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# Natural Crayons, Natural Learning: An Art-Based Programme for Children with Autism

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## Abstract

Commercial crayons are sometimes made with pigments that are unsafe for children, and art materials used in special education rarely address this concern directly, despite children with autism often having heightened sensitivity to smell, texture, and other sensory properties of the materials placed in front of them. This study developed and evaluated a set of crayons made from three natural pigments—marigold, indigo, and lac—and used them in an art-based educational programme, delivered by special-education teachers rather than by a qualified art therapist, for children with autism. The work proceeded in three phases: five experts assessed the quality and the suitability of the crayons for use with children; ten children with autism (aged 7 - 12) took part in a six-week programme of art activities, assessed before and after with four behavioural rating scales; and three teachers and ten parents were interviewed about what they observed. Colour measurements confirmed that each pigment produced a distinct, reproducible hue, and blends extended the palette without losing distinguishability. After the programme, the children showed statistically significant gains in creativity, attention, fine-motor and eye-hand coordination, and positive behaviour, all with large effect sizes by conventional standards for this kind of test. Teachers and parents rated the programme very positively, particularly its effect on the children's mood and behaviour. Because the crayons, the open-ended activities, repeated practice and teacher support were introduced together, the design cannot isolate the contribution of any single component, and no chemical contaminant or skin-safety testing was carried out. These findings are brought together in a five-part framework—the Natural Crayon Art Learning Model—describing how natural materials assessed as suitable for children, used in open-ended art activities, generate the kind of sensory experience that supports creative and behavioural growth in children

with autism.

## Keywords

Natural Crayons, Art-Based Education, Autism, Creativity, Sensory Learning

## 1. Introduction

People have coloured surfaces with natural pigments since before the invention of writing, and the practice of dyeing textiles with plant extracts has developed continuously alongside it. Synthetic dyes largely replaced these traditions because they are cheaper and easier to produce at scale, but they carry health risks that natural extraction methods do not, which has renewed interest in plant- and insect-based colorants for textiles, food, and art. Some of this renewed interest is also cultural rather than purely practical: reviving a natural dyeing or pigment-making process preserves a set of traditional techniques that would otherwise be lost, and often turns out to solve a specific, local problem more elegantly than an imported synthetic alternative would.

Children's crayons illustrate the underlying safety problem well. Production standards vary widely between manufacturers, and contaminants such as lead, mercury, or asbestos fibres have occasionally been found in low-cost products, usually traced to the pigments themselves or to the manufacturing process rather than to the wax base. Because crayons are among the first art materials most children handle directly and repeatedly, often before they have learned not to put things in their mouths, the pigment used is not a minor formulation detail—it is a genuine safety question, and one that conventional manufacturing does not always answer well. Regulatory testing for children's art supplies typically focuses on a defined list of known contaminants, which is useful but leaves open the question of newer or less-studied additives, and does very little to address the sensory experience of the material—its smell, its texture, how it feels to hold—which for many children with autism is at least as important as chemical safety in determining whether a material can be used comfortably at all.

Children on the autism spectrum often struggle in classrooms built around verbal instruction and written assessment, even when their intellectual ability is unaffected; difficulties with reading, writing, or sustained attention in these settings can affect academic confidence and social adjustment quite apart from cognitive ability itself. Art offers a different route into learning, one that does not depend on language: children can explore, choose, and express themselves through colour and form rather than words. This is the premise behind art therapy, which uses drawing, painting, and modelling both to support emotional development and to open a channel of communication for children who find verbal expression difficult. The idea has some grounding in how learning is understood to work more generally—meaningful engagement with material seems to matter more than pas-

sive reception of instruction—and it has direct empirical support in this population: free and self-directed drawing has been shown to increase originality and flexibility in children with autism (Rahmani & Rahmani, 2014), and art activities more broadly have been linked to improved attention, motivation, and emotional expression in this population.

In Thailand, art-based approaches are increasingly used in special-education settings, but the materials themselves are almost always conventional, chemically manufactured crayons and paints—a particular concern for children with allergies or sensitivity to chemical odours, who may already be more sensitive to sensory input than their peers. A natural crayon, made from pigments such as turmeric, butterfly pea, or marigold, addresses this safety gap while also giving children a first, concrete encounter with basic scientific ideas: extraction, colour mixing, and experimentation. It is, in effect, a small piece of STEAM education built into an art material, and a way of using natural resources conscientiously rather than treating art supplies as disposable, chemically produced consumables.

The idea that art activities support cognitive and emotional development is not new, but it is worth stating why it is plausible rather than treating it as self-evident. Art therapy is generally understood to engage planning and analytical regions of the brain alongside those involved in imagination and visual perception, which is roughly the pairing that brain-based learning theories argue is needed for learning to stick (Jensen, 2000; Caine & Caine, 1990). None of this depends on an autism diagnosis specifically—it is a general account of how people learn—but it applies with particular force to children whose main obstacle in a conventional classroom is language rather than reasoning ability. For a child who struggles to say what they think or feel, being able to show it instead is not a minor accommodation; it can be the difference between participating and not.

None of this addresses the material question directly, though, which is where the present study starts. Whatever the activity, the object placed in a child's hand still has to be safe, and, for children with heightened sensory sensitivity, still has to feel and smell acceptable. A natural, beeswax-based crayon is a modest and concrete attempt to address both conditions at once—an attempt evaluated here through structured expert judgement rather than through laboratory contaminant analysis or dermatological testing—and doing so with a material that is also, as a secondary benefit, kinder to the environment than most petroleum- and synthetic-dye-based alternatives.

There is already a body of work on extracting colour from plant and insect sources for artistic use—testing the fastness of different natural pigments on paper for watercolour painting, for instance, or comparing extraction methods for dyeing hair and textiles—which generally finds that concentration and processing time matter more for colour intensity than the mordant used. What is less developed is the step connecting that materials work to an actual programme with children, particularly children with additional needs, where the pigment's performance has to be judged against a child's real behaviour and preferences rather

than against a colourimeter alone. That gap is what this study tries to close, by carrying a natural-pigment crayon all the way from expert material evaluation through to a six-week programme with children and a set of interviews with the adults who watched it happen.

This study had three aims: to develop a natural extract-based crayon and to obtain a structured expert assessment of its quality and of its suitability for use with children; to examine how an art programme built around these crayons affects the creativity, attention, fine-motor coordination, and behaviour of children with autism; and to record how teachers and parents perceived the programme and the material itself.

## 2. Method

### 2.1. Design

The study combined a research-and-development approach with a one-group pretest-posttest design (O1 → X → O2), carried out in three phases: development and expert review of the crayons; a six-week art programme with children, measured before and after; and a round of interviews with teachers and parents once the programme ended. This combination was chosen deliberately: the research-and-development phase treats the crayon itself as something to be designed and validated before use, in the way a piece of educational equipment normally would be, while the pretest-posttest phase treats the programme built around it as an intervention to be evaluated on its own terms. Running both phases in sequence, with the same small group of children, let the study connect a materials question to an educational outcome rather than addressing either one in isolation.

One point of terminology should be made explicit at the outset. The programme reported here was neither delivered nor supervised by a registered or otherwise qualified art therapist. All sessions were planned by the research team and conducted by the children's own special-education class teachers as part of the centre's ordinary teaching timetable. The programme is therefore described throughout this article as an art-based educational programme, and not as art therapy. Where art-therapy literature is cited (Sections 1 and 4), it is cited as theoretical background for the use of art as a non-verbal channel of expression, not as a claim that the present intervention constitutes therapeutic practice.

The intervention should likewise be understood as a package of four components introduced simultaneously: 1) the natural-pigment crayons themselves; 2) open-ended activities in which the child, rather than the teacher, decided what the finished piece would look like; 3) repeated practice of the same fine-motor actions across 8 - 12 sessions; and 4) individualised teacher support and pacing. Because no component was withheld from any child and no comparison condition was run, the design cannot attribute any observed change to one component in isolation. The interpretation offered in Section 4.1 therefore states, for each outcome, which component or combination of components is proposed as the most plausible explanation, and how confidently that proposal can be held.

## 2.2. Participants

The demographic profile of participants across the three phases of the study is summarised in Table 1.

Table 1. Demographics and selection of research participants by phase.

| Phase | Group | n | Selection |
|---|---|---|---|
| 1 | Experts (art education, special education, materials science) | 5 | Purposive |
| 2 | Children with autism, aged 7 - 12, Loei Special Education Center | 10 | Purposive; confirmed ASD diagnosis; parental consent |
| 3 | Special-education teachers / parents | 3/10 (n = 13) | Purposive |

All ten children were enrolled at a single special-education centre and had a confirmed autism diagnosis; none had a physical condition that would have prevented them from holding or using a crayon. Sample size was constrained by the number of eligible children willing and able to complete the full six-week programme, which is typical of intervention studies of this kind in a single special-education setting.

## 2.3. Materials

The crayons were made from marigold, indigo, and lac pigments, extracted with a low-temperature solvent method and blended into a beeswax base at 10%, 30%, and 50% (w/w) pigment-to-wax ratios. The extraction procedure and the resulting colour measurements are reported in full in a companion paper; only the results needed for context are repeated here (Section 3.1).

The programme ran on-site at the same special-education centre the children already attended, in a familiar classroom, at a time of day chosen by staff to avoid overlap with other therapies. Running the study in situ rather than in a separate research setting was a deliberate choice: introducing an unfamiliar environment alongside an unfamiliar material would have made it harder to isolate what the crayons and activities themselves were contributing.

The finished crayons applied on paper are shown in Figure 1.

Figure 1. Close-up of the natural extract-based crayons applied on paper, showing distinct hue and texture from marigold-, indigo-, and lac-derived pigments.

## 2.4. Instruments

The instruments used across the three phases of the study are summarised in Table 2.

Table 2. Research instruments, evaluation purposes, and measurement formats.

| Instrument | Purpose | Format |
|---|---|---|
| Expert evaluation form | Expert-assessed quality and suitability of the crayons | 5-point scale |
| Attention scale (pre/post) | Sustained attention, distractibility, task completion | 5 items, each rated 1 - 5; score = mean item rating (range 1 - 5) |
| Fine-motor/eye-hand scale (pre/post) | Grip, pressure control, boundary control, coordination, dexterity | 5 sub-skills, each rated 0 - 10; total = sum of the 5 sub-skills (range 0 - 50) |
| Creativity scale (pre/post) | Originality, variety, imagination, elaboration | 5 items, each rated 1 - 5; score = mean item rating (range 1 - 5) |
| Behaviour scale (pre/post) | Confidence, participation, satisfaction | 5 items, each rated 1 - 5; score = mean item rating (range 1 - 5) |
| Semi-structured interview | Teachers' and parents' reflections | 3-part guide |

Content validity was checked by three to five experts using the Index of Item-Objective Congruence (IOC ≥ .50); a try-out with ten children informed minor revisions before the instruments were finalised. Each rating scale was completed independently by the child's class teacher, who observed the child during structured activities before the programme began and again after it ended, using the same five behavioural anchors each time so that pre- and post-scores were directly comparable. A typical creativity item, for example, asked the teacher to rate how many different ideas the child incorporated into a single piece; a typical fine-motor item asked whether the child could keep colour within a marked boundary for most of a coloring task.

The scoring of each instrument was as follows. The attention, creativity and behaviour scales each contained five items rated on a 1 - 5 behaviourally anchored scale (1 = the behaviour is not observed; 5 = the behaviour is observed consistently and without prompting); the score reported for each child is the mean of the five item ratings, so possible scores range from 1.00 to 5.00. The fine-motor and eye-hand coordination instrument is constructed differently: it comprises five sub-skills—grip stability, pressure control, colouring within boundaries, coordinated hand-eye movement, and hand dexterity—each rated on an 11-point scale from 0 (the child cannot perform the action) to 10 (the child performs the action fluently and unaided). The total score reported in Section 3.4 is the arithmetic sum of the five sub-skill ratings and therefore ranges from 0 to 50; the pre- and post-programme group totals (34.70 and 38.50) are the sums of the five sub-skill means reported in the same section. Sub-skill and total scores are thus on different metrics and should not be compared directly with the 1 - 5 means reported for the other three scales.

The expert evaluation form covered five domains: colour quality and range, texture and ease of application, absence of any irritant odour, residue or skin reaction perceptible on inspection and handling, durability under normal use, and overall suitability for children. Each domain was rated on a five-point scale and accompanied by open comments, which were used to refine the wax-to-pigment ratio before the crayons were used with children. It should be emphasised that this procedure yields a structured professional judgement of suitability, not a chemical or toxicological clearance: no heavy-metal or contaminant assay, migration test, or dermatological patch test was performed on the finished crayons. Claims made in this article are accordingly limited to expert-assessed suitability for classroom use under teacher supervision.

## 2.5. Procedure

After institutional approval and a briefing for teachers and parents, children completed the four pretest scales, then took part in the six-week programme (2 - 3 sessions per week, 30 - 45 minutes each). The 8 - 12 sessions moved from simple, low-demand tasks toward more structured ones: early sessions offered free colouring with no set goal, so children could get used to the material itself; later sessions introduced shape-based composition and small guided themes (for example, colouring within a boundary, or building a picture from basic shapes), while still leaving room for the child to decide what the finished piece would look like. The same four scales were administered again as a posttest once the programme ended, and teachers and parents were interviewed shortly afterward using a three-part guide covering the child's participation, observed changes at home or in class, and their view of the crayons themselves.

A typical sequence ran, roughly: free colouring on plain paper with no set subject (sessions 1 - 2); colouring a pre-drawn outline while staying inside the lines (sessions 3 - 5); combining basic shapes into a simple scene of the child's choosing (sessions 6 - 8); and, for children who progressed quickly, an open-ended final piece incorporating anything covered earlier (remaining sessions). Teachers were free to adapt the pace to each child, and no child was required to move to the next type of activity before they were ready.

Attendance was recorded on a session-by-session register kept by the class teacher, who logged, for each child and each session: whether the child attended, the activity type delivered, the approximate duration of active engagement, and any deviation from the planned sequence. Across the six weeks the ten children completed a mean of 9.40 sessions (SD = 1.35; range 8 - 12) out of the 12 sessions scheduled. Every child completed at least the eight sessions required to cover the full planned activity sequence; three children completed exactly eight sessions, and the remaining seven completed between nine and twelve, the additional sessions being used for the open-ended final piece described above. Differences in exposure reflected absence from school rather than withdrawal from the study, and all ten children contributed both a pretest and a posttest score. Pacing adap-

tations were recorded on the same register using three fixed codes—activity repeated, activity simplified, or progression to the next activity type deferred by one session—so that the number of adaptations per child could be counted afterwards rather than reconstructed from memory. Adaptations were logged for four of the ten children, most often at the transition from free colouring to boundary-constrained colouring. Because exposure therefore varied somewhat between children, both in session count and in the amount of teacher scaffolding received, the results in Section 3 should be read as the effect of a programme delivered flexibly rather than of a fixed dose.

### 2.6. Ethical Considerations

The centre's administration and each child's parent or guardian gave written consent before the programme began, after receiving an explanation of the crayons' composition, the activities involved, and the purpose of the assessments. Participation was voluntary and children could withdraw at any point without consequence for their usual schooling. No photographs identifying an individual child are used in this article; where artwork is referenced, it is described rather than reproduced, or reproduced only in a form that does not permit identification of the child who produced it.

### 2.7. Analysis

Pre/post comparisons used the Wilcoxon signed-rank test, which is appropriate for the small, non-normally distributed samples typical of single-group designs, and effect sizes are reported as $r = Z/\sqrt{N}$. The colorimetric data were analysed with one-way ANOVA and Tukey's HSD. Interview transcripts were coded thematically by two independent raters and reported by frequency and illustrative comment. Theme frequencies are reported as the raw number of interviewees who raised the theme, out of the full interview sample of 13 (3 teachers and 10 parents), with the corresponding percentage of that denominator given in parentheses and rounded to the nearest whole number. Teachers and parents were pooled for this count because each theme was raised by both groups; where a theme was raised by only one group this is stated in the text. Percentages reported in an earlier version of this article were calculated on the parent subsample alone and have been recalculated here on the full sample of 13 so that all reported proportions share a single, stated denominator.

## 3. Results

### 3.1. Colour Properties of the Pigments

Marigold produced a bright yellow (high L*, high b*); indigo a dark blue (low L*, negative b*); and lac a strong red (high a*). All CIELAB parameters differed significantly between pigments ($p < .001$; L* F = 5927.36, a* F = 15298.64, b* F = 15993.65, df = 2, 42). Single pigments showed colour differences (ΔE*ab) above

40; blends showed differences of roughly 20 - 30—still clearly distinguishable, but visually more harmonious. In practice, this gave the programme a working palette of six colours (three single pigments and three blends) that children could reliably tell apart, which mattered later on for activities that asked them to select a specific colour rather than simply colour freely.

### 3.2. Creativity

The pre- and post-programme creativity scores are shown in Table 3.

Table 3. Pre- and post-programme creativity scores and Wilcoxon signed-rank test results.

| Variable | Pre M (SD) | Post M (SD) | Z | *p* | r |
|---|---|---|---|---|---|
| Creativity | 2.60 (.52) | 4.30 (.48) | −2.84 | .004 | .64 |

Creativity scores nearly doubled between pretest and posttest, and the effect size falls in the range conventionally described as large for this kind of rank-based test.

Representative examples of children's artwork from early and later sessions are shown in Figure 2.


Figure 2. Representative samples of children's artwork from early sessions (top; Weeks 1 - 2) compared with later sessions (bottom; Weeks 5 - 6), illustrating the shift from simple mark-making toward more varied, structured, and figurative creative expression, consistent with the significant increase in creativity scores (Table, Section 3.2). Note: samples are representative of the group across the program rather than matched single-child pre/post pairs.

### 3.3. Attention

Attention scores before and after the programme are shown in Table 4.

Table 4. Pre- and post-programme attention and focus scores and Wilcoxon signed-rank test results.

| Variable | Pre M (SD) | Post M (SD) | Z | *p* | r |
|---|---|---|---|---|---|
| Attention/focus | 2.40 (.52) | 4.10 (.57) | −2.81 | .005 | .63 |

Attention and focus improved to a similar degree, with all ten children showing some gain and none scoring lower after the programme than before.

### 3.4. Fine-Motor and Eye-Hand Coordination

Total scores on this scale rose significantly after the programme (M = 34.70, SD = 2.06 pre; M = 38.50, SD = 2.92 post; Z = −2.91, $p$ = .004, r = .92). All five sub-skills improved significantly (Table 5); the largest gain was in hand dexterity, where every child improved in the same direction—a pattern that produces an effect-size estimate near the statistical ceiling (r ≈ 1.00) given the small sample, rather than a computational anomaly.

Table 5. Pre- and post-programme fine-motor and eye-hand coordination sub-skill scores and Wilcoxon signed-rank test results.

| Sub-skill | Pre M (SD) | Post M (SD) | Z | *p* | r |
|---|---|---|---|---|---|
| Grip stability | 6.50 (.53) | 7.00 (.47) | −2.24 | .025 | .71 |
| Pressure control | 6.80 (.63) | 7.40 (.70) | −2.45 | .014 | .77 |
| Coloring within boundaries | 6.80 (.92) | 7.70 (1.16) | −2.71 | .007 | .86 |
| Coordinated hand-eye movement | 6.90 (.57) | 7.70 (.67) | −2.83 | .005 | .89 |
| Hand dexterity | 7.70 (.67) | 8.70 (.67) | −3.16 | .002 | ≈1.00 |

### 3.5. Positive Behaviour

Pre- and post-programme scores on the positive behaviour scale are shown in Table 6.

Table 6. Pre- and post-programme positive behaviour scores and Wilcoxon signed-rank test results.

| Variable | Pre M (SD) | Post M (SD) | Z | *p* | |
|---|---|---|---|---|---|
| Positive behaviour | 2.40 (.52) | 4.40 (.52) | −2.86 | .004 | .64 |

This was the largest mean gain of the four scales, consistent with teachers' and parents' own impression, reported separately below, that behavioural and emotional change was the most noticeable outcome of the programme.

### 3.6. Teachers and Parents

Interviews converged on four themes. Of the 13 interviewees (3 teachers, 10 parents), greater participation was raised by 12 (92%), longer sustained attention by 10 (77%), and more varied creative expression by 10 (77%); positive emotional

and behavioural change was the most frequently mentioned theme and was raised by all 13 interviewees (100%). Counts are of individual interviewees, and percentages are calculated on the denominator of 13 and rounded to the nearest whole number. Ratings across six items averaged 4.78 out of 5 (SD = .41); emotional change and the safety of the crayons were rated highest (4.90 each), followed by participation (4.80), overall satisfaction (4.78), attention (4.70), and creativity (4.60). The consistency between the two data sources—quantitative scales completed by teachers and open interviews with teachers and parents together—is itself worth noting: nobody who took part in the programme rated it, or described it, in negative terms, and the aspects rated most highly by number (safety, emotional change) were also the aspects most frequently raised unprompted in the interviews.

## 4. Discussion

### 4.1. Attributing Outcomes to Intervention Components

Before interpreting the individual outcomes it is necessary to state plainly what this design can and cannot support. Four components were introduced together—the natural-pigment crayons, the open-ended structure of the activities, repeated practice across 8 - 12 sessions, and individualised teacher support—and no child received any subset of them alone. Every association reported below is therefore an association with the package as a whole. What follows is a set of proposals about which component is most plausibly doing the work in each case, offered as hypotheses for testing rather than as conclusions the present data can establish.

For creativity, the component with the strongest prima facie claim is the open-ended structure of the activities rather than the material: an activity with no single correct outcome is, by construction, the condition under which originality and variety of ideas can be expressed at all. The crayons are proposed here as a facilitating rather than a driving condition—a palette of six reliably distinguishable colours gave children something to choose between—but a conventional crayon set offering the same range of choice might plausibly have produced a comparable result, and this study cannot rule that out.

For fine-motor and eye-hand coordination, the most plausible explanation is repeated practice. The five sub-skills assessed are precisely the actions the activities required children to perform many times per session, and the boundary-colouring tasks introduced from session 3 onward target them directly. Neither the natural origin of the pigment nor the open-ended framing has any obvious mechanism of action on grip stability or pressure control; a task-practice account is sufficient, and is the account this article adopts.

For attention, the components cannot be separated even in principle by this design, because the motor demands, the material and the teacher's scaffolding were all present inside the same task that was holding the child's attention. The account offered in Section 4.4—that attention is sustained by an activity the child finds worth attending to—implicates the open-ended structure and the teacher's

pacing jointly, with the sensory properties of the material as a possible but unverified contributor.

For positive behaviour, teacher support and the absence of comparison or competition are the components most consistent with both the quantitative gain and the interview material, which foregrounded the adults' role at home and in the classroom. The crayons themselves are least likely to be the operative component here, although teachers and parents attributed part of the change to the material's sensory acceptability, and that perception may itself have influenced how the sessions were conducted. Disentangling these possibilities requires the comparative design described in Section 4.7.

### 4.2. An Expert-Assessed Material with Controllable Colour

The three pigments produced clearly distinct, statistically separable colours, and blending them extended the palette without sacrificing distinguishability. This matters for two reasons. First, colour is not decorative in children's art materials—it is one of the primary channels through which young children perceive and respond to what they are given to work with (Arnheim, 1974), so a controllable, natural colour system is a genuine design achievement in its own right, and not merely a question of material suitability. Second, the choice of natural pigment and beeswax over synthetic alternatives reflects what design researchers call material-based design: the material itself shapes how a product is experienced, not merely how it performs (Karana, Pedgley, & Rognoli, 2014). The expert panel's positive assessment of texture, ease of use, and colour quality suggests the crayons succeeded on both counts, and situates the work within a broader move toward natural, low-impact materials in learning tools (Manzini, 2015).

It is worth being explicit about what this adds beyond the suitability assessment alone. A crayon judged acceptable on inspection but unpleasant to use—too hard, too pale, too waxy—would not have produced the engagement seen in this programme. What the experts were evaluating, and what seems to have mattered for the children, was the combined experience of a material that felt good to use and looked good on paper. Assessed suitability and sensory quality are not separate design goals here; they are the same goal, approached from two directions.

It is also worth comparing this, briefly, to what a conventional crayon offers. Commercial crayons are optimised for cost and shelf stability rather than for sensory quality or environmental impact, and a natural crayon cannot compete with them on price or on colour uniformity at scale—a genuine limitation for wider adoption. What it offers instead is a traceable material: a child, or a teacher, can point to the flower or the resin the colour came from.

### 4.3. Why Creativity Improved

Children's creativity scores rose substantially after the programme, which fits a simple explanation: creativity develops when learners are given room to explore and decide for themselves, not when they are taught technique in isolation.

Guilford's (1950) and Torrance's (1966) accounts of creativity both emphasise originality and the generation of varied ideas—exactly what an open-ended activity, free of a single correct answer, is designed to invite. Amabile (1996) adds the motivational piece: children pursue ideas further when the activity itself is intrinsically rewarding, which is consistent with what we observed informally during sessions. The broader principle here is experiential—understanding is built through direct engagement with real material, not through instruction about it (Dewey, 1938; Kolb, 1984).

For children with autism in particular, who often communicate more comfortably through images than words, this matters doubly: art is not just an activity but a legitimate way of knowing and expressing (Eisner, 2002). What the crayons contributed, specifically, was a physical link between sensation and idea—the feel of colour on paper seems to have mattered as much as the finished image. Seen this way, the material and the activity cannot really be separated when explaining the gain in creativity: a duller or less pleasant crayon would likely have produced a duller, less explored session. This also reframes what "teaching" creativity might mean for this group—less a matter of instruction in technique, and more a matter of removing obstacles (an unpleasant material, a fixed correct answer, time pressure) that would otherwise discourage exploration.

### 4.4. Attention and Coordination

Attention scores improved alongside a full set of fine-motor gains—grip, pressure control, staying within a boundary, hand-eye coordination, and general dexterity all showed significant, often large improvements. Both results plausibly stem from the same source: the children were not passive recipients of instruction but active participants throughout, from choosing colours to deciding how to build an image, which is the condition under which engagement is normally sustained (Fredricks, Blumenfeld, & Paris, 2004). Attention, in other words, does not seem to depend only on a child's general capacity for self-regulation; it depends just as much on whether the activity in front of them is one they find worth attending to. An activity that lets a child produce something they consider their own is, on this account, more attention-holding than a technically simpler task with no such stake attached to it.

Repeated, hands-on practice with the crayons—gripping them, controlling pressure, staying inside a shape—doubles as motor training, so the fine-motor gains are not really a side effect of the art programme but a fairly direct consequence of its physical demands: children practised these specific movements dozens of times per session simply by using the material as intended. This is broadly consistent with earlier reviews reporting that art-based work with children with autism is associated with greater flexibility, improved communicative and learning-related skills, and better-directed attention (Schweizer, Knorth, & Spreen, 2014), and with a scoping review finding that creative-arts interventions benefit body functions and process skills in this population (Bernier et al., 2022). The one result that

stands out numerically—dexterity improving in every child, in the same direction, without exception—is best read as a sign of a strong, consistent effect given the sample size, rather than evidence that dexterity is somehow more responsive than the other sub-skills; a larger sample would likely narrow the estimated effect size toward the others without changing the underlying conclusion.

It is tempting to treat attention and fine-motor skill as two separate outcomes that happened to improve together, but the sequence of the activities makes a stronger claim available: the motor demands were embedded inside the same task that was holding the child's attention, not delivered separately. A child staying inside a boundary while colouring is practising fine-motor control and sustaining attention in the same movement, which may explain why both scales moved together as closely as they did across the ten children, rather than one improving well ahead of the other.

### 4.5. Behaviour, Confidence, and the People around the Child

Positive behaviour improved for reasons that look, on reflection, straightforward: children who are given real choices over their own work develop a sense of ownership over it, and that sense of ownership—rather than any particular technique taught—is what self-determination theory identifies as the main driver of sustained motivation and positive behaviour (Ryan & Deci, 2000). The absence of competition or comparison in the sessions likely helped too, removing a source of pressure that more conventional classroom activities often carry, and leaving children free to measure their work against their own earlier attempts rather than against a peer's.

Teachers and parents described very similar changes—more participation, longer attention, franker emotional expression—which is unsurprising given that art has long been used as an alternative channel of communication for children who find verbal expression difficult (Naumburg, 1947; Malchiodi, 2010; Klorer, 2017). Kramer's (1958) idea that the act of making art is therapeutic in itself, independent of any verbal processing afterward, fits what was reported here: children calmed, focused, and cooperated more, without those changes being mediated through conversation about the work. It is also worth noting that teachers and parents were not incidental to these gains—Vygotsky's (1978) notion that learning is scaffolded by more capable others describes fairly well what happened during and after sessions, with teachers guiding in the room and parents reinforcing at home, so that whatever changed during a session had somewhere to be sustained afterward. The assessed suitability and sensory appeal of the crayons themselves—no harsh smell, pleasant to touch, visually engaging—mattered for the same reason sensory-integration theory would predict: well-designed sensory input can support attention and engagement in children with autism rather than overwhelming them (Ayres, 1972). None of this would have been visible from the quantitative scales alone; the interviews were where the emotional dimension of the change actually surfaced. Several parents, for instance, described their child

bringing artwork home unprompted and wanting to talk about it—a small behaviour, but one that several described as new. Teachers, for their part, tended to emphasise a calmer transition into the activity itself: children who had previously needed several minutes of settling before a task could begin were, by the later sessions, picking up a crayon and starting almost immediately. Comparable gains in participation and social engagement have been reported for other arts-based group interventions with young people on the autism spectrum, including integrated group music sessions with adolescents (Eren, 2015). Taken together, these observations suggest that what changed was not only the children's scores on the four scales but something closer to their overall relationship with the activity of making art.

### 4.6. What This Means for Practice

For special-education practice specifically, the clearest implication is that the choice of material is not a peripheral, purely logistical decision. A material assessed by experts as suitable, sensorially pleasant, and colour-controllable changed what children were willing and able to do with an otherwise familiar activity—colouring—and that in turn changed measurable outcomes across creativity, attention, motor skill, and behaviour together. Second, the structure of the sessions themselves—moving from unstructured exploration toward loosely guided tasks, without ever removing the child's choice over the outcome—appears to be at least as important as any specific technique taught. Practitioners designing similar programmes might reasonably prioritise material quality and genuine choice over a tightly sequenced skills curriculum.

There is a broader point here too, about how special education tends to frame children with autism in terms of what they find difficult. Nothing in this programme addressed a deficit directly; instead, it gave children a material and a setting in which they could do something well and be seen doing it well, by teachers and parents alike. The gains recorded across every measure used here look less like the result of correcting a weakness and more like the result of removing obstacles to a strength the children already had. That distinction is not merely rhetorical: it changes what a practitioner is trying to design for, from remediation toward the setting up of conditions in which the child's existing capacities can show themselves.

How does this sit alongside earlier work on art and autism? The direction of every result here—gains in creativity, attention, and behaviour following an open-ended art intervention—matches the general pattern reported in that literature reasonably closely, including the specific finding that free, self-directed drawing increases originality and flexibility in this population (Rahmani & Rahmani, 2014). What this study adds is the material side of that picture: most existing work treats the art medium as incidental to the intervention, whereas here the medium itself—its safety, its colour range, its feel in the hand—was developed and validated as a first, explicit step, and its properties are reported quantitatively (Section

3.1) rather than assumed. Whether that specific choice of material was necessary for the outcomes observed, as opposed to any sufficiently safe and pleasant alternative, is a question this design cannot answer on its own, and is one of the clearer directions for future comparative work.

### 4.7. A Framework and Its Limits

Taken together, these findings can be summarised in a five-part framework—the Natural Crayon Art Learning Model—that links natural materials, open-ended art activities, and the sensory experience they generate to gains in creativity and behaviour. Briefly: natural materials assessed as suitable for children 1) support open-ended art activities 2), which generate rich sensory experience 3), which in turn supports creative development 4) and, through it, the positive learning outcomes observed here 5). The model is offered as a description of what happened in this programme, and as a starting point for similar work elsewhere in special education, rather than as a finished theory.

The study has clear limits. The sample was small and purposively selected—ten children, five experts, thirteen family members and teachers—and the single-group design without a control group means the gains observed cannot be attributed to the programme with full confidence; some part of the change could reflect maturation, novelty, or simply repeated testing. The programme also ran for only six weeks, with no follow-up to check whether the gains held. Replication with a larger, more diverse sample and a comparison group is the obvious next step, ideally one that compares the natural crayons directly against a conventional equivalent used in the same activities, so that the material's specific contribution can be separated from the contribution of the structured, choice-driven session design.

A second limitation concerns measurement. All four outcome scales were completed by the same teacher who ran the sessions, which introduces a risk of observer expectation affecting the scores; an independent rater blind to the timing of assessment would strengthen future work. Finally, because the ten children were drawn from a single centre, the findings should not be generalised to autism as a whole without replication across more varied settings and severity levels; children with more significant sensory sensitivities or motor impairment might respond differently to the same material and activities.

Two further limitations follow directly from the points made above. First, the suitability of the crayons rests entirely on structured expert judgement of colour, texture, handling and observable irritant properties; no heavy-metal or contaminant assay, migration test, or dermatological assessment was conducted, and the article therefore makes no claim that the crayons are non-toxic or safe in the regulatory sense of those terms. Formal laboratory testing against the relevant children's art-material standard is a necessary step before any wider recommendation for classroom use. Second, because the crayons, the open-ended activity structure, the repeated practice and the teacher support were delivered as a single package,

the component-level proposals set out in Section 4.1 remain untested; a factorial or matched-comparison design, in which the same activities are delivered with conventional crayons, is the minimum required to separate the material's contribution from that of the programme built around it.

None of these limitations undermine the basic finding that a carefully designed natural material, used inside a well-structured but genuinely open-ended activity, was associated with broad gains across four different outcome measures and was received positively by every adult who observed it. They do mean that the specific magnitude of the effects reported here should be treated as a first estimate rather than a settled figure, pending replication under more controlled conditions.

## 5. Conclusion

A set of crayons made from marigold, indigo, and lac pigments produced a distinct and controllable colour palette that a panel of five experts assessed as suitable for use with children. When used in a six-week art programme, they were associated with significant, large gains in creativity, attention, fine-motor and eye-hand coordination, and positive behaviour among children with autism, and teachers and parents rated both the programme and the material itself very positively.

Beyond the specific numbers, the study's contribution is really about showing that these two strands—a materials-science question about how to make a natural, colour-controllable crayon suitable for classroom use, and an educational question about what kind of art programme helps children with autism—can be addressed together, in the same piece of work, rather than treated as separate research problems that happen to share a subject. These results are summarised in the Natural Crayon Art Learning Model, a five-part framework that may be useful for designing similar art-based programmes for children with special needs, whether or not the specific pigments used here are available in a given setting. Future work should test the model with larger and more varied samples, a control group, and longer follow-up, compare natural crayons directly against commercial alternatives under otherwise identical activity conditions, and examine whether the same approach transfers to other natural art media, such as pastels or clay-based paints.

For now, the more modest and defensible claim is this: a natural crayon, developed and validated with the same care normally given to any piece of equipment used with vulnerable children, is a workable and apparently beneficial addition to art-based programming for children with autism, and the process used to develop and test it here—expert review, then a structured programme measured before and after, then a round of interviews with the adults involved—is a reasonable template for evaluating other natural materials proposed for similar use.

## Author Contributions

Conceptualization, I.C. and T.P.; methodology, I.C.; software, T.S.; validation, I.C., T.P. and T.S.; formal analysis, I.C.; investigation, I.C.; resources, I.C.; data

curation, I.C.; writing—original draft preparation, I.C.; writing—review and editing, I.C., T.P. and T.S.; visualization, T.S.; project administration, I.C.; funding acquisition, I.C. All authors have read and agreed to the published version of the manuscript.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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