UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ERGONOMIC DESIGN OF CRAYONS USING 3D PRINTING MOULD

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in fulfillment of the requirements for the degree of
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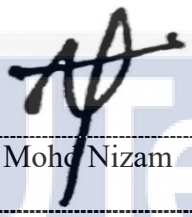
DECLARATION

I declare that this thesis entitled “Ergonomic Design Of Crayons Using 3D Printing Mould” is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

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APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology with Honours.

Signature : .....

Supervisor Name : Nor Faizah Binti Haminudin

Date : 20/1/2023

DEDICATION

This report is dedicated to all of my lecturers of FTKMP faculty – past and present. My supervisor that have thought and guide me many things that don't know, Pn Nor Faizah Binti Haminudin. To my panel Pn. Sushella Edayu Binti Mat Kamal, Ts. Mohd Harris Fadhilah Bin Zainudin and Ts. Dr. Norfariza binti Ab Wahab who pointed out my mistake during the presentation and also for their advice. I also want to dedicated to my family and friend members who supported me while I researched and wrote the report. My fellow friends on FTKMP, Mom, Dad – thank you all. I'm grateful for your support.

ABSTRACT

Multiple studies have demonstrated the benefits of using crayons in the occupational therapy programme. Colouring using crayons improving better motor skill that aids in the development of other abilities. Crayons assist youngsters in developing the skills necessary to wield a pencil, and the ergonomic component is critical in this process. Thus, the aim of this project is to design a new shape of organic crayon mould by considering several aspects such as holding style, grip position and other related aspects. The reason of doing this project is because of the lack consideration of designing the shape of crayon which most of the commercial crayon has cylinder-like shape with blunt tip at the end. The common shape of the crayon causes it to easily break and sometimes difficult for young children to hold it properly. The new design of crayon mould is based on output obtained from a quantitative survey. The survey has been answered by 100 children at the age of 4 to 6 years old. From the survey, the main findings of the survey show majority of Malaysians children was heavily taught to use type J, dynamic tripod style in holding pencils. A lot of research has been done and proving the importance of that style towards the ergonomic of children's pencils and crayons. After gathering the data survey, a set of selection criteria was considered. Those criteria were matched to form five conceptual designs. the Pugh's method was applied and evaluated the best design out of five conceptual designs. The final design, however, has limitation in terms of cost and weight. Thus, some modifications have been made before designed in SolidWorks software. Overall, three simulation tests and one physical test have been conducted on the mould. There is weight test, static analysis test and thermal test. The last physical test was done to get the duration of complete set of crayons. Finally, the expected outcome from this project is to have a mould for crayons that will assist children in their writing and drawing journey according to their needs.

ABSTRAK

Pelbagai kajian telah menunjukkan faedah menggunakan krayon dalam program terapi pekerjaan. Mewarna menggunakan krayon meningkatkan kemahiran motor yang lebih baik yang membantu dalam perkembangan kebolehan lain. Krayon membantu anak-anak muda dalam membangunkan kemahiran yang diperlukan untuk menggunakan pensel, dan komponen ergonomik adalah penting dalam proses ini. Justeru, matlamat projek ini adalah untuk mereka bentuk acuan krayon organik baharu dengan mengambil kira beberapa aspek seperti gaya pegangan, kedudukan cengkaman dan aspek lain yang berkaitan. Alasan melaksanakan projek ini adalah kerana kurangnya pertimbangan dalam mereka bentuk bentuk krayon yang mana kebanyakan krayon komersial mempunyai bentuk seperti silinder dengan hujung tumpul di hujungnya. Bentuk krayon yang biasa menyebabkan ia mudah pecah dan kadangkala sukar untuk kanak-kanak kecil memegangnya dengan betul. Reka bentuk baru acuan krayon adalah berdasarkan output yang diperoleh daripada tinjauan kuantitatif. Tinjauan tersebut telah dijawab oleh 100 kanak-kanak pada usia 4 hingga 6 tahun. Daripada tinjauan tersebut, dapatan utama tinjauan menunjukkan majoriti kanak-kanak Malaysia banyak diajar menggunakan gaya tripod jenis J, dinamik dalam memegang pensel. Banyak kajian telah dilakukan dan membuktikan kepentingan gaya itu terhadap ergonomik pensel dan krayon kanak-kanak. Selepas mengumpul tinjauan data, satu set kriteria pemilihan telah dipertimbangkan. Kriteria tersebut dipadankan untuk membentuk lima reka bentuk konsep. kaedah Pugh telah digunakan dan menilai reka bentuk terbaik daripada lima reka bentuk konseptual. Reka bentuk akhir, bagaimanapun, mempunyai had dari segi kos dan berat. Oleh itu, beberapa pengubahsuaian telah dibuat sebelum direka dalam perisian SolidWorks. Secara keseluruhannya, tiga ujian simulasi dan satu ujian fizikal telah dijalankan ke atas acuan. Terdapat ujian berat, ujian analisis statik dan ujian haba. Ujian fizikal terakhir dilakukan untuk mendapatkan tempoh set krayon yang lengkap. Akhir sekali, hasil yang diharapkan daripada projek ini adalah untuk mempunyai acuan untuk krayon yang akan membantu kanak-kanak dalam perjalanan menulis dan melukis mengikut keperluan mereka.

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LIST OF SYMBOLS AND ABBREVIATIONS

′′	-	Inches
cm	-	Centimeter
mm	-	Milimeter
L	-	Litre
ml	-	Mililitre
°C	-	Degree celcius
N/m^2	-	Newton per metre square
TPU	-	Thermoplastic Polyurethane
ABS	-	Acrylonitrile butadiene styrene
PA	-	Polyamide
PTFE	-	Polytetrafluoroethylene

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background Study

Crayons, as seen in Figure 1.1, are a 200-year-old waxed base sketching medium. There was a lot of advancement and improvement in the materials utilised and production procedures throughout that time (Barnett, 2006). There are a variety of production methods for crayons and other waxed-based drawing medium. Molding or extrusion is the most typical method (Williams & Susan, 1982). However, there are various aspects to consider while constructing the custom crayon mould. The first is the material that will be cast into the mould and will be able to endure several temperature changes. Quick temperature changes, on the other hand, might produce inherent stress, which can harm the product and reduce the mould's lifespan (Brtan, 2016). Finally, there are the dimensions and form of these crayons to consider.

Figure 1.1 Example of crayons

In order to successfully promote handwriting skills efficiency, ergonomic considerations in design should be addressed. As the kid writes, ergonomic aspects such as paper location, pencil grip, upper extremity stability, writing posture, and mobility must be considered. The association between pencil grip posture and handwriting skills has been studied in several research (Smith, 2004; McHale et al., 1992; Chu, 1997; and Cermak, 1991). Only a small portion of this has been put into effect. The present market design focuses less on macro-ergonomics concerns including learning settings, ergonomics pedagogy, and curriculum content or structure (Legg, 2007). Given that handwriting is a dynamic process with spatial, kinematic, and temporal components, computerised techniques that are more objective and quantitative have been employed to analyse dynamic aspects (Rosenblum et al., 2003).

Therefore, this study will consider the important factor mentioned above in designing the new crayon mould using 3D printing. 3D printing, as in Figure 1.2, is a rapid-emerging technology that can produce physical objects from a geometrical representation using successive material addition.

Figure 1.2 Example of 3D

1.2 Problem Statement

In today's market, a lot of crayons are made with lesser consideration of the ergonomics aspect. As a result from the lack of ergonomic design for children's crayons might be underdevelopment of in-hand handling, which could lead to issues with drawing and handwriting in school-aged children. In addition, issues such as a poor grip pattern are thought to be a mirror of insufficient used-hand manipulation capability on performance of handwriting (Feder & Majnemer, 2007). One of the vital factor is grip pattern because it enables for the small movement required for drawing and writing, and an insufficient pencil grasp might make grading and isolating distal joint motions difficult (Feder & Majnemer, 2007). Different studies came up with their own definitions of grip patterns in order to differentiate between mature and immature grab patterns (Rosenbloom & Horton, 1971; Schneck & Henderson, 1990). Because kids spend the majority of their time writing at school, immature grasp habits may produce handwriting issues (Dennis & Swinth, 2001). An uncomfortable grasp is frequently caused by fine motor impairment, particularly weak finger muscles. A lack of coordination occurs when the finger muscles are undeveloped. Thus, it is important to take into consideration of several aspects in designing the new mould for the crayons. Aspects such as gender, holding sides, holding style, grip force, and grip circumference data of children at the age of 4 to 6 will be tabulated and analysed. All the aspects mentioned are crucial in order to avoid future difficulties faced by the children and also improve their motor-skills.

1.3 Research Objective

The main aims of this research are:

1. To analyse the criteria of children's ergonomics in handling crayons.
2. To create a suitable design according to the data from the quantitative survey.
3. To fabricate the ergonomic crayon mould using 3D printing.

1.4 Scope of Research

The scopes of this project are as follows**:**

- Selecting 100 children age 4 to 6 years old in Malaysia as a respondent.
- Survey question including the data of gender, age, holding side and holding style of pencil shape, ball and cube respectively, and finally, grip test and circumference.
- Determine the average size (length, diameter, shape) of Crayola Jumbo Triangular Crayons due to its claimed to be a design with easy to grasp function and won't allow them to roll away.
- Sketch conceptual design according to the survey data and apply the Pugh method to choose the best final design to compare with Crayola Jumbo Triangular Crayons.
- Create the mould using 3D printing using nylon material.
- Testing the mould using SolidWorks simulation and physical test.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of crayons

Previously known as wax pastel, a crayon is a coloured wax drawing or writing utensil. Pastels containing oil pastels and a dry binder like gum Arabic. However, wax crayons show it differ by having a wax and oil binder. Crayons are inexpensive and easy to use, and they come in a variety of colours. Wax crayon was said to be less sloppy than most paints and markers. It is available in a variety of colours, and have blunt points which removes the risk of sharp edges when used. By having these components, it makes them perfect utensil to teach young-aged children the art of drawing, as well as for student and professional artists.

2.2 History of crayons

The word ‘crayons’ is a derivation from the French word craie that means a chalk, which originally from the Latin word creta which means Earth. It was first used in the 16th century to signify "chalk pencil" (Merriam, 2004). Later, the term was simplified to "pencil," that are still denotes in modern language of French (Daven, 2011). It has been thousands of years the idea of mixing a kind of wax with colour been around. Encaustic painting is a technique that involves binding colour into stone with heated beeswax and coloured pigment. The picture was then "burned in" and fixed in place using a heat source. Pliny the Elder, one of the famous Roman scholar, is considered to have described the earliest wax crayon sketching methods (Girdler, 1967).

Romans, Egyptians, Greeks, and including indigenous peoples in the Philippines adopted this technology, which is being used today. However, because the procedure was not employed to create crayons in a form that could be handled and coloured with, it was ineffectual for use in a school or as children's crafts (Ward & James, 1914). C. Harold Smith and Edwin Binney invented and marketed the Stanol marking crayon in 1902. In 1903, Alice Stead Binney, Edwin Binney's wife, invented the name Crayola by combining the French word for craie and chalk, with the first part of oleaginous, another term used to define paraffin wax used to produce the crayons, as shown in Figure 2.1 (Ward & James, 1914).

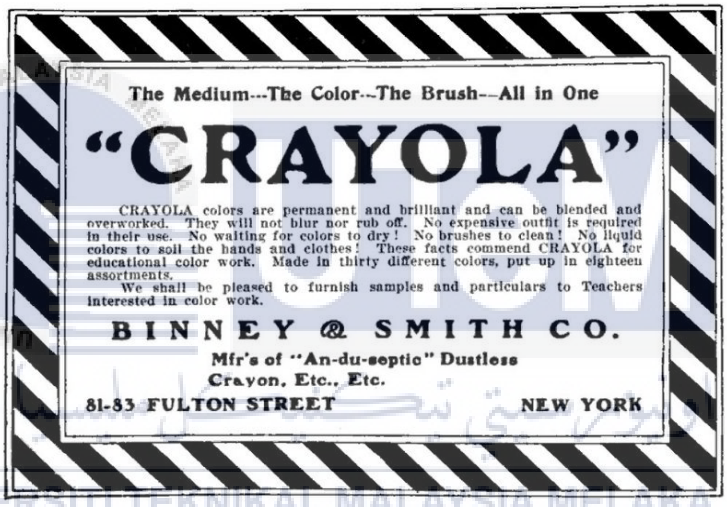

Figure 2.1 Crayola label

2.3 Early Crayons Design

In Europe, the "modern" crayon, a man-made cylinder resembling current sticks was developed. Cone-shaped crayon tips were commonly used, as depicted in Figure 2.2. They can draw thick, waxy lines on almost any surface, making them perfect for drawing rough, highly visible lines or colouring in larger portions of a project. This type of tip is commonly found on children's crayons. The complete hand is in touch with the item in a cylindrical hold, which is curled with thumb opposition. Gross grip is a typical phrase for this type of

grasp (Bailey, 1988; Harris & Livesey, 1992; Schneck, 1991; Weil & Amundson, 1994; Ziviani & Elkins, 1986). In order to bend the fingers around curved objects, a cylindrical grip necessitates the utilisation and strength of the extrinsic and intrinsic muscles of the hand. The thumb is abducted and flexed in this posture. To grip a broom handle, baseball bat, or ice cream cone, you'll need a cylindrical grasp. The cylindrical grip usually develops early in development, starting with the palmer grasp around the age of 12 months. This grip is an early pre-writing grasp that precedes fine motor development. With thumb abduction and finger abduction variations, this grip pattern matures into the cylindrical grasp.

Figure 2.2 Example of cone-shaped tips crayons

2.4 Factors Influencing Children Writing Skills

Students utilise writing to record, express, and share ideas throughout their educational careers (Tseng & Cermak, 1993). Students who fail to study and dominating handwriting abilities will surely feel anxious and frustrated, in which may influence their overall academic achievements (Bonney, 1992). Majority of childrens with handwriting problems are sent to occupational therapy for a variety of reasons, either as a major reason or in combination with other challenges (Bonney, 1992; Weil & Amundson, 1994). Several

studies have been undertaken in recent years with the goal of exploring the numerous elements that affect handwriting skill (Bailey, 1988; Harris & Livesey, 1992; Schneck, 1991; Weil & Amundson, 1994; Ziviani & Elkins, 1986). The link between perceptual-motor skills and handwriting ability was the focus of several of these investigations. Other research looked at the link between ergonomic parameters like pencil grip and writing pressure and writing performance. Teachers or doctors may generally see these ergonomic aspects in the classroom, as opposed to perceptual motor skills. Understanding the ergonomic aspects that influence handwriting might aid in the development of handwriting programmes.

2.4.1 Pencil Grasp

At an early age, children usually acquire their preferred pencil grip (Erhardt, 1994; Rosenbloom & Horton, 1971). Children between the ages of one and two handled their crayons or pencils in a palmar-supinate configuration, as seen in Figure 2.3 (a). (Erhardt, 1994). The arm moves as a complete unit from the shoulder, fisted around the pencil with the ulnar side toward the pencil tip. The digital pronate grip, Figure 2.3 (b), appears at the age of 2 to 3 years. The pencil tip is closest to the index finger and thumb, with the rest of the fingers wrapping around the top shaft and the pencil's end protruding beyond the ulnar side of the hand. Around the age of 3 to 4, a static tripod grip appears shown in Figure 2.3 (c). The pencil is held on the radial side of the middle finger with the pad of the index finger on top of the shaft and the pad of the thumb in opposition to the index finger. The arm continues to move as a unit, with some wrist and elbow movement. The dynamic tripod grip, Figure 2.3 (d), appears between the ages of 4 and 6, as the child's fine motor control develops. The pencil is held in the fingers in the same position as in a static tripod, but the proximal arm joints are stable, and the writing action is controlled by intrinsic hand muscles.