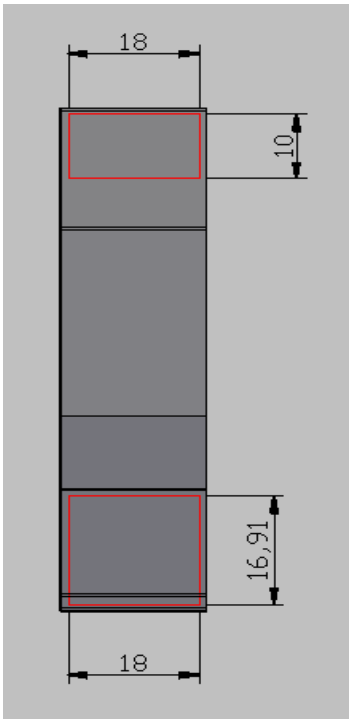


Figure 3.17: Dimensions of the stitching point on the strap

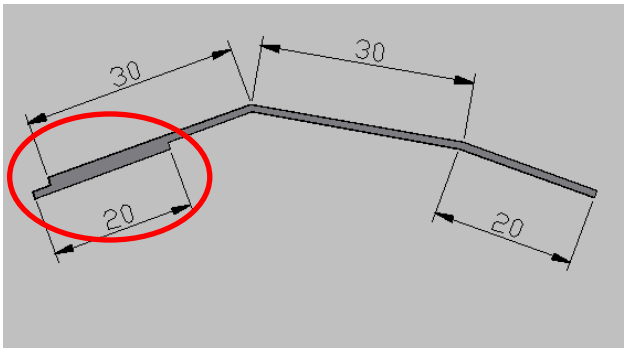


Figure 3.18: Dimensions of the strap attached with the Velcro end

3.4 Regulating the 3D Printer

The chin guard and the mouth guard are printed using this 3D printer. Polylactide (PLA) which is made of biodegradable thermoplastic aliphatic polyester is the material being used for the printing of the two objects. Few calibrations have to be made to have a well levelled bed, before printing the objects. This will make the printed object to have the precise dimensions needed. Sequentially, the nozzle must be tightened until it slightly touches the bed to hold a well level bed. These measures will let the plate brought to the standardize height before printing was started.

The primary stage was to explain the procedures and inspecting the back positions. This is the process where the plate for printing and the nozzle were cleaned before and implementation of the printing. Fig. 3.19 shows the action that appears on the computer.

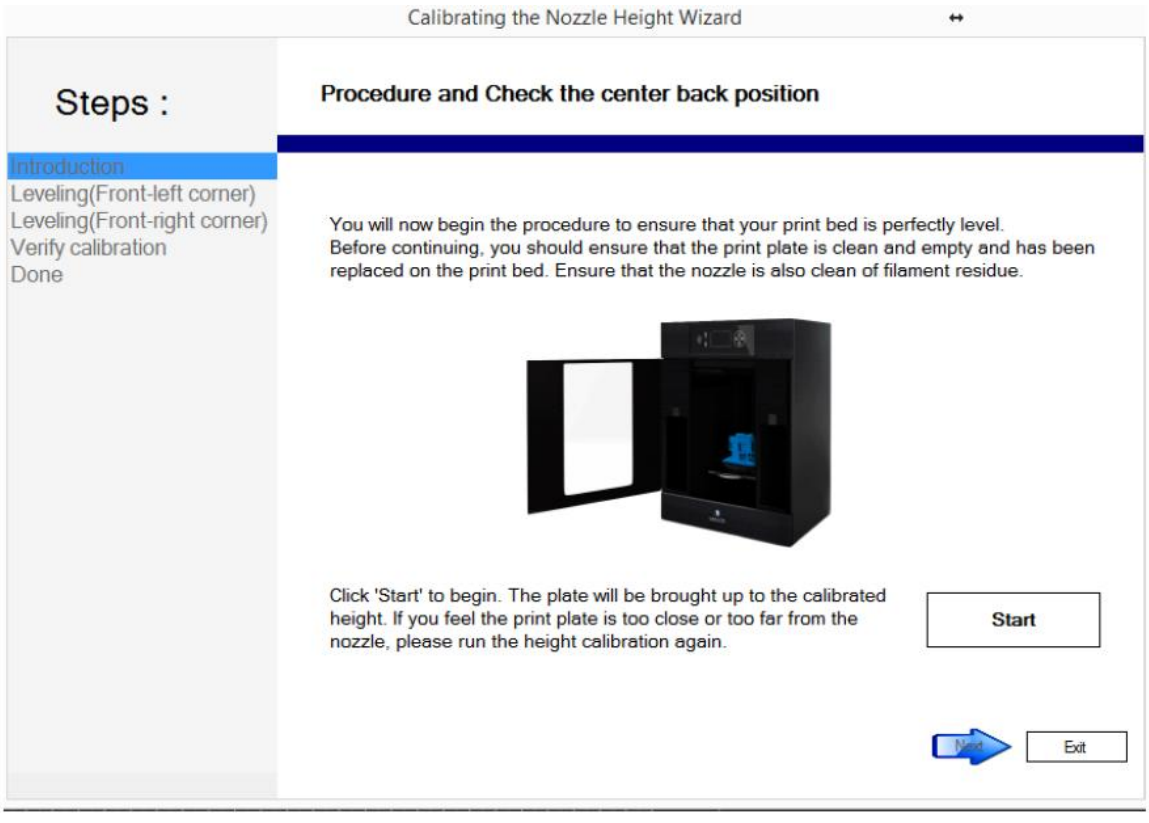


Figure 3.19: Procedure and check centre back positions

The second step was levelling the front-left corner of the plate. The distance between the plate and nozzle was decreased by tightening the adjustment knob while loosening the knob will reduce the distance. After that, levelling of the front-right corner was done. It is the same process as the previous step. Fig. 3.20 and Fig. 3.21 show these two stages.

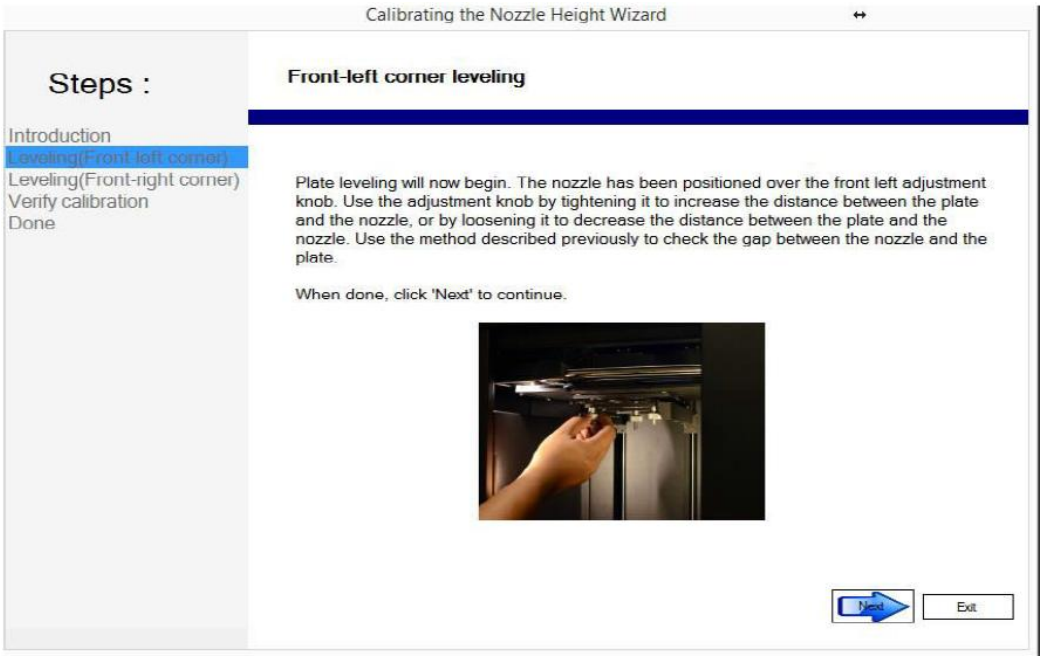


Figure 3.20: Front-left corner levelling

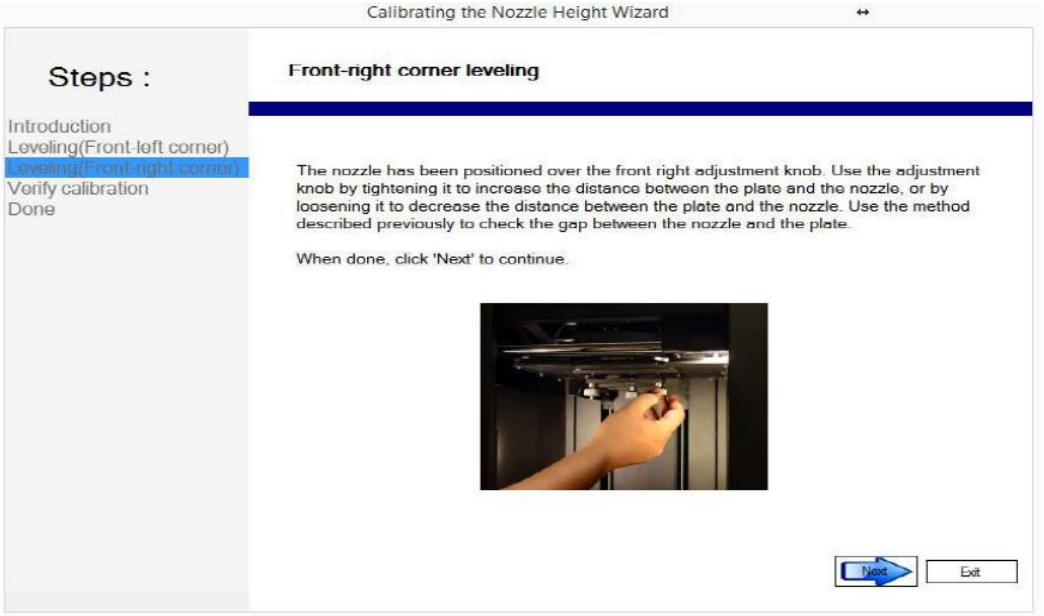


Figure 3.21: Front-right corner levelling

The last stage was the verification of the calibration of all the steps above where three buttons were used to move the nozzle to centre back, front left and front right positions. It certifies that the gap between the print plates is satisfactory at each point. Lastly, the next button was clicked to complete the calibration, after verifying the levelling. Fig. 3.22 shows this step.

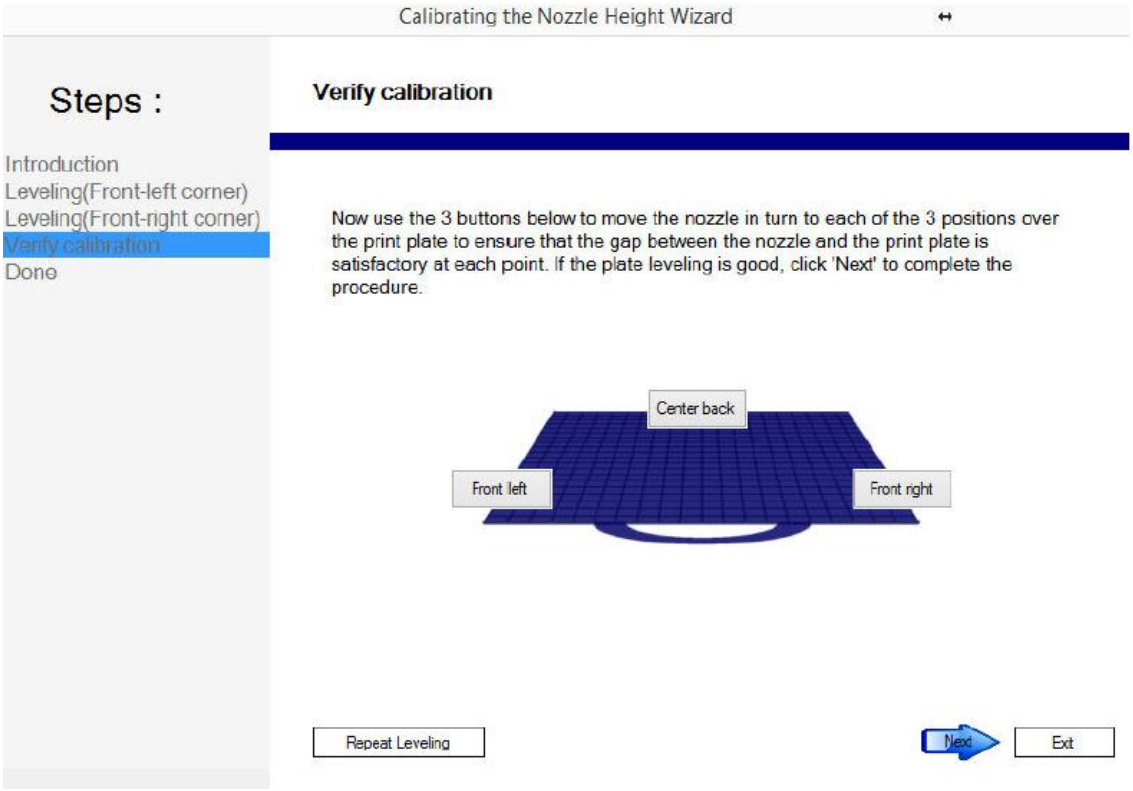


Figure 3.22: Verify calibration

3.5 3D Printing the Chin Guard and Mouth Guard

The printing was started after the height of the printing bed was checked and adjusted to be flat. Then, the image of the product was loaded and placed to the accurate orientation. A correct orientation will be in blue colour and a wrong orientation will be in red colour. Next step was to choose the required product qualities which are low, medium and high. The quality is directly proportional to the time where the higher the quality, the longer the time taken for printing the products. In addition, the resolution of the printing was chosen in terms of microns and the printing was started after that.

CHAPTER 4

RESULTS AND DISCUSSION

4.0 Overview

In this chapter, the results obtained from the survey, user scenario method, objective tree method and house of quality method were discussed. Besides, the final designs of the improved safety helmet such as the chin guard, mouth guard, straps on top of the safety helmet and the knob at the end of the chin strap of the safety helmet were presented. In addition, AutoCAD and Solid Works were used to design the improvements on the safety helmet. The designs saved in AutoCAD file must be converted into solid works before the chin guard and mouth guard were printed using the 3D printer as the printer can only interpret drawings from solid works. Solid Works was also used in the joining of all the separate parts improved in the safety helmet together.

4.1 Survey Results

Based on the survey conducted in the Paediatric department of Hospital Raja Permaisuri Bainun Ipoh, the outcome of the survey were categorised into two different aspects. It is distinguished under the basis of causes of head injuries suffered by the toddlers and parents willingness to purchase these safety helmets for toddlers.

From the first aspect, Fig. 4.1 to Fig. 4.5 summarizes the result into five different factions such as the number of parents consent about the occurrence of the head injuries, how it occurs, the number of cases admitted in hospital due to head injuries, age of the children and the severity of the head injuries.

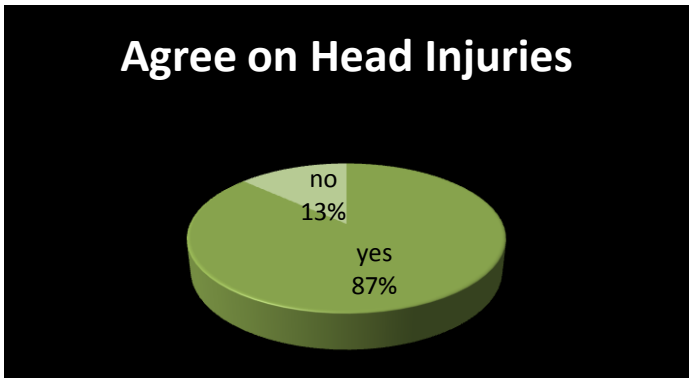


Figure 4.1: The percentage of parents agrees on the occurrence of head injury

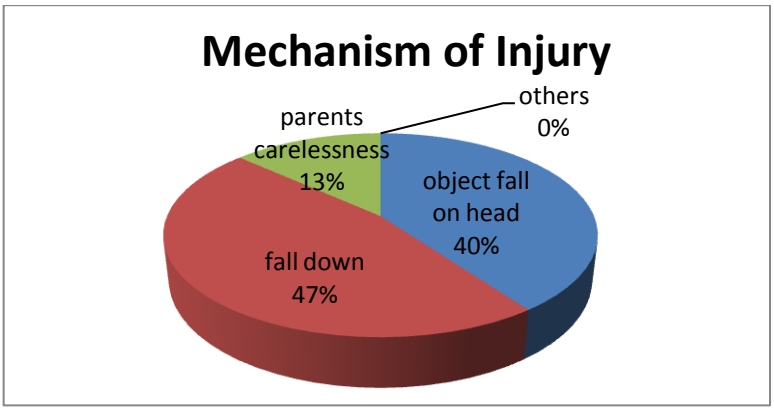


Figure 4.2: Mechanism of injury suffer by the toddlers

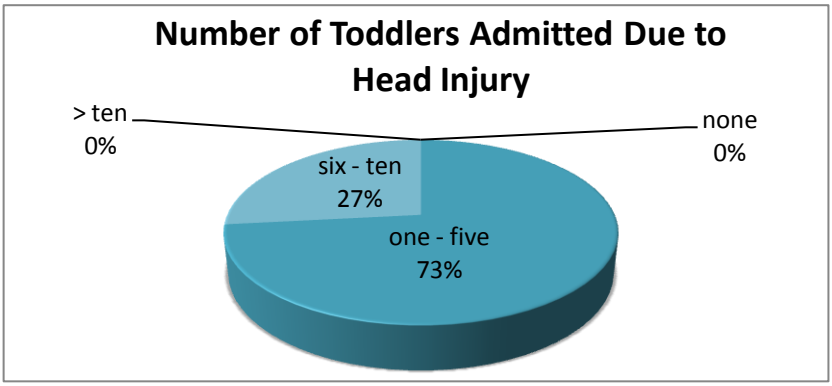


Figure 4.3: The number of toddlers admitted into the hospital due to head injury per day

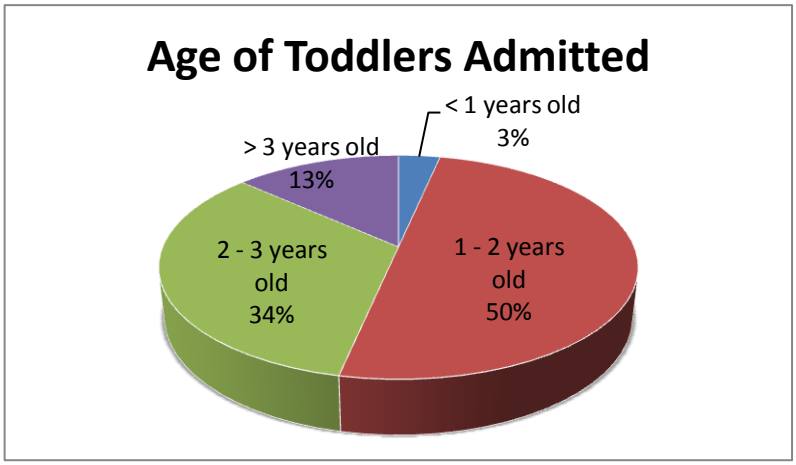


Figure 4.4: Age of toddlers admitted into the hospital due to head injuries

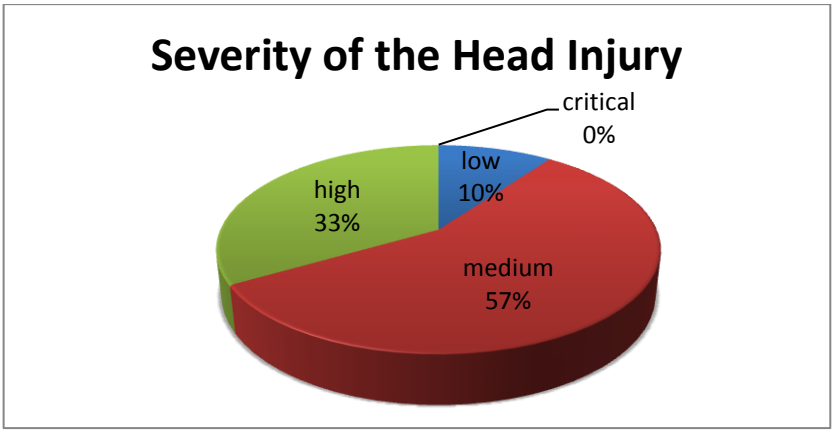


Figure 4.5: Severity of the head injury suffered by the toddlers admitted

Based on Fig. 4.1, 87% of the parents agreed that their children are prone to head injuries. The prime cause of this injury has been proven to be due to toddlers themselves with 47% rather than parent's carelessness which shows an insignificant percentage of 13%. Coming across Fig. 4.3, 73% of the nurses claimed that one to five admission cases were to be registered per day for toddlers suffering from head injuries. This could lead to a critical situation where the number of admission cases could increase if no precaution is taken. Half of the cases are from toddlers at age of one to two years old whereas one third of the percentage stated to be under age group of two to three years old. This is an age group where the kids are usually getting used to their surroundings and gets hurt unintentionally. Moreover, the severity of the head injuries suffered by the toddlers is quite acceptable from Fig. 4.5.

Secondly, the other aspect focuses on the willingness of parents to procure the toddlers safety helmet to avoid injuries. They are broken up into six divisions which are clearly illustrated through Fig. 4.6 to Fig. 4.11. To start with, the awareness of the parents and nurses on the existence of this safety helmet, parents income, the number of nurses willing to recommend the safety helmet to the parents followed by the number of parents willing to purchase the safety helmet and the estimated budget parents willing to spend on the safety helmet for toddlers.

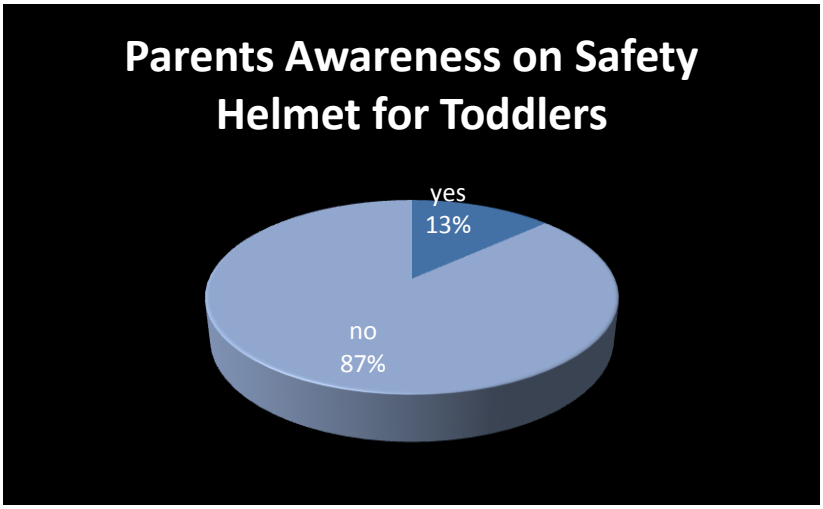


Figure 4.6: Parents awareness on the existence of toddler's safety helmet

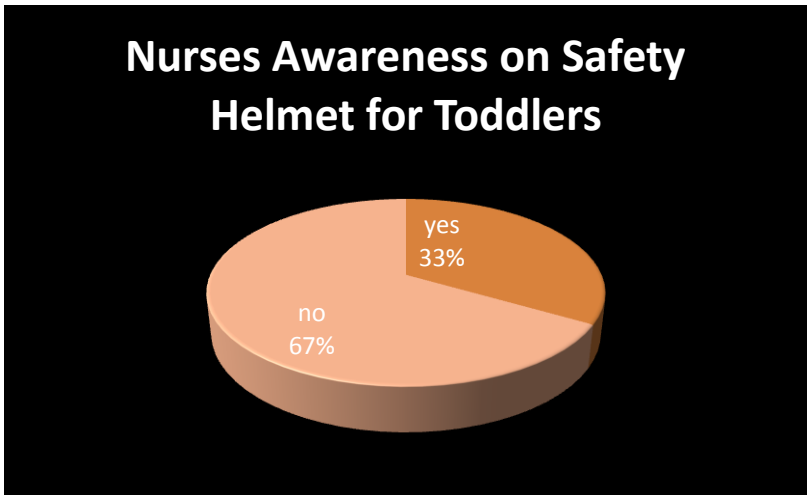


Figure 4.7: Nurses awareness on the existence of toddler's safety helmet

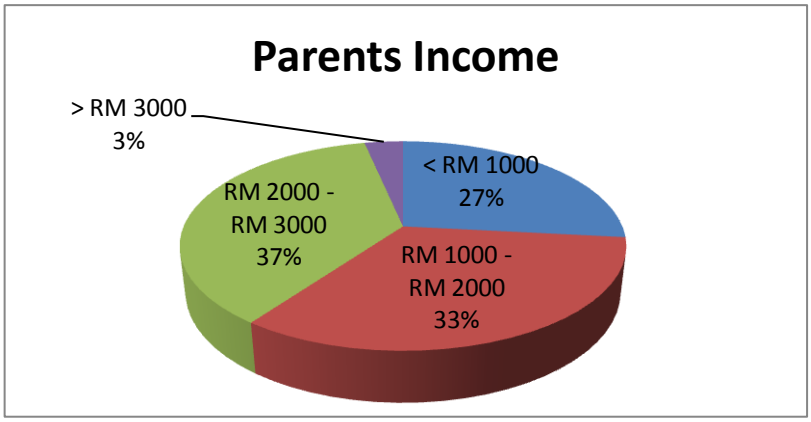


Figure 4.8: Parents income

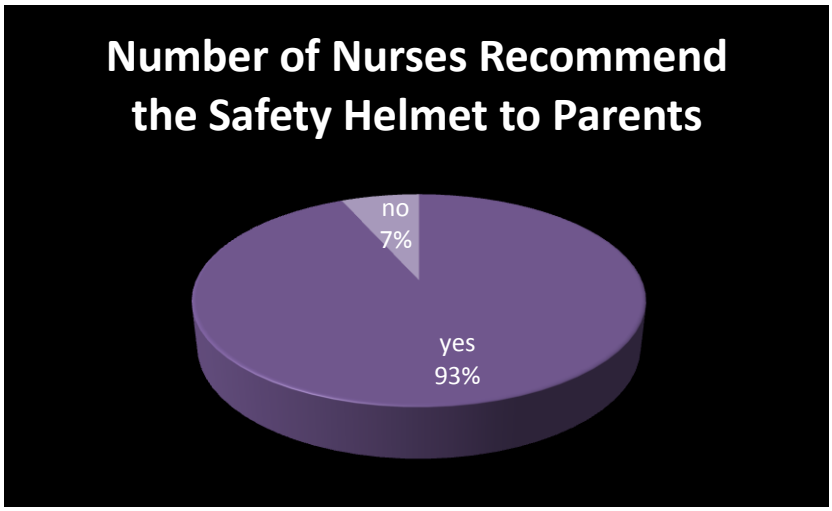


Figure 4.9: Number of nurses recommends the toddler's safety helmet to the parents

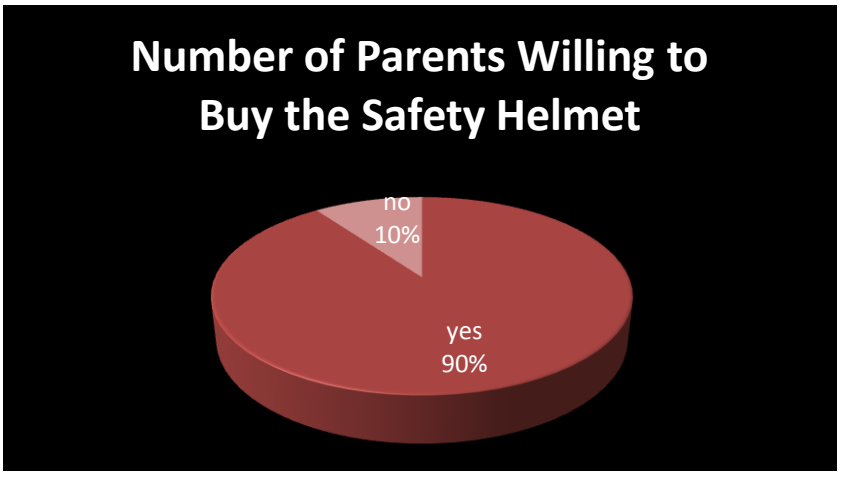


Figure 4.10: Number of parents willing to buy the toddler's safety helmet

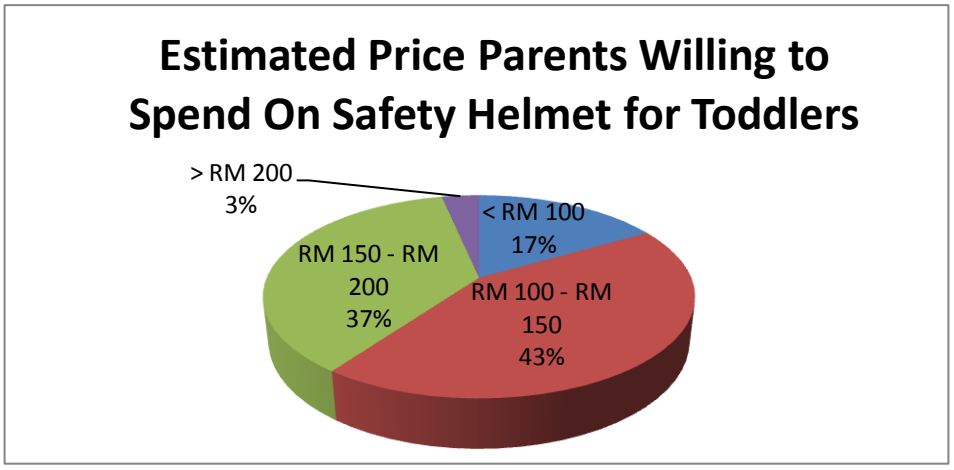


Figure 4.11: Estimated price parents willing to spend on the safety helmet

According to Fig. 4.6 and Fig. 4.7, it is clearly shown that the awareness about the safety helmet between the parents and nurses are very low with only 13% from parents and 33% from nurses. Even though the awareness is less, 90% of the nurses willing to recommend the safety helmet to the parents to help reduce the number of head injuries. This affiliates to income of parents to afford the toddler's safety helmet. Figure 4.8 is analyzed to have a total of 70% of parent's income between RM1000 to RM 3000. Minority belongs to the group of parents earning below RM 1000. Concerning to their toddlers safety, around 90% of parents are prepared to purchase this safety helmet. 80% of parents are willing to obtain the safety helmet if the price is between RM 100 to RM 200 whilst 17% of the parents suggest the price should be below RM 100. In conclusion, there are a large group of parents willing to purchase the helmet if the price is reasonable between RM 100 to RM 200 even though the awareness is low.

4.2 Observing the User

Since the users aged in between 1 year old to 3 years old, the observation of the users required patience and good interaction skills as the observation process was found to be challenging.

Observing the 1 year and 5 months old boy was the hardest. The user hesitated to wear the safety helmet in the beginning and the appearance of the safety helmet played a part to convince the user. The helmet was a bit loose even though the strap was tightened. Additionally, the user also suffered from chin injury during the observation and it was further observed that the user tried to remove the helmet but failed as the strap was tight. This may cause the user to chock and it is very hazardous. Another important observation was that the user did not sweat wearing the safety helmet. On the other hand, it was observed that the parents were shocked to notice that the product was made of soft material as they assumed it to be made of hard surface. Fig. 4.12 shows the 1 year 5 months old user.

Figure 4.12: Image of the 1 year 5 months old boy

Observation of the 2 years 6 months old girl was easier compared to the previous user. This user was very attracted to the safety helmet and wore it without hesitance. The helmet was fit and not loose as the previous user experienced. It was also observed the user started to cycle around the hall while wearing the helmet and after a while, the parent removed the helmet without facing any problem and the girl

had sweat a bit. On the other hand, from the observation it was also found that the parents were amazed with the weight of the safety helmet which weighs less than 100 grams. Fig. 4.13 shows the 2 years 6 months old user.

Figure 4.13: Image of the 2 years 6 months old girl

Based on the observations, the availability of the owner manual of the product was found to be crucial as both the parents were searching for the details of the safety helmet. It was important to note that the user was still exposed to injuries on the face while wearing the helmet. Moreover, the helmet was loose for the younger user which also very important to take into consideration. The appearance was attractive as both the users were attracted to it and the safety helmet was generally very comfortable for the users. Finally, the holes in the safety helmet were quite efficient in allowing the air flow into the helmet.

4.3 The Objectives Tree Method

From the objective tree method generated, the focal points of our study are to improve the existing safety helmet for toddlers with selective objectives to be achieved. The objectives are safety, convenience, appearance and cost.

These four objectives are branched out into sub objectives where for safety; the helmet must be reliable and manage to result in low injury rates and this is why

the helmet was made of high collision absorption foam. From this material, a chin guard and a mouth guard has been suggested to give a better protection to the head and also other part of the face. Another objective is convenience where it must be lightweight, user friendly, comfortable and washable. To be light weight, the helmet weighs less than 100 grams with the usage of ultra lightweight high density foam and cushion (soft spun poly/lycra) material. The soft spun poly/lycra also satisfied another sub-objective, which was washable. Other than that, the usage of Velcro straps in the helmet contributed to achieving the sub-objective of user friendly. It aids the user in adjusting the helmet while wearing the helmet plus the removing process would also be smooth. Providing user guide in the form of a CD player or a manual book would help in using the safety helmet efficiently.

In order to be comfortable, the input of ergonomic design, holes for air ventilation and cushion inside the helmet plays an important role too. The helmet must also fit the user and add-on straps could be attached to the top of the helmet so that the user can tighten the helmet if it is wobbly. Plus, the safety helmet must also be attractive in order to exert a pull on small toddlers example like cartoon characters or colourful emblem in addition to its rabbit ears on it. The essential key experiential throughout the survey was found to be its preferable pricing range from RM 100 to RM 200 which could be achieved if the helmet is available locally in order to reduce the shipment cost.

4.4 The Quality Function Deployment Method

Based on the house of quality chart in Fig. 3.3, safety was rated as the highest priority by the customers followed by reliability, comfortable, lightweight, easy to use and the appearance of the helmet. Furthermore, based on the importance rating, the functional requirement of inventing the chin guard and the mouth guard obtained the highest rating score of 92, followed by the cushion inside the safety helmet; high collision absorption foam and the usage of soft materials with the importance score of 90, 70 and 60 respectively. The functional requirement that obtained the least score of 5 was the high visual appeal.

In addition, technical evaluation of the competing products with the toddler's safety helmet such as SGV motorcycle helmet and bicycle helmet was also carried out through the house of quality method. Therefore, it illustrated that the cushion provided in the toddler's safety helmet was of highest quality compared to the other two helmets and the toddler's safety helmet was made of soft material components fully. Other than that, the evaluation also showed that the toddler's safety helmet had a better air flow with many holes compared to the SGV helmet and bicycle helmet. The toddler's safety helmet was also evaluated as very flexible as it was stretchable and had a higher concentration of high collision absorption foam compared to the other two helmets. In conclusion, the toddler's safety helmet has obtained a good ranking compared to the SGV motorcycle helmet and bicycle helmet which have their own functions for different purposes.

4.5 Designing the Improved Parts for the Safety Helmet

All the drawings of the improved parts for the safety helmet such as the chin guard, mouth guard; knob at the end of chin strap and the straps to attach to the top of the helmet was designed using the AutoCAD software. The AutoCAD file was saved in .dwg format before it is converted to solid works in the .stl format as the 3D printer could not interpret files in .dwg format. The sapphire software was used in the 3D printer to load the .stl file and placed them in the correct orientation before printing the object. The orientation of the object was altered by rotating or moving the object according to its preference. Fig. 4.14 shows the files saved in .dwg format before converted to .stl format.

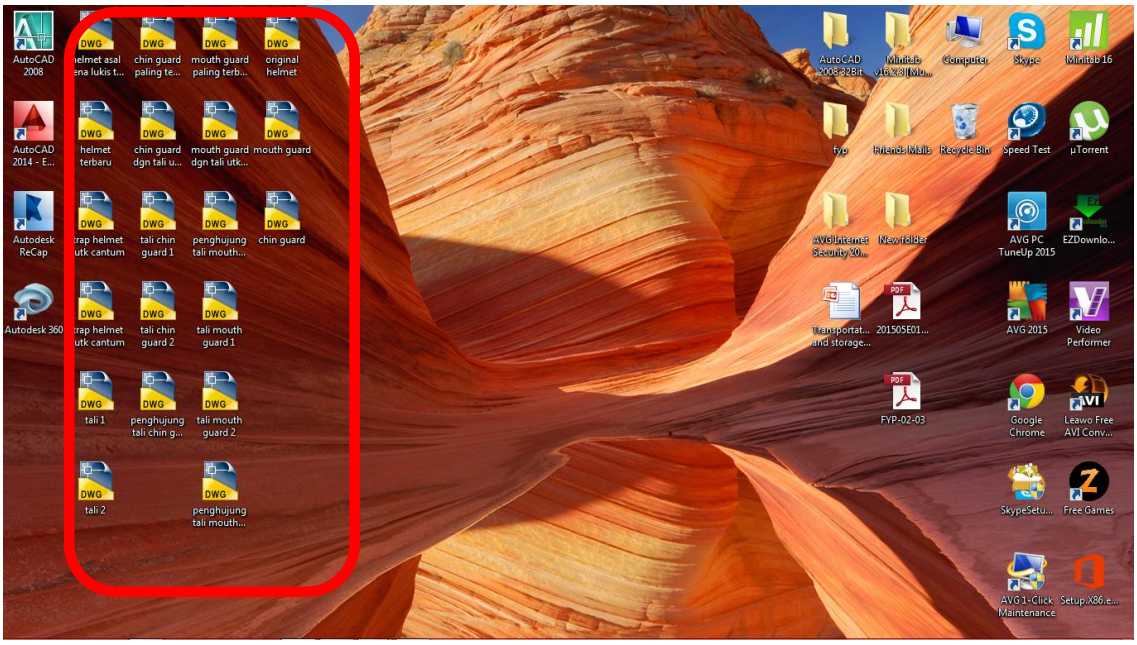


Figure 4.14: Files saved in .dwg

4.5.1 Chin Guard

The design of the chin guard was loaded and the printing was executed. Fig. 4.15 shows the object was placed flat downwards with the end of the two bending part touching the bed of the printer in order for the 3D printer to print the bending parts and the strap holders without any breakage.

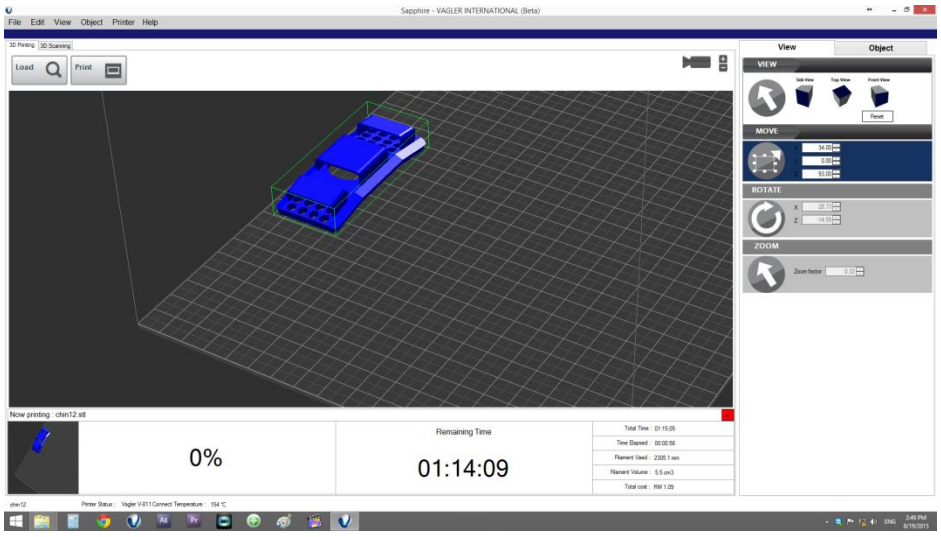


Figure 4.15: Chin guard

For this design, the required printing time was 1 hour and 15 minutes and consumed the filament volume of 5.5 cm3. The printing also required a temperature of 154 degree Celsius to melt the polylactide (PLA) material to produce the desired design. The printing would cost only RM 1.09. Fig. 4.16 shows the chin guard printed by the 3D printer and Fig. 4.17 shows the testing of the chin guard on the user.

Figure 4.16: The chin guard printed by 3D printer

Figure 4.17: Testing the chin guard on the user

The chin guard was designed specially to further enhance the coverage of the safety helmet towards the full face of the toddler. The main purpose of this chin guard was to protect the chin when the toddler suffers a fall. The chin guard would be very flexible and ergonomically designed as it has two stretchable parts and bended according to the growth of the chin and cheek of the toddler. The centre part of the chin guard has a hole to hold the toddler's chin to their comfort. It would be advisable to fabricate the chin guard using the same material used to produce the safety helmet so that the manufacturing process would be easier, faster and cheaper.

Furthermore, the chin guard was designed to be fixed to the existing strap of the safety helmet it cannot be removed from the safety helmet. This is due to the release end of the chin strap that has a green tab bigger in size of the holder which is designed for the strap to enter. Fig. 4.18 illustrates the situation clearly.

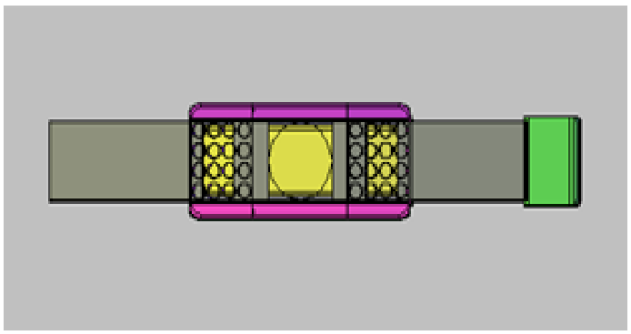


Figure 4.18: The chin guard with the green tab

4.5.2 Mouth Guard

The design of the mouth guard was loaded and the printing was executed. Fig. 4.19 shows the object was placed flat on the bed of the printer for the 3D printer to print the object without any breakage. The object was placed in such order because it cannot be placed on the opposite surface as it has four small objects which will not be stable for printing the object.

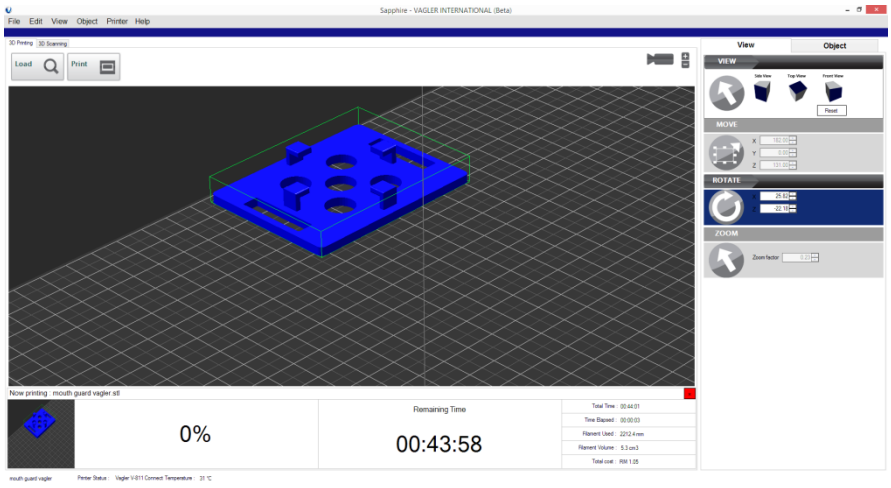
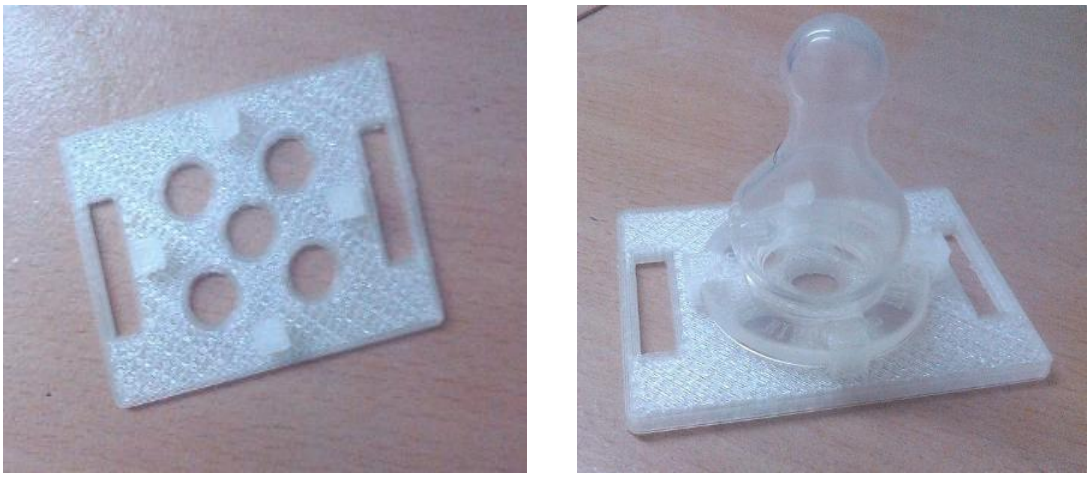


Figure 4.19: Mouth guard

For this design, the required printing time was 44 minutes and consumed the filament volume of 5.3 cm3. The printing also required a temperature of 31 degree Celsius to melt the polylactide (PLA) material to produce the required design and the printing would cost only RM 1.05. Fig. 4.20 shows the mouth guard printed by the 3D printer and a pacifier attached to the mouth guard. Besides, Fig. 4.21 shows the testing of the mouth guard on the user.



(a) Top view of the printed mouth guard (b) The mouth guard with a pacifier

Figure 4.20: The mouth guard printed by 3D printer

Figure 4.21: Testing the mouth guard on the user

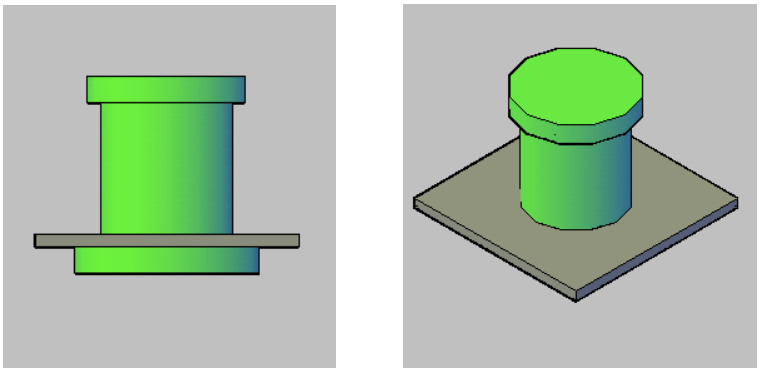
The designed mouth guard has dual functions. The main purpose of the mouth guard was to prevent the toddlers from chocking due to putting toys into their mouth. In the other hand, it can be turned around to be used as a pacifier which will satisfy both objectives of safety and convenience. This mouth guard is very flexible as it can be removed when not using and attached when using. The mouth guard can be used as a pacifier due to its design which has four small size holders to hold the pacifier when fixed to the mouth guard. The mouth guard would be attached to an additional strap which was designed together with the mouth guard to be fixed slightly on top of the chin guard strap. Furthermore, the mouth guard strap can be removed completely from the helmet if not in use. This is possible because it has a knob towards the end of the other side of the releasing strap end which is entered and removed through a hole created in the helmet for this purpose.

4.5.3 Comparing the Chin Guard and Mouth Guard

Based on the chin guard and mouth guard printed using the 3D printer, there were differences in the time, cost and volume. It was due to their respective designs where the chin guard had more openings and more complex design compared to the mouth guard which has a shape of a solid cube. The more complicated the object designed, more time and volume of filament required and was proven as the chin guard required 1 hour 15 minutes and 5.5cm3 volume of filament for printing while the mouth guard only needed 44 minutes with 5.3cm3 volume of filament. Lastly, the cost of printing is directly proportional to the amount of material used where the chin guard used more material cost RM 1.09 slightly higher than mouth guard cost of RM 1.05.

4.5.4 Final Design of the Knob at the End of Chin Strap

There was a need to improve on the strap of the helmet which was hazardous to the toddlers based on the outcome of the user scenario method carried out before the designing process. In the initial design of the safety helmet, the opposite side of the releasing strap end was stitched to the safety helmet which would restrict the user from moving the strap. So, the strap end was replaced by a small knob that will be inserted through the strap and the helmet. A hole was created on the helmet and the strap for the knob to enter the helmet and hold the strap together with it. With these changes, the possibilities of the hazard reoccurring can be reduced. Fig. 4.22 illustrates the knob with the strap clearly.



(a) Side view (b) Top view

Figure 4.22: 3D view of the knob with strap

4.5.5 Final Design of the Straps on Top of the Safety Helmet

The strap on top of the safety helmet was created due to the feedback stating that the helmet was loose on the user who was 1 year 5 months old. So, this strap was specially designed on top of both front and back of the safety helmet as it helps to tighten the safety helmet from the top while the user is wearing it. The design of this object is slightly curvy due to the curve surface of the safety helmet for toddlers. There are many different types of strap closure that can be used but the strap closure that used for this safety helmet is the Velcro closure. Fig. 4.23 shows the strap on top of the toddler's safety helmet clearly.

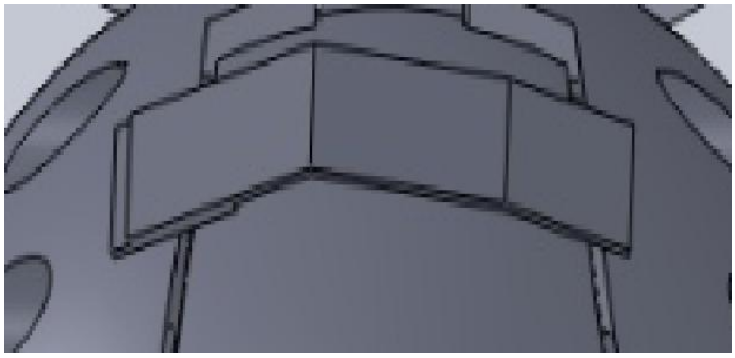
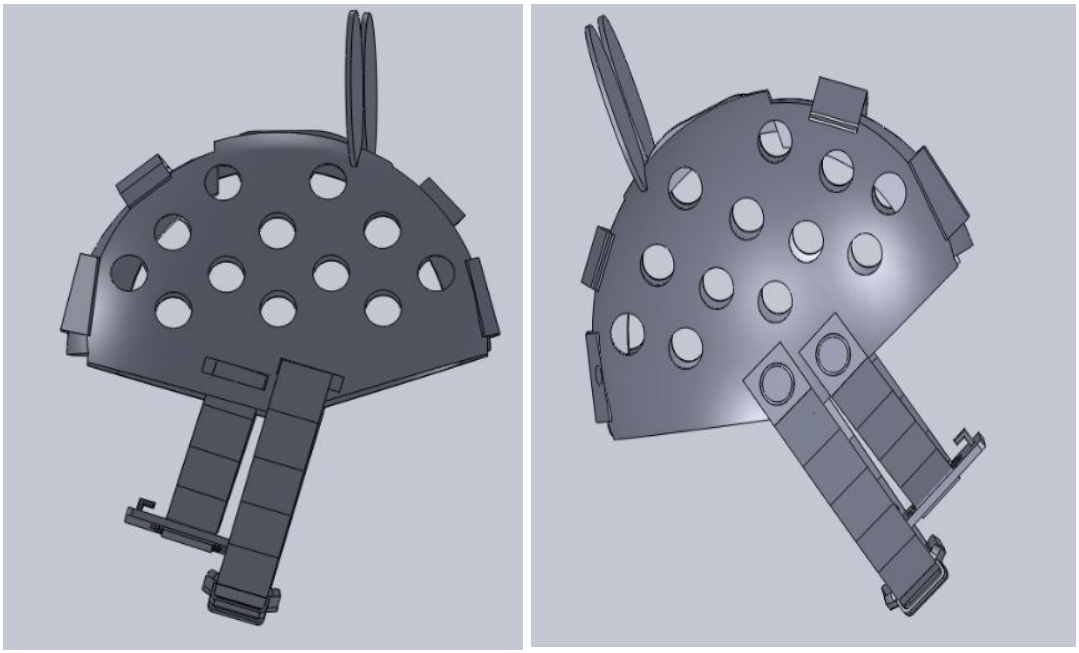


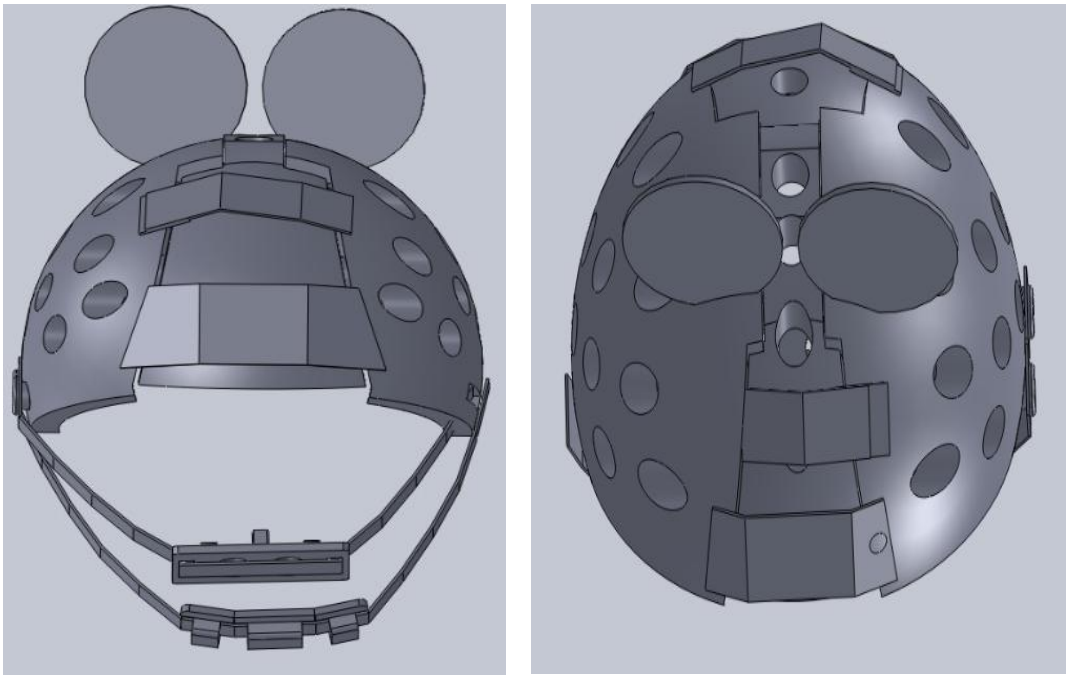
Figure 4.23: Strap on top of the safety helmet

4.5.6 Assembling the Designed Parts Using Solid Works

All the improved parts were assembled using the solid works software. Each part was required to be saved in separate .dwg files before converting to the .stl format as the assembly process can only be carried out one object at a time. The attachments of all the parts are clearly shown in four different views of the final design of the safety helmet. Fig. 4.24 part (a) shows how the chin guard and mouth guard are attached to the safety helmet where two rectangle shape holes are created for the straps to enter. Fig. 4.24 part (b) shows how the knob at the end of the chin strap and strap for the mouth guard were designed as there was only one strap attached to the original safety helmet by stitching. Fig. 4.24 part (c) and (d) shows the straps on top of the front and back of the safety helmet.



(a) 3D Left side view (b) 3D Right side view



(c) 3D Front view (d) 3D Back view

Figure 4.24: Final design of the improved toddler's safety helmet

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the survey conducted in Hospital Raja Permaisuri Bainun Ipoh, the head injuries suffered by the toddlers in Malaysia were found to be very high. Hence, there is a need for this safety helmet for toddlers to come to the fore as it can help reduce the injuries. However, the parents and nurses are mostly not aware of the existence of this safety helmet due to the lack of publicity but they are willing to purchase the safety helmet if the price is reasonable in the range of RM 100 – RM 200. So, the marketing team of this safety helmet should find a way to solve this issue.

This project focuses on redesign the toddler's safety helmet using the design techniques in industrial engineering. A flowchart had been proposed and every significant stage was satisfied in order to follow up with the objectives. This will eventually help the redesigning process of the toddler's safety helmet with some clearer ideas on what the customer really needs before making the improvement on the safety helmet.

The designing of the improved parts such as the chin guard, mouth guard, knob at the end of the chin straps and straps on top of the helmet were completed after the methodologies parts were gone through part by part. The purpose to put forward a chin guard and mouth guard add on was because the toddlers suffers

injuries to their chin while falling down and get chocked by putting toys inside their mouth. This invention will surely support in solving this issues.

Other than that, further improvement on the end of the chin strap where a knob was designed and the additional Velcro straps on top of both front and back of the safety helmet were based on the outcome of the observation carried out on the users. There were issues such as the chin strap is hazardous as it may cause chocking while the toddlers remove the safety helmet by themselves and the safety helmet was not fit enough for the younger toddler observed during the observation. So, the improvement on these two areas would minimize the severity of the issues. All this improvements are further supported from the results of the objective tree method and house of quality gathered where the improvements made to the safety helmet satisfy all the objectives and needs of the customer and users.

In conclusion, the designing of all the improved parts based on the methodologies carried out satisfied the main function of the safety helmet which is to protect the toddlers head and face.

5.2 Recommendation

This project was about improving the toddler's safety helmet by designing the improvements to the safety helmet but there is a lack of facility and equipments to carry out the testing part of the product. Testing process is a very important procedure in designing a product as it would enable us to know whether the product is safe and of high quality. Therefore, it is very important to have all the necessary facilities and equipment to carry out the testing of the product produced and it would help the future studies. Before hand, it has to be monitored under in vitro studies. Looking eye to eye in this matter of study, researchers should approach in various factors in improvising this safety helmet and exposing it to the community.

REFERENCES

Thudguard.com, (2015). Why is Thudguard unique? [Online] Available at: http://www.thudguard.com/faq/why-is-thudguard-unique [Accessed 19 March 2015].

Thudguard.com, (2015). What is Thudguard made of? [Online] Available at: http://www.thudguard.com/faq/what-is-thudguard-made-of [Accessed 16 Mar. 2015].

Cdc.gov, (2015). CDC | TBI Data and Statistics | Traumatic Brain Injury | Injury Center. [Online] Available at: http://www.cdc.gov/traumaticbraininjury/data/index.html [Accessed 3 March 2015].

Cdc.gov, (2015). CDC | Rates of TBI-related Emergency Department Visits by Age Group | Traumatic Brain Injury | Injury Center. [Online] Available at: http://www.cdc.gov/traumaticbraininjury/data/rates_ed_byage.html [Accessed 5 March 2015].

Cdc.gov, (2015). CDC | Percent Distributions of TBI-related Emergency Department Visits by Age Group and Injury Mechanism | Traumatic Brain Injury | Injury Center. [Online] Available at: http://www.cdc.gov/traumaticbraininjury/data/dist_ed.html [Accessed 21 March 2015].

Cdc.gov, (2015). CDC - Injury - Safe Child - Background - National Action Plan. [Online] Available at: http://www.cdc.gov/safechild/NAP/background.html [Accessed 13 Mar. 2015]

Thudguard.com, (2015). What safety standards does Thudguard meet? [Online] Available at: http://www.thudguard.com/faq/what-safety-standards-does-thudguard-meet [Accessed 22 March 2015].

Babyhealthsafety.com, (2015). Reviews: Baby's First Head Thudguard Baby Safety Helmet – Blue | baby health safety. [Online] Available at: http://www.babyhealthsafety.com/reviews-babys-first-head-thudguard-baby-safety-helmet-blue/ [Accessed 3 Mar. 2015].

Clark, E. (2015). Thudguard safety hat for toddlers. [Online] Gizmag.com. Available at: http://www.gizmag.com/thudguard-safety-hat-for-toddlers/9126/ [Accessed 30 Mar. 2015].

Control, N. and Prevention, C. (2015). Ten Leading Causes of Death and Injury - PDFs|Injury Center|CDC. [Online] Cdc.gov. Available at: http://www.cdc.gov/injury/wisqars/leadingcauses.html [Accessed 1 Apr. 2015].

Kidsafetyhats.com, (2015). Kid Safety Hats. [Online] Available at: http://www.kidsafetyhats.com/ [Accessed 31 Mar. 2015].

Sciencebuddies.org, (2015). The Engineering Design Process. [Online] Available at: http://www.sciencebuddies.org/engineering-design-process/engineering-design-process-steps.shtml [Accessed 28 Mar. 2015].

Thudguard.com, (2015). What is the difference between Thudguard and a cycle helmet? [Online] Available at: http://www.thudguard.com/faq/what-is-the-difference-between-thudguard-and-a-cycle-helmet [Accessed 25 Mar. 2015].

Thudguard.com, (2015). What safety standards does Thudguard meet? [Online] Available at: http://www.thudguard.com/faq/what-safety-standards-does-thudguard-meet [Accessed 3 Apr. 2015].

Abraham, V., Gaw, C., Chounthirath, T. and Smith, G. (2014). Toy-Related Injuries Among Children Treated in US Emergency Departments, 1990-2011. Clinical Pediatrics, 54(2), pp.127-137.

N. Borse, N., Cilchrist, J., A. Rudd, R. and F. Ballesteros, M. (2008). The CDC Childhood Injury Report: Patterns of Unintentional Injuries among 0-19 Year Olds in the United States, 2000-2006. Atlanta: National Center for Injury Prevention and Control, Centers for Disease Control and Prevention.

World Health Organization, (2015). Helmets: A Road Safety Manual For Decision-Makers and Practitioners. Geneva: WHO Press.

Zeegers, T. (2011). Why bicycle helmets are not effective in the reduction of injuris of cyclists. Nationaal verkeerskundecongres, p.39.

Pennington, N. (2010). Head Injuries in Children. The Journal of School Nursing, 26(1), pp.26-32.

Sangvai, S., Cipriani, L., Colborn, D. and Wald, E. (2007). Studying Injury Prevention: Practices, Problems, and Pitfalls in Implementation. Clinical Pediatrics, 46(3), pp.228-235.

Sleet, D., Schieber, R. and Gilchrist, J. (2003). Health Promotion Policy and Politics: Lessons From Childhood Injury Prevention. Health Promotion Practice, 4(2), pp.103-108.

Starosolski, Z., Kan, J., Rosenfeld, S., Krishnamurthy, R. and Annapragada, A. (2013). Application of 3-D printing (rapid prototyping) for creating physical models of pediatric orthopedic disorders. Pediatr Radiol, 44(2), pp.216-221.

Elwany, A. (2014). Additive manufacturing faces a number of challenges that IEs are well-equipped to solve. Making 3-D futures reality.

L. Martin, R., S. Bowden, N. and Merrill, C. (2014). 3D printing in Technology and Engineering Education. Technology and Engineering Teacher.

Li, P. (2014). 3D Bioprinting Technologies: Patents, Innovation and Access. Law, Innovation and Technology, 6(2), pp.282-304.

Overton, G. (2014). How does additive manufacturing ‘stack up’ against subtractive methods?. Laser Additive Manufacturing.

Sullivan, A. and Moorefield-Lang, H. (2012). 3-D Printing in Your Libraries and Classrooms. Knowledge Quest.

APPENDICES

Appendix A: Questionnaire for Parents

UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF ENGINEERING GREEN AND TECHNOLOGY

BACHELOR OF ENGINEERING (HONS) INDUSTRIAL ENGINEERING

FINAL YEAR PROJECT

TITLE OF TOPIC:

IMPROVING THE INFANT'S OR TODDLER'S SAFETY HELMET USING INDUSTRIAL ENGINEERING DESIGN TECHNIQUES

SURVEY QUESTIONS

Dear Respondents:

I am an undergraduate student from Universiti Tunku Abdul Rahman (UTAR), currently pursuing my degree in Bachelor of Engineering (HONS) Industrial Engineering. As a partial requirement of our degree program, I am conducting a research study. I truly appreciate your willingness to participate in this questionnaire. All the information provided in this survey will be kept strictly private and confidential and will be only used for academic purpose.

Thank you for your time and effort taken to complete this questionnaire.

Section A

1. Based on your parenthood, is it common the babies/toddlers prone to injuries?

   ☐ Yes
   ☐ No

2. Among the injuries suffered by toddlers, head injuries occur quite often. Do you agree?

   ☐ Yes
   ☐ No

3. Based on your experiences, how does a toddler get the head injuries?

   ☐ Object fall on head
   ☐ Fall down while playing
   ☐ Parents carelessness
   ☐ Others: please specify: ……...

4. As parents, what are the common steps that you would take once your child suffers from the head injury?

   ☐ Bring to hospital
   ☐ Apply ice-cubes
   ☐ Apply medicine
   ☐ Others: please specify: ……

5. In your point of view, what are the necessary steps should be taken to prevent the head injuries to toddlers?

   ……
   ……
   ……

6. There is an invention of safety helmet for toddler's indoor usage. Are you aware about it?

   ☐ Yes
   ☐ No

7. If yes, how often are you using the safety helmet for toddlers?

   ☐ All day long
   ☐ Not using at all
   ☐ When busy and can't take care of kids
   ☐ Others: please specify: ……

8. If No, what do you think are the causes of your lack of awareness about the safety helmet?

   ☐ Lack of publicity
   ☐ Expensive
   ☐ Not interested
   ☐ Others: please specify: ……

9. What are the areas/factors can be improvised from the existing toddler's safety helmet?

   ☐ Accessories
   ☐ Air-flow
   ☐ Accessibility
   ☐ Others: please specify: ……

10. Apart from head injuries, toddlers are prone to chin injuries and chocking while playing with toys and other stuffs. So, will you recommend a safety helmet with a chin guard and mouth guard for your toddler?

    ☐ Yes
    ☐ No

11. If there is a new innovation of safety helmet fulfilling all your needs that protect your child, would you buy it?

    ☐ Yes
    ☐ No

12. What is your budget if you have decided to buy a safety helmet?

☐ RM 100 below
☐ RM 100 – RM 150
☐ RM 150 – RM 200
☐ RM 200 above

Section B: Demographic Profile

1. Gender:

☐ Male
☐ Female

2. Status:

☐ Single
☐ Married

3. Age:

☐ Below 25 years old
☐ 25-35 years old
☐ 35-45 years old
☐ 45-55 years old
☐ Above 55 years old

4. Ethic group:

☐ Malay
☐ Chinese
☐ Indian
☐ Others: please specify: ……

5. Number of Children:

☐ None
☐ 1-3
☐ 4-6
☐ 6 above

6. Parents Income:

☐ Below RM 1000
☐ RM 1000 - RM2000
☐ RM 2000 – RM3000
☐ RM 3000 Above

7. Education Level

☐ PMR
☐ SPM/STPM
☐ Masters
☐ Diploma
☐ Degree
☐ Others: please specify: ……

Appendix B: Questionnaires for Nurses in Hospital Permaisuri Bainun in Ipoh, Perak

UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF ENGINEERING GREEN AND TECHNOLOGY

BACHELOR OF ENGINEERING (HONS) INDUSTRIAL ENGINEERING

FINAL YEAR PROJECT

TITLE OF TOPIC:

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SURVEY QUESTIONS

Dear Respondents:

I am an undergraduate student from Universiti Tunku Abdul Rahman (UTAR), currently pursuing my degree in Bachelor of Engineering (HONS) Industrial Engineering. As a partial requirement of our degree program, I am conducting a research study. I truly appreciate your willingness to participate in this questionnaire. All the information provided in this survey will be kept strictly private and confidential and will be only used for academic purpose.

Thank you for your time and effort taken to complete this questionnaire.

Section A

1. How frequent are the infants or toddlers being admitted due to the head injuries per day?

   ☐ 1-5 ☐ 6-10 ☐ 11-15 ☐ 15 Above

2. Among the cases admitted, how many of them are prone to head injuries?

   ☐ 1-5 ☐ 6-10 ☐ 11-15 ☐ 15 Above

3. Which of the followings is the root causes of the head injuries among toddlers?

   ☐ Object fall on the head
   ☐ Fall down while playing
   ☐ Parent's carelessness
   ☐ Others: please specify: ……

4. Which of the following age range below were admitted the most?

   ☐ Below than 1 year old
   ☐ 1-2 years old
   ☐ 2-3 years old
   ☐ Above 3 years old

5. How severe are the toddler's head injury cases brought to the hospital?

   ☐ Low severity
   ☐ Medium Severity
   ☐ High Severity
   ☐ Critical

6. There is a safety helmet for toddlers in the market. Are you aware about the existence of this safety helmet?

☐ Yes
☐ No

7. From your point of view, is the toddler's safety helmet sufficient to protect the head injuries suffered by toddlers?

☐ Yes
☐ No

8. If yes, will you recommend the safety helmet to the parents?

☐ Yes
☐ No

9. If yes, in your opinion, will the parents spend their money to purchase the toddler's safety helmet?

☐ Yes ☐ May be
☐ No ☐ Other please specify: ……..

10. From your observation, was there any cases toddlers being admitted due to usage of the safety helmet?

☐ None ☐ 1-5 ☐ 6-10 ☐ 10 Above

11. What are the common problems suffered by toddlers admitted due to the usage of safety helmet?

☐ Itchiness ☐ Neck Pain
☐ Skin Allergic ☐ Other please specify:

12. Is there a better need for a new innovation of the safety helmet?

☐ Yes
☐ No

13. If yes, what are the areas/factors to be improvised from the existing toddler's safety helmet?

☐ Weight ☐ Size
☐ Accessories ☐ Air flow inside helmet
☐ Accessibility ☐ Other please specify: ……..

Section B: Demographic Profile

1. Gender

☐ Male
☐ Female

2. Age

☐ Below 25 years old
☐ 25-35 years old
☐ 35-45 years old
☐ 45-55 years old
☐ Above 55 years old

3. Ethic Group

☐ Malay
☐ Chinese
☐ Indian
☐ Other please specify: ……..

4. Education Level

☐ SPM/STPM
☐ Diploma/Advance Diploma
☐ Degree
☐ Other: please specify: ……..

5. Experience in Paediatric Department

☐ Less than 1 year
☐ 1-3 years
☐ 4-5 years
☐ More than 5 years