TECHNICAL RESEARCH REPORT



Colour Creature

Liam Cloete

Industrial Design 300, Open Window 2026

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Colour Creature



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ID300 Theory

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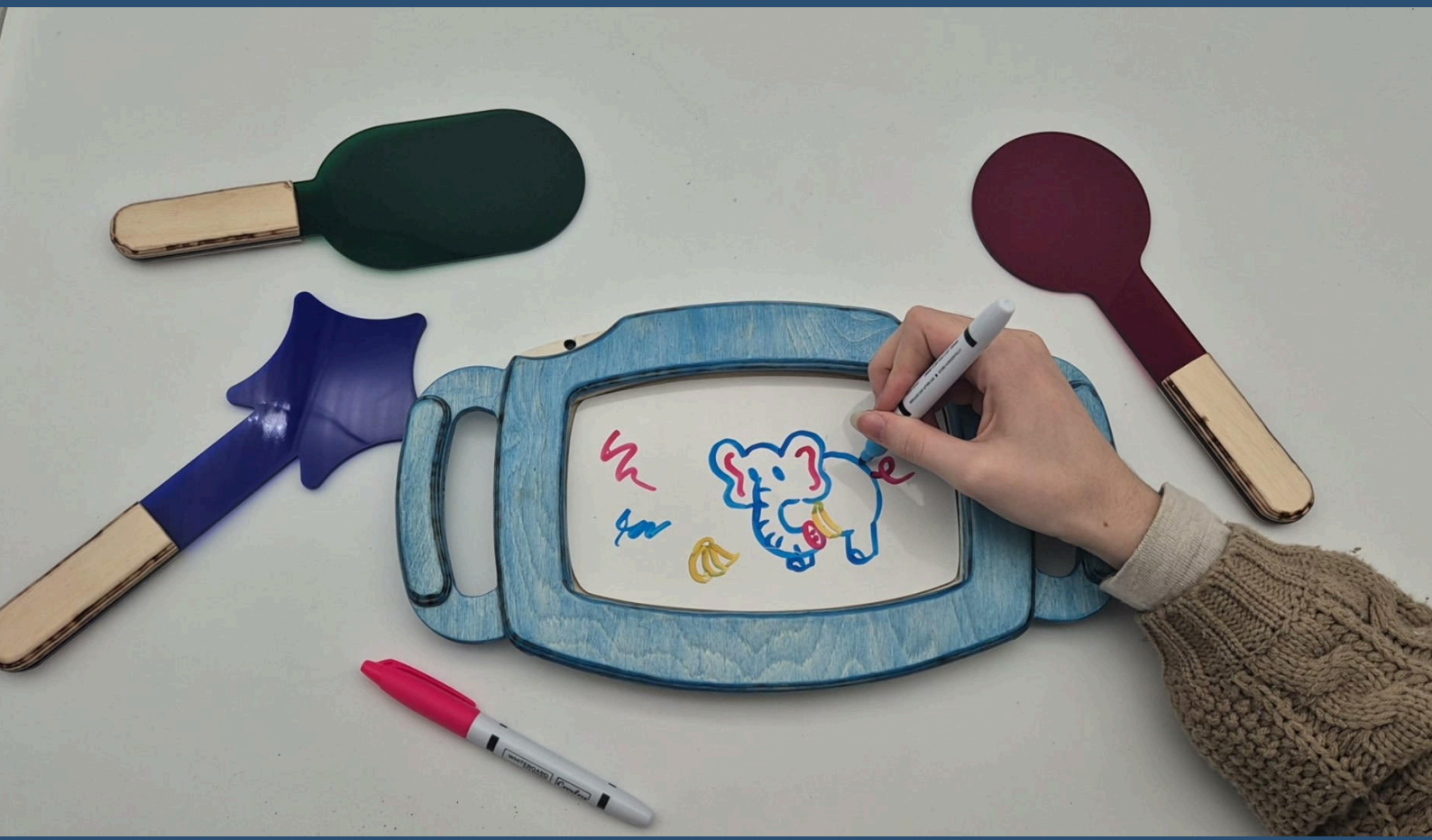
Introduction:

The brief for this term requires us to create a functional Final Prototype that serves to stimulate critical thinking and curiosity in the realm of STEM products. The target end-user is childhood development, particularly the earlier stages. Which means the product needs to have high educational value whilst still being intuitive, safe, durable and fun for the user. The Colour Creature is a tactile educational tool that decodes the optical science of subtractive colour mixing through analogue physical play. The main aim of this report is to demonstrate the technical, safety, and manufacturing feasibility of the Colour Creature. Good industrial design is the harmony of material, user and manufacturing process. This report charts development and implementation, from pedagogical research to technical CAD, rendering and manufacturing.

The design intention is rooted in de-digitalising childhood and moving from "Tech as Magic" to "Technical Transparency". Where many STEM toys hide their technical secrets behind plain white plastic and phone apps, the Colour Creature enables children to see inside the system. By manually inserting PMMA (Acrylic) slides into a wooden structure, children discover the Carnovsky Effect and colour theory with their hands.

Design Analysis/ Methodology

This section will go through the conceptual process behind the creation of the STEM product, considerations made, the mapping of ideas and the path that led to the final product. In this Analysis, we will focus on what is required of us to make a final STEM toy and the workflow that led to it through multiple phases.



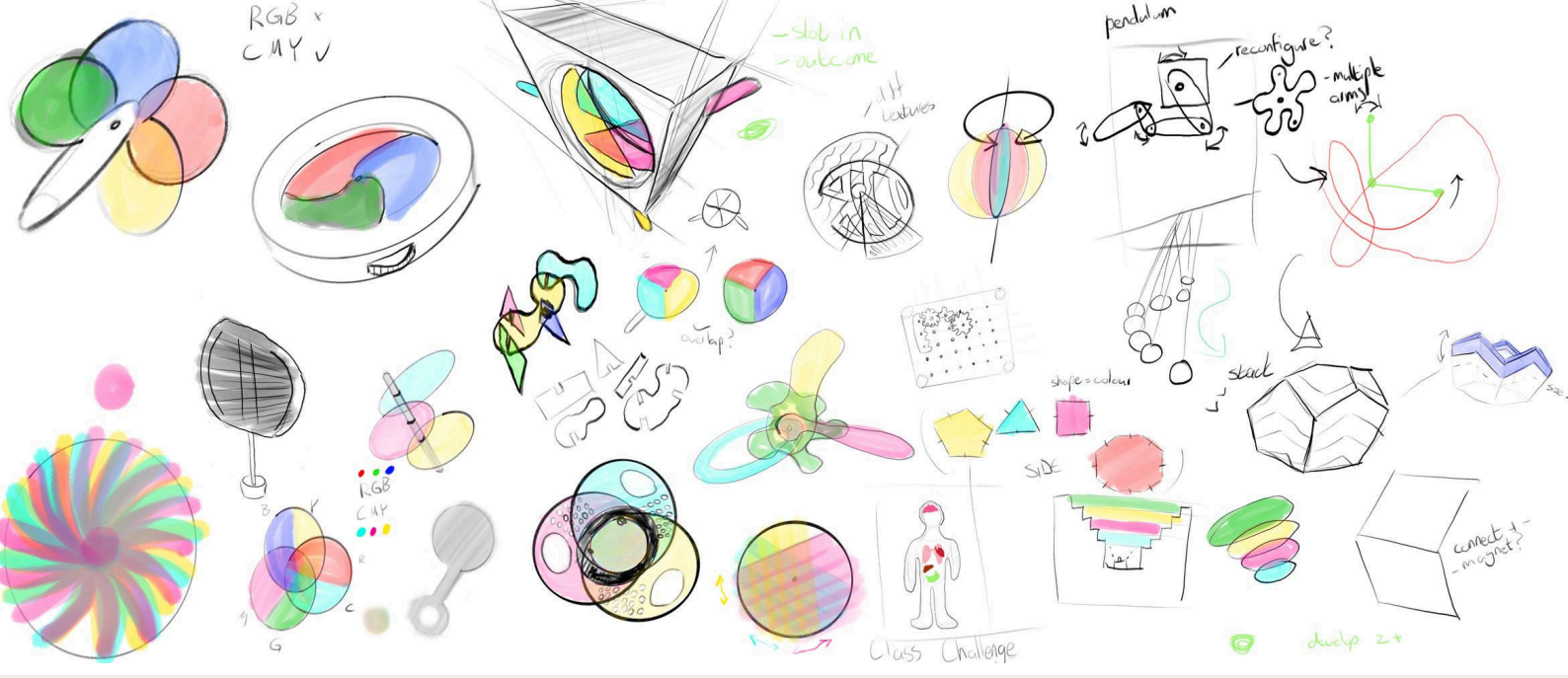


FIGURE 1

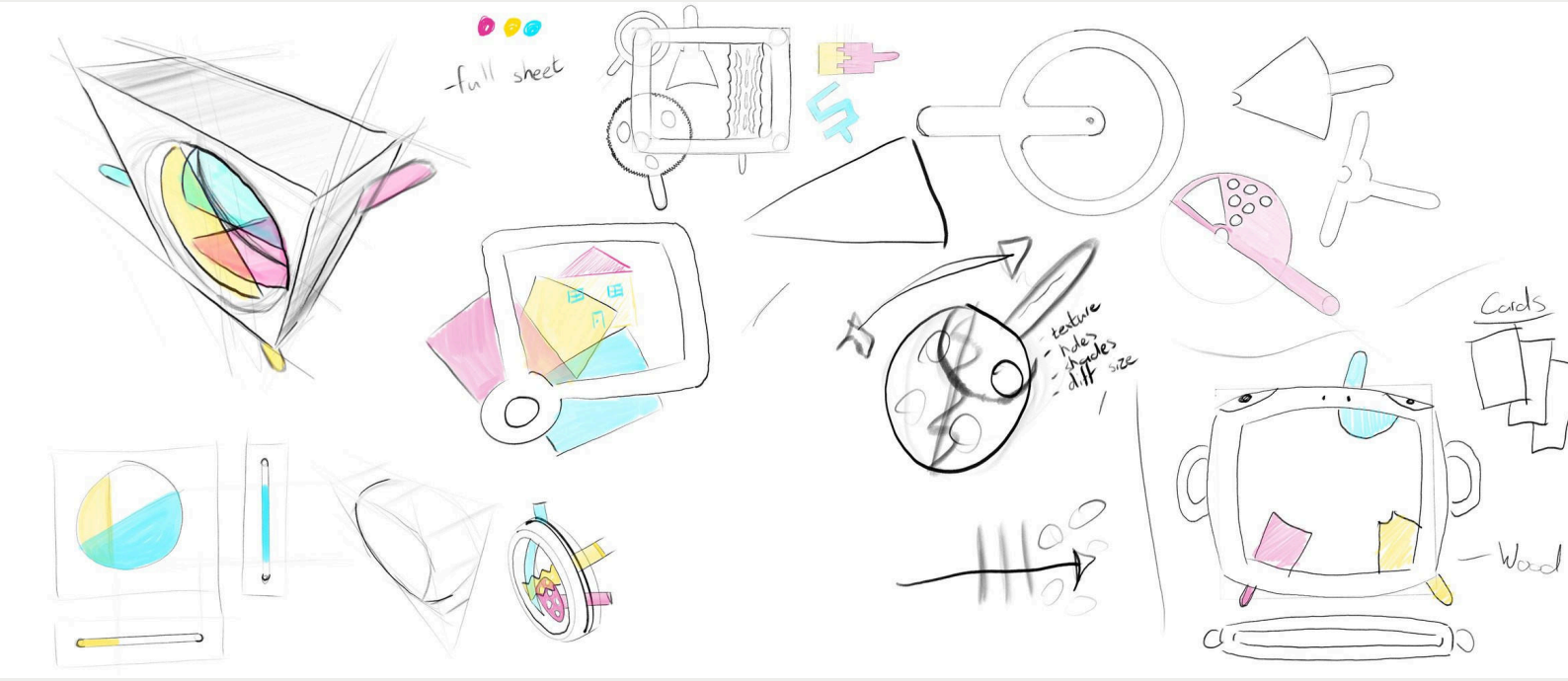
Ideation

The initial phase of the Design Analysis was Ideation, which focused on many sketches showing organic geometry, colours, interlocking filters and movement. Immediately, colour became the seed of the product in the sense that the product's main purpose was to teach colour theory, physics, science and maths, which we came to conclude in the research that would follow. In these sketches, we can see on the top left a form that holds many rings of translucent colour wheels, which can overlap to mix new colours. This developed to many different forms of overlapping colours for different purposes. There is a design where the colours overlap in a fan shape so that the colours would refract differently; some designs showed RGB (Red, Green, Blue) as well as some showed the contrasting colours being CMY (Cyan, Magenta and Yellow).

There are also some ideas of the layers flipping on themselves on a pole to create a lamp/ helix shape. Also, for more interactivity, some of the designs show that they can interlock and create unique forms that refract light differently; some experimented with hole cutouts and etching, which would all result in different end products or effects. Moving towards the right side, some integrated other learning systems like the anatomy of a body, as well as in the top right area, more experimentation with movement. Specifically, pendulums, double arm pendulums and Newton's Pendulum. There is also some designs that instead of relying on learning about colours through looking through the filters, you would use an external light source that casts light through the filters and manipulates light, shape and colour for different results.

FIGURE 2

Exploration 1



Moving on to the exploration of those ideas. The first idea we further developed was the colour perspex filter box form. You can see how the design developed from a box that overlapped filters with handles to manipulate the end resulting colour. Then we explored some forms as well as how the filters could be moved, if they were locked in place or if they could slide or even be removed. Then it was settled that the filters could be removable and be handheld, but differ in shape and size. You can also see experimentation with filter shapes, patterns and etching into the surfaces. The final concentrated idea that was explored here was the design at the bottom right. There we see a frame that looks like a monster with an open mouth; the ears can serve as handles as well as the frame serves to show the colour filters and allows inlays of coloured art or paper to be set inside. You can also see the slot mechanism in the top-down view. Also, there is an early demonstration of a feature, that being drawing Cyan/Magenta/Yellow onto a surface and then using filters to subtract that colour, which 'hides' the art and creates magic for the kids.



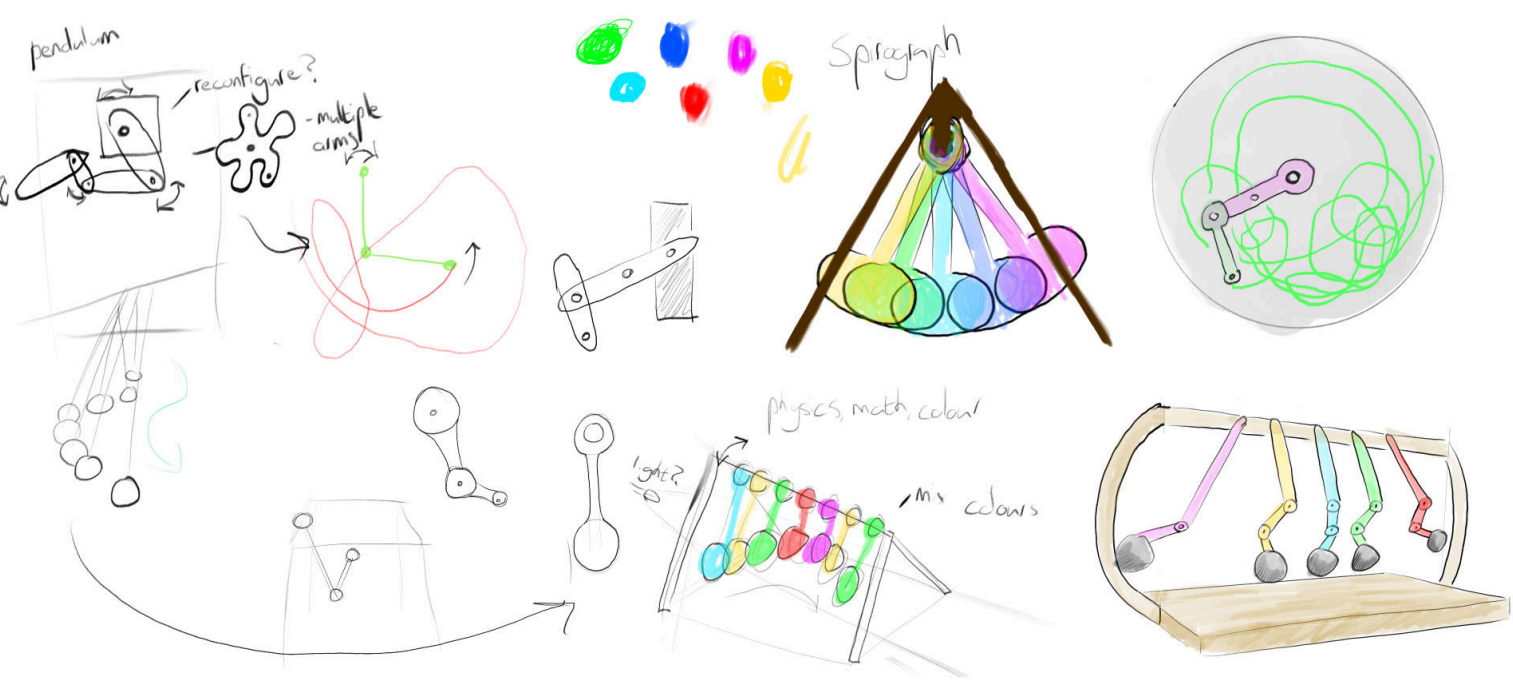
FIGURE 3

Exploration 2

Now looking at this exploration we still are dealing with colour theory and the manipulation of it. Form wise it initiated as a stepped wall which would allow for certain sizes of the colour perspex to fit and with that you could layer the perspex and allow light to shine through it to create different colours. Similarly it could serve as a lamp or be played with in the dark. Initially on the left the filters would just be different sizes so you could only put the certain colour at a certain layer of the product only allowing you certain variations in the final end product. So we developed on that by allowing the layers to be different colours, shapes, sizes as well as have cut outs to manipulate the light and colour further. So there are 3 variables: colour, shape and orientation at the middle of this, which allowed for 27 different initial resulting outcomes, but with more orientation, there could be more. The final condensed idea for this exploration was to have multiple filters of sectioned steps which allowed the perspex filters to slot in at the vertices, we also decided to make the sectioning filters smaller so the perspex sides could serve as a feature by illuminating as the final product wouldn't just be the light show with manipulating the filters but also the side as perspex illuminated nicely on the cut faces.

FIGURE 4

Exploration 3



Looking at this last exploration we can see more building up on the idea of Newtons Law, Momentum, Pendulums and Newtons Cradle. Looking at the top left we see a 3-armed pendulum that would be different coloured perspex too. So when this filter is put together it manipulates the colours constantly as it moved erratically, This then developed further to Newtons Cradle so that the different filters of colour would pass and do a wave of different Colours. This conjoined with the prior exploration in a sense where there was an Idea that you would have a light source shine through the Newtons Cradle and manipulate light through the many layers moving at once. The idea at the top was also a pendulum product that does similar things than what was prior mentioned but adding on that have a flat plate or perspex or wood that is coated or made with Photoluminescent powder, so as well as seeing light be manipulated with the coloured pendulum arms there would be a light source at the end of the arm that would then shine on the glow and the dark material. So when the arm swings you can see the lifespan and directions the pendulum swings. The final idea of this exploration we can see at the bottom right is a combination of all of the features previously mentioned, it would be similar to newtons cradle, be a set of 4 double arm pendulums, as well as have different coloured arms to manipulate the light.

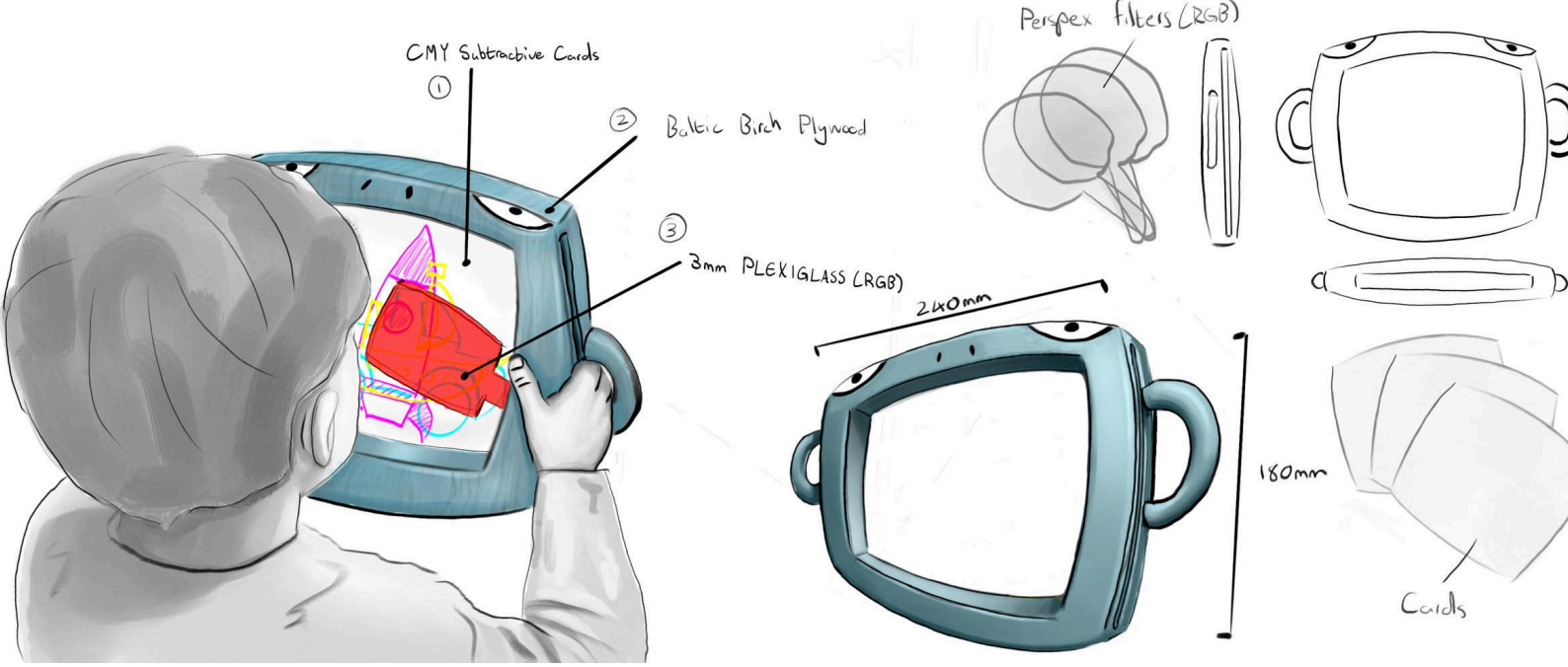


FIGURE 5

Explanation

Looking at the culmination of these ideas we decided on the Colour Creature. In the explanation sketch we see the target demographic child that being 6-8 year old, interaction with the toy which has CMY subtractive cards and the colour filters. This is going to be a diluted blue which contrasts the stark colours that are the CMY and RGB. We see that the product comes with cards that will be inlaid, Perspex filters and the main creature toy. In the demonstration sketch we see the child moving the filter over the CMY artwork and seeing how the colours fade away and then the corresponding colour to the filter gets darker and more prominent. In this case the red and Cyan. The creature will be multiple layers thick of 6mm Baltic Birch Ply and the eyes will incave which allows a parallax effect which makes it look like the eyes are following the user. The colour filters will be 3mm perspex. We also get a sense of dimensionality as we can see the child interacting with the toy as well as there are added dimensions to give a better sense of scale.



Figure 6: Prototype

The last part to this design process was the Rapid Prototyping. Here we can see how the rapid prototype tested the core features, verifying the intuitiveness of the slide and slot in mechanism. It validated the physical scale, hand-grip comfort especially towards the ergonomics of the target group and spacial proportions for the 5-8 age demographic. The prototype showed the parallax effect oh how the eyes follow the end user. The actual play of the toy was intuitive and easy as well as the product felt fit well in hand. The prototype was tested with double wall corrugated cardboard and sheets. The testing showed that in the initial design the filters were made to fit flush with minimal clearance to move within the top and bottom frame, So we created a double layer gap allowing for a lot more clearing and still avoiding the finger entrapment problem.

Research & Information Synthesis

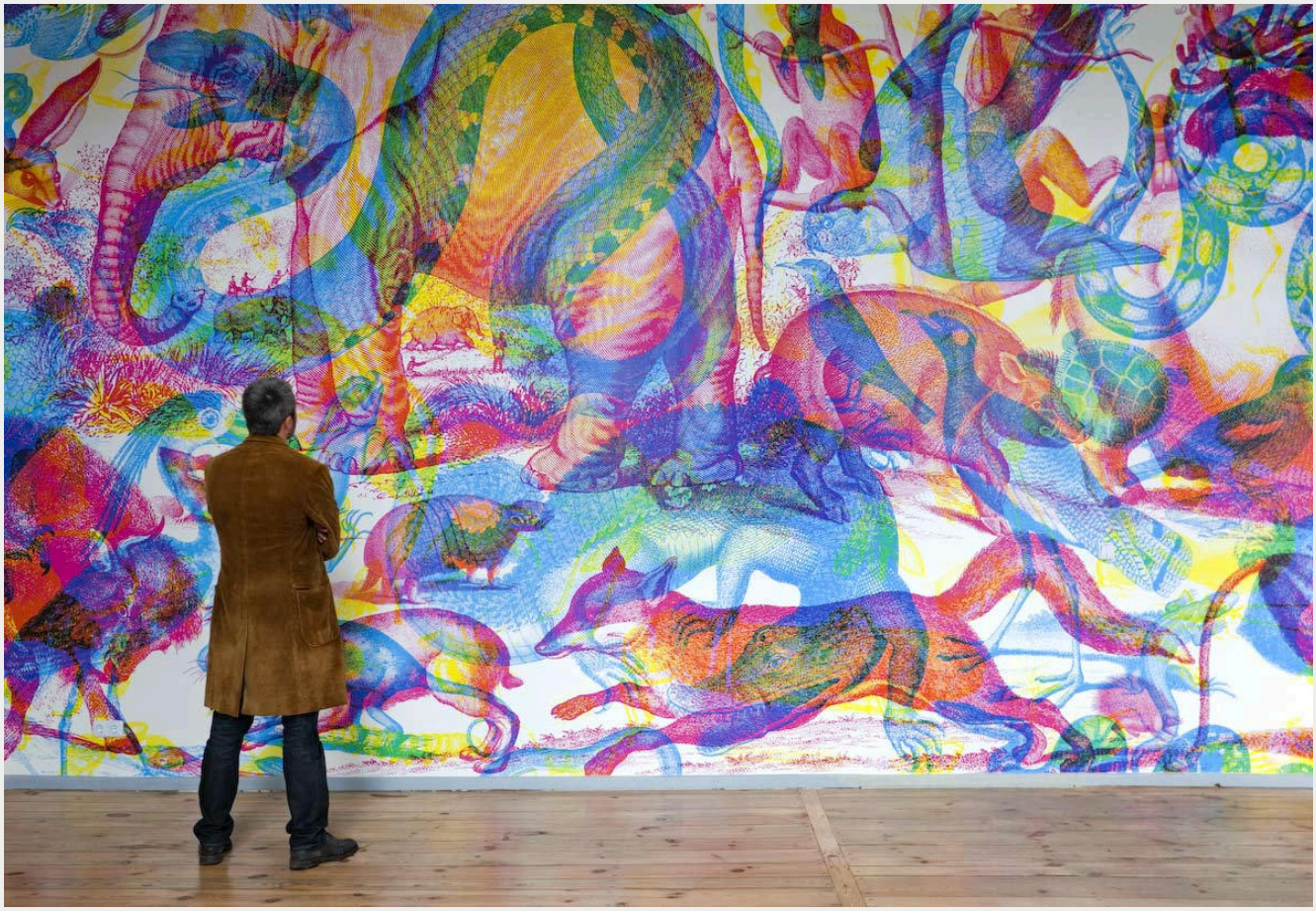


Figure 7: Carnovsky Effect

Target Age Group: The final decision was made to be for children aged 3-6 years old, which fits into the early childhood education frameworks we researched. This segment highlights something that Dr. Maria Montessori identified as the First Plane of Development, a phase which is characterised by a shift or change from the "unconscious absorbent mind" to the "conscious mind" (Montessori Academy, 2025). During this phase, the child transitions from absorbing environmental stimulus aimlessly to organising, categorising and imposing cognitive order on their surroundings. Looking at it from a neurological standpoint, the brains development progresses at its fastest during this window period, with up to 90% of human child functional brain volume being established by age 5 (Montessori Academy, 2025). This rapid formation highlights the importance of giving high fidelity sensory feedback. So introducing systematic physical play during this period builds the foundations of cognitive structures that support scientific and spatial reasoning downstream. (Koch, 2024).

Piaget's Theory: Concrete Operations & Physical Anchors: Looking at Piaget's stages of cognitive development, children from the range of 3-6 occupy the pre-operational stage and begin to move towards Concrete Operations (Koch, 2024). A defining part of this cognitive state is that they are incapable to process abstract, symbolic,

or hypothetical concepts without external measures or support. If a child in this group were to be shown for example a colour wheel. They may be able to recognise some colours but, they would struggle to conceptualise the mechanis of the colours, their wavelengths and that they flow into one another with regards to how colour is transmitted and absorbed. The Colour creature attempts and does address this boundary by providing real tangible physical anchors. The transparent coloured acrylic will serve as tangible embodiments of the abstract ideas, that being optical variables. When a child inserts the filters and they overlap and create a new colour or do the hiding effect this directly ties to physical, kinesthetic action. By sliding and stacking filters the user internalises cause and effect relationships through the physical manipulation. This will harden the neuron connection and establish a reliable baseline for later abstract logical reasoning.

Montessori Principles: The physical interaction is grounded in a Montessori principle: the hand is the instrument of intelligence (Montessori Academy, 2025). To use the toy, a child has to grip the filter with a modified pincer grasp, orient it, and thread the tabs down into narrow housing slots. The guides are unforgiving enough that a clumsy approach fails visibly — so kids self-correct, repeatedly, without being told to. That repetition matters beyond colour theory. Fine motor work of this kind strengthens the pathways between the motor cortex and spatial cognition (Koch, 2024), and that link shows up directly in school-readiness measures like hand-eye coordination and spatial awareness (Montessori Academy, 2025). The filter insertion is not just a delivery mechanism for the optics lesson — it is its own lesson.

Whole-Brain Interaction & Social Play: Siegel and Bryson argue that children develop best when logical sequencing and open-ended discovery happen in the same activity, not in separate modes (2011). The Colour Creature's workflow does this without forcing it. Choosing which filter to insert is deliberate and systematic; watching the image transform is neither — it's abrupt, visually strange, and kids react to it before they've had time to process it. The two experiences sit right next to each other. The viewing window is oversized on purpose. One child fits easily, but so do two or three, and that changes the social texture of play immediately. Suddenly there's something to argue about — which colour to try next, whose theory about the image was right, who gets to pull the filter out. Peer negotiation of that kind is one of the more reliable drivers of early language development (Siegel & Bryson, 2011), and here it emerges from the design rather than being engineered into the instructions.

RGB vs CMY Additive vs Subtractive Mixing: Most children already have a working intuition for additive colour — every screen they've used mixes red, green, and blue light, and white is what you get when all three are at full intensity. The Colour Creature runs on the opposite logic, and that gap is what makes it worth building around (The Stem Lab Guide, n.d.). Subtractive colour starts with white light already present. The material doesn't project anything — it absorbs certain wavelengths and lets the rest through. Filters take away; they don't add (Lefteri, 2014). The filters work as physical bandpass filters. Cyan transmits green and blue while absorbing red. A second filter cuts another band. Stack enough of them and almost nothing gets through (PLEXIGLAS® Standard Color Catalog, 2025). Each filter doesn't blend colours so much as it narrows what's left — kids can see the light budget shrinking in real time as they add layers.

The Carnovsky Effect: The Colour Creature's core visual mechanic comes directly from the Carnovsky Effect. Francesco Rugi and Silvia Quintanilla, a Milan-based design duo, developed the technique around what they call "surface deepness" — the idea that a flat, static surface can hold multiple distinct images simultaneously (Carnovsky, 2026). Three separate, highly detailed illustrations are printed directly on top of one another, each rendered in one of the three CMY primary colour channels (The Stem Lab Guide, n.d.). Under ordinary white light, the overlapping linework reads as visual noise — dense, tangled, and illegible. Slide a coloured filter in front of it and the noise resolves immediately into a single clean image. Each filter is a bandpass filter that only

transmits its own wavelength (PLEXIGLAS® Standard Color Catalog, 2025). Under a red filter, the red ink reflects the same wavelength passing through the filter — it becomes indistinguishable from the white background and vanishes. The green and blue ink lines absorb that red light, which is why they read as sharp, dark images against it. Under a green filter the same logic applies in reverse: the green linework disappears, and the red and blue layers — which absorb green light — emerge clearly (Carnovsky, 2026). Each filter reveals a completely different picture (Carnovsky, 2026; Koch, 2024).

A survey of Toy Kingdom and Toys R Us in Cape Town (May 2026) turned up 54 STEM products across both stores. Engineering and assembly kits dominated at 37% of shelf space, science kits followed at 33%, technology at 20%, and physics or optics products came in at 11%. The two brands with the biggest footprint were 4M — selling under the KidzLabs, KidzRobotix, and KidMaker names — with 20 products, and Bubblegum STEM with 14. Between them they covered most of what either store carried. Nearly all competitor products target 6-year-olds and up, and almost everything on the shelf was either a chemistry experiment kit — think KidzLabs Kitchen Science and Crystal Growing — or a wooden build-kit like the Bubblegum STEM Shuttle Gear Car. Neither store stocked anything that teaches optical science or colour mixing as something you physically interact with. The closest products in that area, the Bubblegum STEM Fibre Optic Light and the Bright Sparks Microscope, deal with light and observation but not with colour as a combinatorial, hands-on system. So the shelf gap is real, and it is specific.

A short questionnaire went out to 16 participants — mainly early childhood educators, parents, and developmental specialists — to check whether the product was solving a real problem or an invented one. The results were fairly consistent. Building kits and electronic learning devices made up around 70% of the educational toys participants had bought or seen in regular use, while optical science and colour theory tools barely featured, accounting for roughly 11%. Most participants also flagged the pace of digitisation in early learning as a concern, with several pointing out that screen-based tools tend not to build genuine spatial reasoning or physical intuition in the way that hands-on materials do. Those two findings — the shelf gap and the frustration with screens — are exactly what Colour Creature is built around.

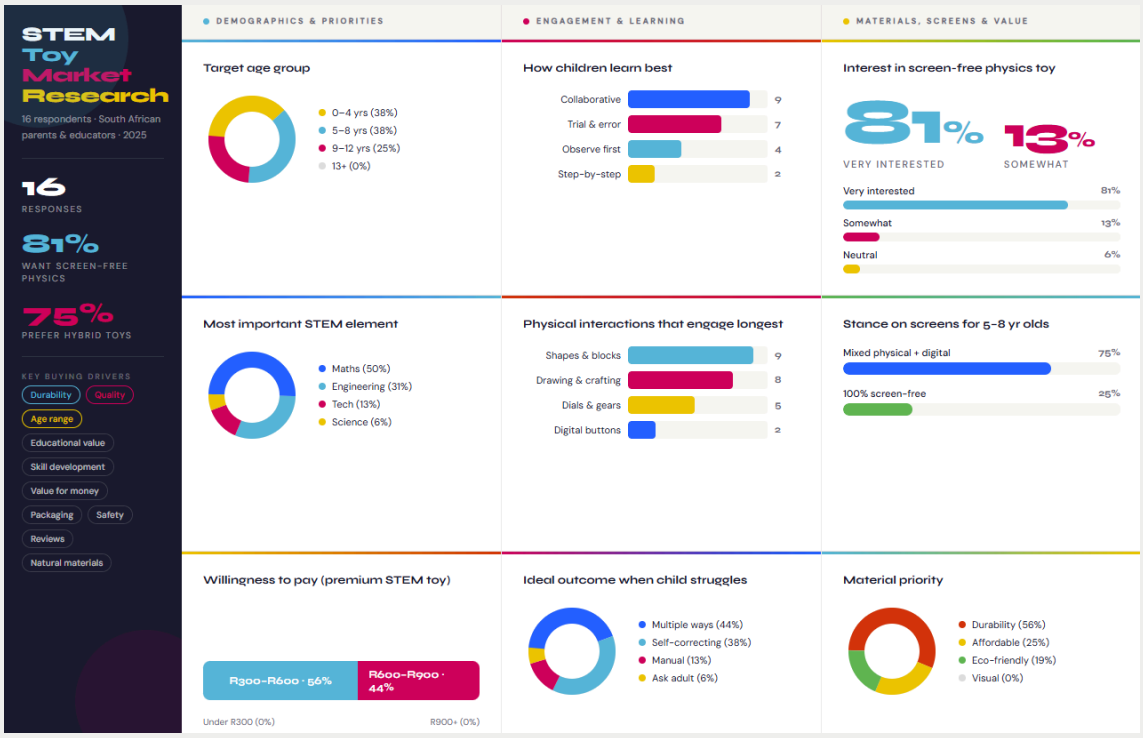


Figure 8: STEM Questionnaire

Development



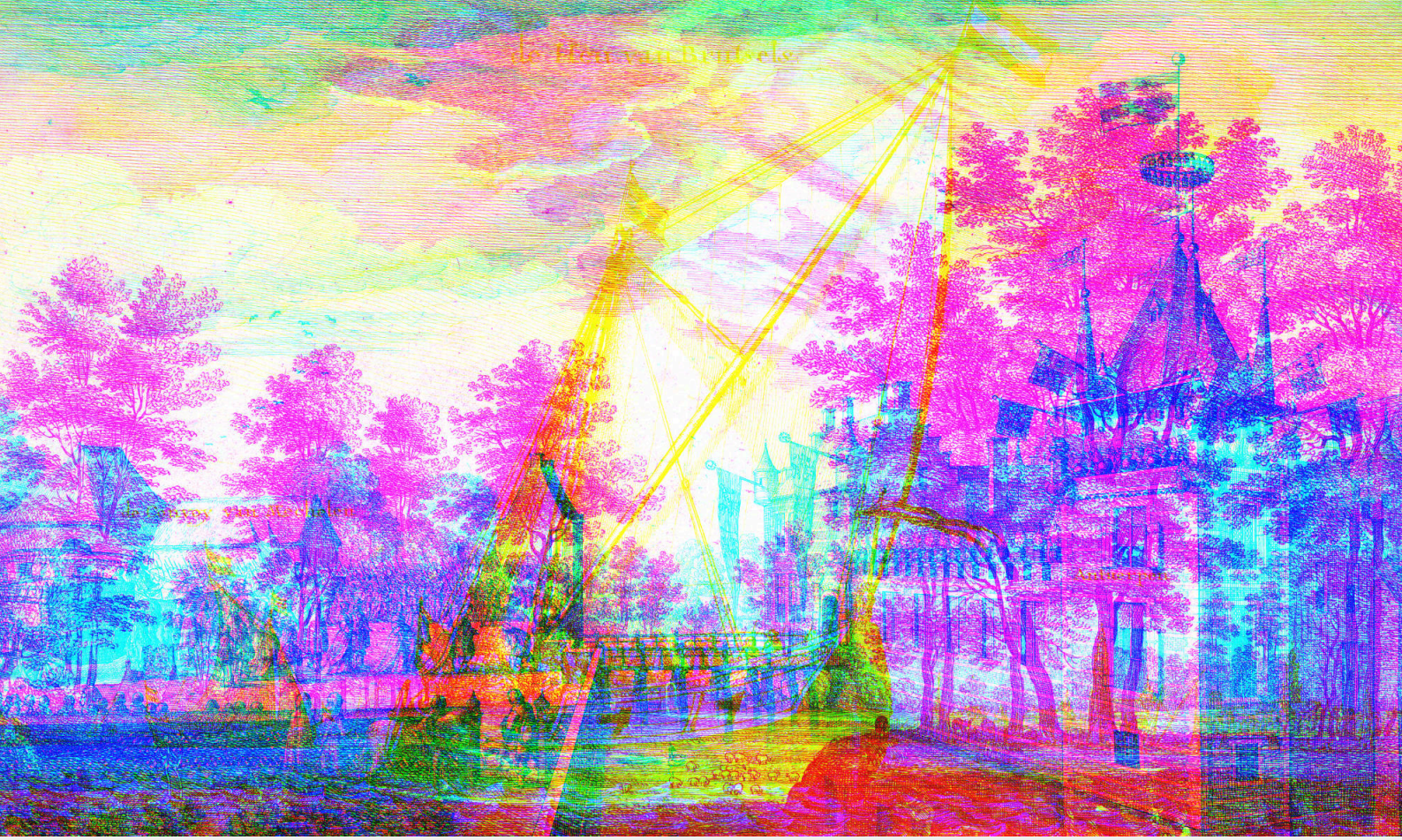


Figure 9: CMY Art

The development process started in Photoshop rather than the workshop. Before any wood was cut, the artwork was mapped out using exact CMY channel separations calibrated against the RGB wavelengths the physical filters would need to block. The Multiply blend mode stood in for the real filter plates, letting the hidden image mechanics be tested digitally before anything went to print. This turned out to be a necessary step — commercial print ink has to land precisely on its designated CMY wavelengths, because even a small calibration drift causes the filters to stop masking the right layer, and the illusion falls apart.

Once the colour behaviour was confirmed, the housing was designed as a four-layer Baltic Birch stack, each sheet 6mm thick, with no metal hardware or external fasteners. Layer one is the front face and entry guide for the filter parts. Layer two creates the internal bypass tracks. Layer three reinforces those tracks and keeps the filters from binding. Layer four is a flat backplate that closes the rear of the unit, bracing the full assembly and stopping the acrylic filters and artwork inserts from warping or pulling free.

Safety geometry was handled parametrically. The faces received a continuous 5mm fillet, removing sharp corners throughout. Internal channel clearances were held to 4mm — enough room for the 3mm acrylic filters to move freely, but too tight for a child's fingers to reach the tracking pathways. The pinch risk is designed out rather than labelled.

The handle tabs were reworked at the same time. Stacking multiple timber layers onto each tab and machining them to a rounded cylindrical profile brought the grip closer to how a child's hand actually closes. It also created a physical gap between the front frames, the internal tracks, and the backplate — which turned out to matter visually too. With the foreground and background elements sitting at different depths, shifting viewing angles produce a parallax movement in the creature's eyes that pulls children into the active viewport in a way a flat frame would not.

The whiteboard insert slots into the same utility track as the printed artwork cards. Children draw

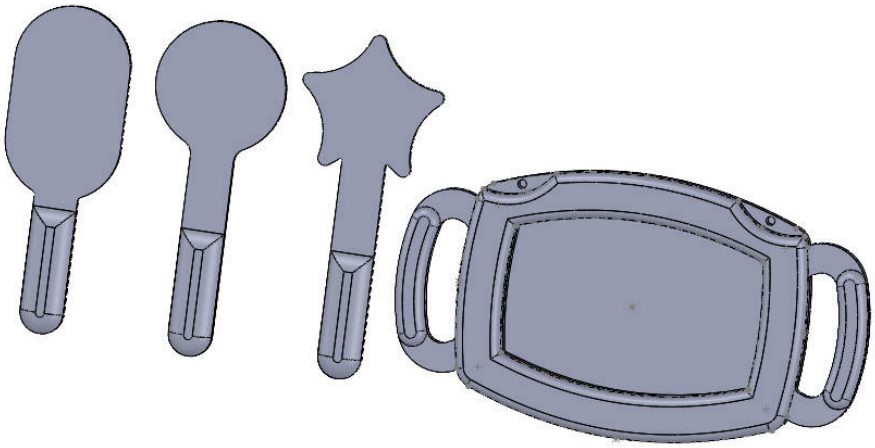


Figure 10: CAD Assembly

on it with CMY dry-erase markers, then drag the filter parts across their own drawing to watch it shift, split, or disappear. That single design decision turns the toy from a demonstration into something the child is running themselves.

Before the files went to the CNC router, the full assembly was rendered using custom dielectric material nodes with calibrated absorption distance values for each filter — not standard transparent colour approximations. The renders had to calculate actual light absorption behaviour to be useful, confirming both the timber layer clearances and the visual outcome of the CMY overlap with enough accuracy to trust the result.

Looking at the Technical and Proof Of Concept Posters: To communicate the finalised design comprehensively, two primary presentation posters were generated. The Technical Poster synthesises the precise engineering parameters, detailing the four-layer Baltic Birch architecture, exact component dimensions, and the manufacturing material matrix required for production. Complementing this, the Proof of Concept poster contextualises the Colour Creature within an active early childhood learning environment, illustrating the toy's scale, user ergonomics, and the practical application of the subtractive colour mechanics during play. Together, these visual artifacts provide a complete overview of both the strict mechanical specifications and the intended interactive user experience.

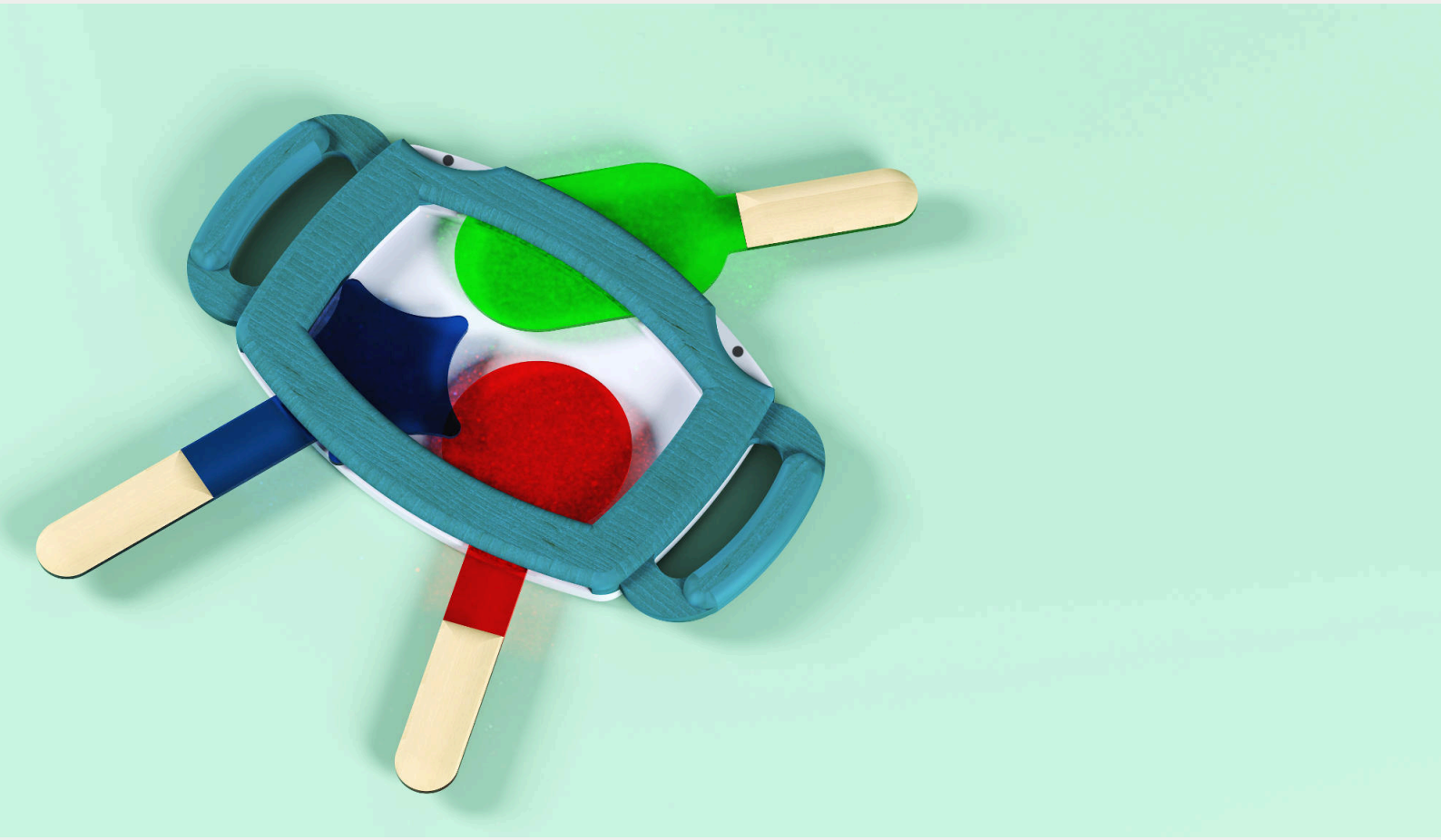
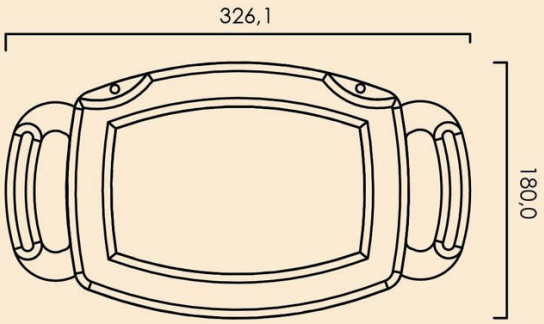


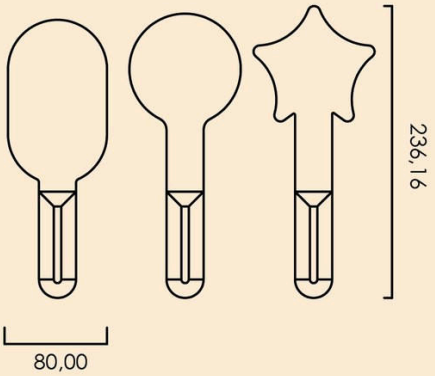
Figure 11: Render

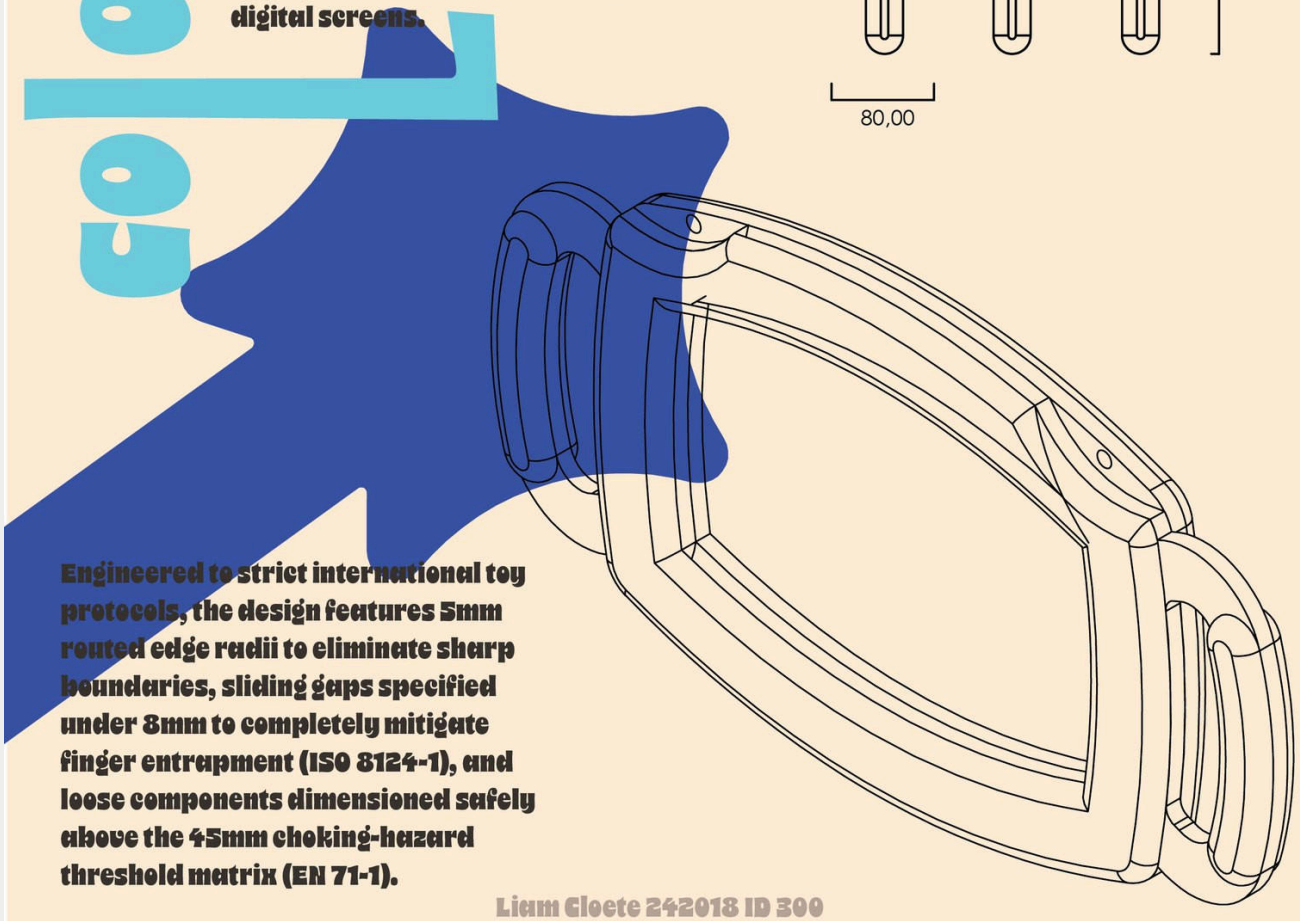
COLOUR CREATURE

Crafted from 5-ply cross-laminated 6mm Baltic Birch plywood and shatter-resistant 3mm PLEXIGLAS® XT, the assembly is sealed with zero-VOC water-based polyurethane and non-toxic natural dyes to ensure premium tactile longevity and absolute optical clarity.



Colour Creature translates abstract color physics into physical cause-and-effect by allowing children to slide cyan, magenta, and yellow optical filters through a multi-layered wooden frame, mechanically demonstrating subtractive wavelength absorption without digital screens.





Engineered to strict international toy protocols, the design features 5mm routed edge radii to eliminate sharp boundaries, sliding gaps specified under 8mm to completely mitigate finger entrapment (ISO 8124-1), and loose components dimensioned safely above the 45mm choking-hazard threshold matrix (EN 71-1).

Liam Cloete 242018 ID 300

Figure 12: Technical Poster

Colour Creature: The Magic of Subtractive Optics

"Merging Tangible Interaction with Optical Science."

ID 300 · Project 2
Student 242018
Year: 2026

Most STEM toys treat science as spectacle — hiding the mechanism behind the magic. Colour Creature inverts this: it begins with wonder and reveals the physics. Children aged 5–8 slide PLEXIGLAS® colour filters through a hand-crafted Baltic Birch frame, observing how cyan, magenta, and yellow absorb wavelengths to produce mixed hues — subtractive colour theory, taught without a single screen.

01 — INSPIRATION & MARKET

The Carnovsky Effect

The RGB wallpapers of Studio Carnovsky — where hidden images reveal themselves under coloured light — proved that subtractive optics can be viscerally surprising. Scandinavian material minimalism supplied the aesthetic grammar: exposed birch, clean layout, and honest geometry.

R + G absorbs violet & blue ⊠ Yellow

R + B absorbs green ⊠ Magenta

G + B absorbs red ⊠ Cyan

MARKET GAP ANALYSIS

Engineering	37%
Science Kits	33%
Technology	20%
Physics/ Optics	11%

Colour Creature addresses this underrepresented 11% gap.

02 — DEVELOPMENT & PLAY

Smart Features

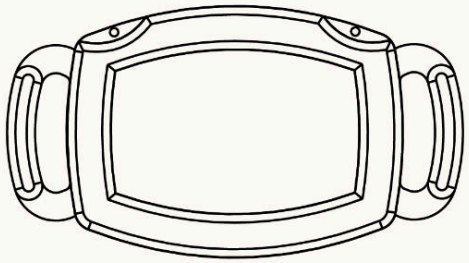
- Creative Expansion — Includes 4 CMY 'magic' artworks, 3 whiteboard markers (Cyan, Magenta, Yellow), and a whiteboard surface so children can draw and decode custom optical illusions.
- Concrete Operations — Replaces abstract theory with physical anchors.
- Motor Refinement — Paddle insertion trains hand-eye coordination.
- Cause-and-Effect — Direct color feedback dynamically alters narratives.

03 — ERGONOMICS & TESTING

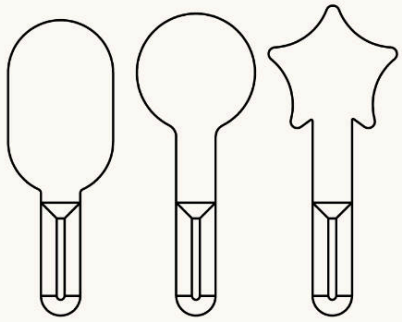
User Insights

- 26 mm Grip Span — Tailored to fit 5th-percentile hand breadth of ages 3–6.
- Educator Feedback — 88% cite lost pieces as a concern; resolved via semi-protruding paddle design.
- 5mm Edge Routing — All external frame corners are softened for comfort and safety.

PRODUCT HERO — ASSEMBLED CONFIGURATION



326.1 mm TOTAL FRAME WIDTH	14.8% CNC NESTING WASTE
5.0 mm ERGONOMIC RADIUS	4 / 3 / 1 ART / MARKERS / BOARD



04 — MATERIAL SCIENCE

Specifications

- 6 mm Baltic Birch Plywood — Premium 5-ply cross-laminated layout provides exceptional stability and prevents warping.
- 3 mm PLEXIGLAS® XT — Shatter-resistant acrylic delivering absolute optical clarity superior to glass.
- Child-Safe Finishes — Water-based polyurethane clear coat, natural dyes, and chalk paint ensuring zero VOC off-gassing.

05 — MANUFACTURING

Production Details

- Flat Down-Cut CNC Routing — Eliminates top-face splintering and ensures razor-sharp edge profiles.
- Optimized Sheet Nesting — Engineering toolpaths achieved an efficient 14.8% material wastage metric.
- Local Sourcing — Precision machined locally at FAR products .

06 — REGULATORY COMPLIANCE

ISO Standards

ISO 8124-1 (Mechanical Safety)
5mm routed corners eliminate sharp boundaries. Sliding channel gaps specified <8mm to completely avoid finger entrapment.

ISO 8124-3 (Chemical Safety)
Verified non-migration of toxic element profiles. PLEXIGLAS® XT is food-contact certified; water-based top coats are solvent-free.

EN 71-1 (Structural Safety)
All minimum loose component dimensions engineered well above the 45mm choking-hazard threshold matrix.

0-3 Warning per ISO 8124-1 §4.2: Not suitable for children under 36 months due to small handling items.

Colour Creature — Subtractive Optics Presentation Poster

ID 300 · Liam Cloete · 242018

Figure 13: Proof of Concept Poster

Ergonomic Analyses

The dimensions of the toy were worked out from the anthropometric profiles of 3–6-year-olds (Department of Trade and Industry, 1998). The 326.1mm chassis width keeps the centre of gravity low enough that the unit stays upright during play, which is a real constraint when a child is repeatedly pulling and pushing filter paddles with some force. The four-layer Baltic Birch stack — front face, internal spacers, secondary alignment frame, flat backplate — adds the structural mass that holds everything stable on flat surfaces while enclosing the sliding tracks completely.

The handle tabs were built up with additional timber layers and machined to a cylindrical profile rather than left as flat offcuts. This matches the power-grasp pattern children in this age group default to, spreading gripping pressure more evenly and reducing hand fatigue across repeated use (Case-Smith et al., 2014).

Safety geometry was addressed directly in the parametric model. Every exterior edge on the timber chassis carries a continuous 5mm fillet, removing sharp corners and potential splinter points throughout to comply with laceration hazard prevention guidelines (ISO 8124-1, 2022). Internal channel clearances run at 4mm — enough room for the 3mm acrylic paddles to slide freely, but below the 5–12mm finger entrapment and crushing zone under ISO 8124-1, Clause 4.13. The PMMA filter paddles are dimensioned at 238mm × 150mm, well above the threshold of a standard small parts cylinder, ruling out choking risk in early childhood environments (ISO 8124-1, 2022). Water-based stains and zero-VOC polyurethane sealants are used throughout, keeping chemical exposure within safe limits during haptic interaction (ISO 8124-3, 2020).

When a filter paddle or whiteboard insert reaches the base of the guide track, it drops into a seat and produces a short tactile thud. This tells a child the panel is correctly aligned without requiring adult input. The sealed Baltic Birch surface holds a consistent neutral texture across the whole frame, which matters for sensory-sensitive users who respond poorly to unpredictable tactile variation (Primary Questionnaire Findings, 2026).

The four 6mm plywood layers place the front face, the sliding filters, and the background illustrations at physically distinct depths. As a child shifts their viewing angle, the foreground silhouettes and background canvas shift relative to each other, producing a parallax movement in the creature's eyes. It keeps attention on the viewport while the colour experiment is running.

The whiteboard insert uses the same utility track as the printed artwork cards. Children draw on it with CMY dry-erase markers, then slide the filter paddles across their drawing. Lines split, shift colour, or disappear depending on which paddle is used. The child is observing light absorption directly, on something they made themselves (The Stem Lab Guide, n.d.).

Technical Analyses

The chassis is cut from 6mm Baltic Birch plywood, B/BB grade. The 5-ply cross-laminated structure runs at 680 kg/m³ with a void-free core, which is what makes fastener-free mechanical joinery feasible at this scale — the material holds tolerances that lower-grade plywoods with voids or inconsistent glue lines cannot. It also resists hygroscopic warping well enough for a product that will spend its life in classrooms and homes with varying humidity, and it takes edge impact without delaminating. The optical filters are machined from 3mm PLEXIGLAS cast acrylic (PMMA), at 92% light transmission and a surface hardness that cuts clean without micro-fracturing. The three paddles use PLEXIGLAS XT continuous-cast sheet — Cyan (5C01), Magenta (3C01), Yellow (6C77) — each held to a 5% light transmission window. That tolerance is tighter than it sounds; let it drift and colours bleed into adjacent channels, and the subtractive mixing stops working as intended. Frame components are routed on a 3-axis CNC with a 4mm two-flute flat down-cut carbide bit. Down-cut orientation applies axial force downward through the cut, compressing top wood fibres against the core instead of lifting them. This prevents veneer chipping on the show face, which would be visible and structurally problematic at the paddle entry slots. A rotating milling bit cannot produce a true internal 90-degree corner — it leaves a radius matching half the cutter diameter, here 2mm. Dog-bone corner fillets in the vector toolpaths fix this. The bit overshoots each corner vertex, cuts a small circular relief pocket, then returns to the primary path. The square-edged acrylic paddles seat fully flush in the routed tracks as a result. Nesting was handled through automated software. A single unit occupies 8% of a standard plywood sheet, leaving 14.8% waste — inside the 20% maximum in the project brief. The pro-rata Baltic Birch cost at that utilisation rate is R51.04 from a R638 sheet. Three PMMA colours add R164.36, surface finishes R20.00, and CNC routing R300.00, bringing the unit total to R535.40. That leaves R214.60 of headroom under the R750 limit.



Figure 14: Product Photo 1

Evaluation

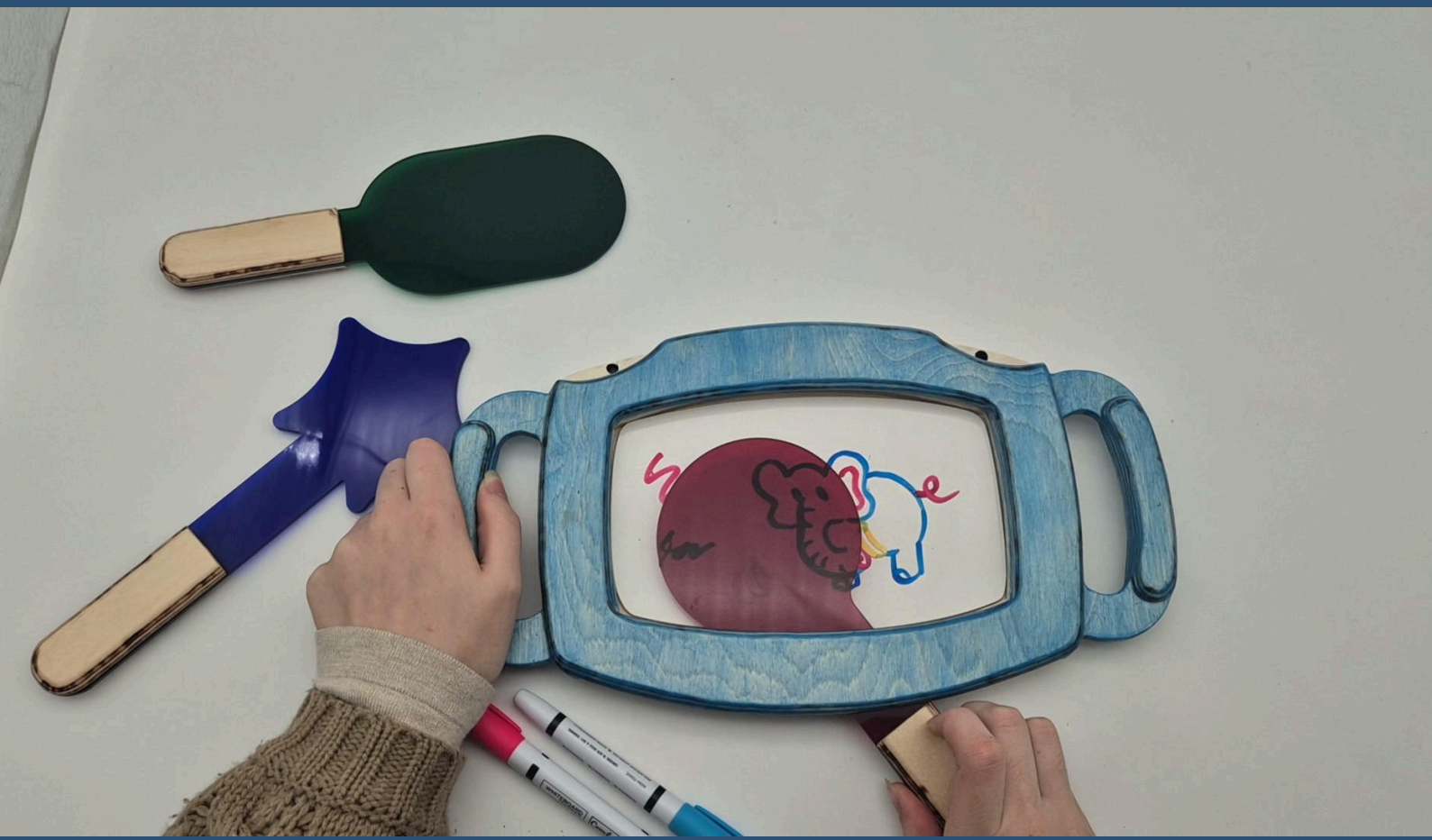
CNC routing and nested component geometry kept tolerances consistent across the build. The 6mm Baltic Birch stack produced a chassis that is rigid without being unwieldy, and physical prototyping resolved the clearance issues before final production — the 238mm paddles ended up with enough grip area for children to use them without needing adult help. Waste came in at 14.8% and the unit cost sits comfortably below R750. The assembled filters fit well, the surfaces are smooth, and the water-based finishes are child-safe. The optical mechanics do what they are supposed to — the PMMA filters block and pass the correct colour channels and the hidden artworks reveal cleanly. Two things are worth addressing in a future iteration. The retail packaging does not currently explain how the toy works from the shelf, which is a real problem for a product where the mechanism is the entire pitch. Expanding the filter range and adding more artwork cards would also increase play value without touching the structure. The gap in the market is real and not subtle. Engineering kits and electronic learning devices fill most of the shelf. Optical science and light-based physics tools make up around 11% of what is available, and most of that 11% is microscopes and fibre optic novelties rather than anything that teaches colour mixing directly. Colour Creature sits in that space — a physical, screen-free tool for subtractive colour theory aimed at the age group that learns best by handling things.



Figure 15: Product Photo 2

Conclusion

The Colour Creature works because the mechanism is the toy. There is nothing hidden — the child slides a filter, a colour vanishes, and the question of why is right there in front of them. That is the point where Piaget's concrete operations and Montessori's tactile learning framework converge: children at this age do not pick up abstract concepts from being told about them. They need something in their hands that behaves in a consistent, observable way. A translucent paddle that blocks a specific wavelength of light does exactly that. The manufacturing side held up. ISO requirements for finger entrapment, edge profiles, chemical safety, and choking hazard dimensions are all met, and the Baltic Birch and PMMA combination kept the unit cost under R750 without any compromise to optical performance. The product does what it is supposed to do, safely, and at a price point that makes it viable for the educational market it is designed for.



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