Psychology Research, Sep.-Oct. 2026, Vol. 16, No. 5, 239-250
doi:10.17265/2159-5542/2026.05.001

Cognitive and Psychological Characteristics of Children Engaged With DIY Candy Kit (Chiiku-Gashi): Instructional Design and Psychological Processes During Confectionery Making

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This study examined the educational value of interactive confectionery-making kits through three experiments with children. Experiment 1 investigated the effects of information load and presentation format on comprehension of preparation instructions. Comprehension decreased as information load increased, and a significant interaction was found between information load and presentation format. Experiment 2 showed an overall increase in self-esteem from before to after the confectionery activity. Although the confectionery type × time interaction was not significant for the overall eight-item self-esteem score, item-level analyses revealed significant interactions for two of the eight items. The more open-ended product also received higher ratings for willingness to persist and to share or explain the completed product. In Experiment 3, behavioral observations indicated more frequent trial-and-error and creative behaviors with the open-ended product, together with some behaviors suggesting positive self-evaluation, such as showing or explaining completed products to family members. Overall, interactive confectionery-making may provide an experiential learning activity in which children comprehend instructions, carry out tasks, engage in trial and error and creative exploration, and achieve successful completion. These findings also suggest that educational design should balance clear, cognitively manageable instructions with opportunities for autonomous exploration.

Keywords: DIY Candy Kit (Chiiku-Gashi®), working memory, self-esteem, experiential learning, trial and error

Introduction

Recent education emphasizes not only knowledge acquisition but also the development of thinking, judgment, and creativity through active, interactive, and deep learning. This has increased interest in materials that allow children to learn through direct experience and in activities that integrate play and learning. One example is DIY

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Candy Kit (Chiiku-Gashi®), a line of interactive confectionery-making kits in which children mix powders and liquids and experience changes in color, shape, and physical properties while producing an edible product. Since the launch of Neruneru nerune® in 1986, such products have become widely used and have also been discussed as materials that may support creativity and autonomous engagement (Nakamura, Ariga, Otani, & Kobayashi, 2023; Ariga, 2021). However, most work on DIY Candy Kit (Chiiku-Gashi®) has focused on product development or educational practice, and empirical research on children's cognitive and psychological responses remains limited.

Working Memory and the Design of Preparation Instructions

Completing an interactive confectionery kit requires children to understand instructions, temporarily retain relevant information, and execute steps in the correct sequence. Working memory is therefore likely to play an important role. It supports the temporary maintenance and processing of information involved in reading, calculation, reasoning, and problem solving (Oka et al., 2010). Baddeley's model includes the central executive, phonological loop, and visuospatial sketchpad, and is later extended by the episodic buffer. Working memory develops throughout childhood, including improvements in visuospatial working-memory capacity during the school years (Oka et al., 2010).

Visual information such as diagrams and illustrations can facilitate comprehension in learning contexts (Doyama, Hashimoto, Hayashi, & Nemoto, 2014). Preparation instructions for DIY Candy Kit (Chiiku-Gashi®) contain multiple sequential operations, such as adding powder, measuring water, and mixing ingredients. As the amount of information presented at one time increases, the load on working memory is also expected to increase. Previous research has shown that adding illustrations to procedural text can improve comprehension and task execution by visually representing objects, operations, and state changes (Kubodera, Yamamoto, & Kishi, 2008). Nevertheless, few studies have examined how information load and presentation format affect children's comprehension of instructions for an experiential product such as DIY Candy Kit (Chiiku-Gashi®).

Confectionery-Making Experiences and Self-Esteem

Children's participation in hands-on cooking programs has been associated with greater cooking self-efficacy (Jarpe-Ratner et al., 2016; Cunningham-Sabo & Lohse, 2014). Interactive confectionery is not only an instructional task but also an activity in which children create a finished product themselves. Such mastery experiences may influence psychological outcomes. Self-esteem, broadly defined as an individual's evaluation and acceptance of the self, is associated with mental health, motivation, and school adjustment. The Rosenberg Self-Esteem Scale (RSES) is widely used internationally, and Japanese versions, including measures adapted for children, have demonstrated acceptable reliability and validity (Uchida & Ueno, 2010; Yokoshima, Uchiyama, Uchida, & Yamasaki, 2020; Nakayama, Nishiyama, & Yanagisawa, 2011).

Cooking and experiential-learning activities have also been examined in relation to children's psychological development. Japanese studies of elementary-school cooking programs have reported improvements in cooking skills, confidence, and self-esteem (Sakamoto et al., 2019; Kondo, Nakashita, & Sakamoto, 2021). International research has similarly shown that culinary education can increase cooking self-efficacy and active engagement (Jarpe-Ratner et al., 2016; Cunningham-Sabo & Lohse, 2014; Policastro, Brown, & Comollo, 2023). Creative group activities have also been associated with improvements in working memory, self-esteem, and mood (Muniroh et al., 2026). These findings suggest that actively progressing from instructions to a completed product may foster challenge, achievement, and confidence. However, few studies have jointly examined cognitive and psychological processes in brief, playful, creative confectionery-making activities.

Accordingly, the present study comprised three experiments. Experiment 1 examined how information load (number of chunks) and presentation format (text only vs. text plus figures) affected comprehension of preparation instructions. Experiment 2 examined changes in self-esteem and subjective evaluations associated with confectionery-making and eating. Experiment 3 used behavioral observation and records of children's utterances and comments to explore the processes that occurred during confectionery making, including challenge, trial and error, task completion, achievement, and behaviors suggestive of positive self-evaluation. Together, the experiments were intended to clarify how instructional design and activity structure may contribute to the educational value of interactive confectionery.

Method

Participants

Experiments 1 and 2. Eighty-nine elementary-school children in Grades 1-6 participated (ages 6-11 years, M = 7.7 years; 43 boys, 41 girls, and 5 with sex not reported). Participants were recruited regardless of prior experience with DIY Candy Kit (Chiiku-Gashi®). Of the 88 children who answered the relevant item, 77 (87.5%) reported previous experience making DIY Candy Kit (Chiiku-Gashi®).

Experiment 3. Fourteen children participated (ages 6-11 years, M = 8.2 years; 8 boys and 6 girls). Four children participated individually and 10 participated as five sibling pairs. Twelve children were accompanied by their mothers, and one sibling pair was accompanied by both parents. All participants had previous experience making DIY Candy Kit (Chiiku-Gashi®).

Study Period and Setting

Experiments 1 and 2 were conducted on May 11, 2026, with 58 children at an elementary school affiliated with the university, and on July 26, 2026, with 31 volunteer participants at the university. On both dates, participants completed Experiment 1 followed by Experiment 2. Experiment 3 was conducted at the university between July 30 and August 9, 2026.

Experiment 1

Design. Experiment 1 used a 2 × 5 mixed design. Presentation format was a between-participants factor with two conditions: text only and text plus figure, as shown in Figure 1. Information load, operationalized as the number of chunks in one instruction panel, was a within-participants factor with five levels (2-6 chunks), as shown in Figure 2. The instructional content was equivalent across presentation conditions. For example, an instruction equivalent to "Put / one cup of water / and powder No. 2 / into the round tray / and mix / with the spoon" was treated as six chunks. Three items were prepared for each chunk level, yielding 15 test trials. To minimize effects of prior product experience, all instruction sequences were fictitious.

Procedure. Experiment 1 was administered in groups. Participants first completed a demographic sheet covering age, grade, sex, awareness of DIY Candy Kit (Chiiku-Gashi®), and previous experience. After two practice trials, they completed 15 test trials. In each trial, an instruction was displayed on a screen for 10 s in either text-only or text-plus-figure format in Figure 1. Participants were asked to remember the content. A video depicting a preparation sequence was then shown. During a 20-s response interval, participants judged whether the video sequence was the same as or different from the previously presented instruction and recorded their answer on paper. The experiment lasted approximately 20 min.

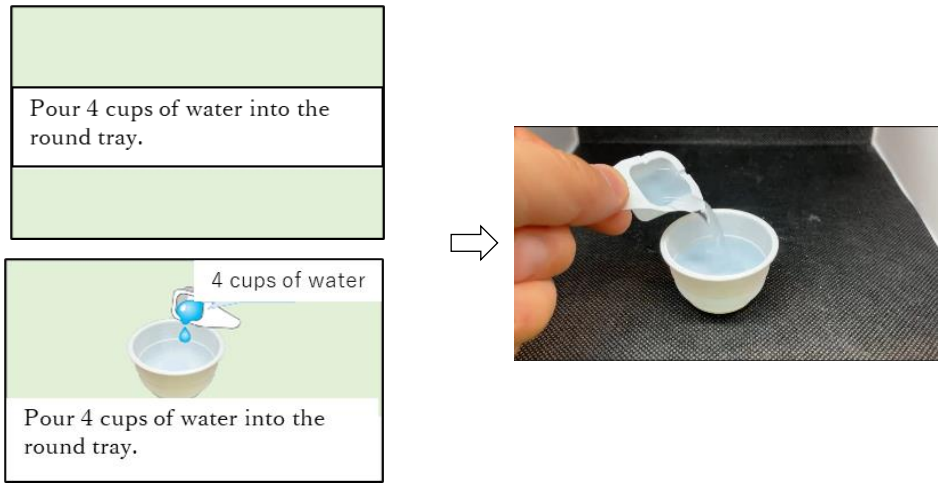


Figure 1. Examples of the stimulus sequence in Experiment 1: (a) text-only and (b) text-plus-figure instructions were presented as the first stimulus, followed by a video of the preparation procedure as the second stimulus.



(a) (b)

Figure 2. Examples of instruction panels containing (a) two and (b) six chunks.

Experiment 2

Design. Experiment 2 used a 3 (confectionery type) × 2 (time: pre-activity vs. post-activity) mixed design. Confectionery type was a between-participants factor with three groups: (a) Neruneruneruneruneruneru®, a relatively structured DIY Candy Kit (Chiiku-Gashi®); (b) Oekaki Gummy Land®, a more open-ended DIY Candy Kit (Chiiku-Gashi®); and (c) a control condition involving conventional confectionery that was not classified as DIY Candy Kit (Chiiku-Gashi®). Neruneruneruneruneruneru® involves mixing water with two powders to produce changes in color and foaming. Oekaki Gummy Land® allows children to create gummies of different shapes and colors by applying colored liquid to powder placed in molds. Time was a within-participants factor measured before and after the confectionery activity.

Measures. Self-esteem was assessed using eight items from a Japanese child version of the Rosenberg Self-Esteem Scale (RSES) (Yokoshima et al., 2020; Nakayama et al., 2011). Yokoshima et al. (2020) conducted factor analysis after excluding two of the original 10 items because of their low factor loadings. Following this approach, and to reduce the response burden on the participating children, the present study also used eight items. After the activity, participants in the DIY Candy Kit (Chiiku-Gashi®) conditions also completed a 10-item study-specific questionnaire assessing perceived ease of preparation, comprehensibility, appearance, enjoyment, achievement, persistence, and willingness to show or explain the product to others.

Procedure. Experiment 2 was administered in groups. Participants first completed the demographic sheet and the RSES. They then engaged with and ate the confectionery assigned to their group during a standardized 20-min period. Support staff were present during DIY Candy Kit (Chiiku-Gashi®) preparation and provided

standardized assistance only when participants could not understand the instructions. After the activity, participants completed the RSES again; those in the DIY Candy Kit (Chiiku-Gashi®) groups also completed the study-specific evaluation questionnaire. The total session lasted approximately 30 min.

Experiment 3

Design. Experiment 3 was an exploratory observational study designed to complement the quantitative findings of Experiment 2. Participants made and ate both Nerunerunerune® and Oekaki Gummy Land®, with product order counterbalanced across the 14 participants. Children's behaviors and emotional reactions during preparation were recorded using a behavioral checklist, together with notes on utterances and comments made during the activity.

Procedure. Sessions were conducted in a university laboratory with either one child or a sibling pair, reflecting the actual participation format. Before the session, the study was explained to participants and their guardians. Children were then presented with the designated product and instructed to prepare and eat it. Accompanying parents sat beside the children and were permitted to talk to them, provide advice, and assist with preparation. The experimenter recorded the occurrence and timing of behaviors using the behavioral checklist.

Ethical Considerations

For the school-based sessions, the school agreed to cooperate with the study and explanatory materials, including information about allergens in the confectionery, was sent to guardians; informed consent was obtained before participation. For participants recruited through online announcements and advance registration, the study and allergen information were explained during recruitment. The study was approved by the Research Ethics Committee of Kyoto Koka University (Approval No. 25-40).

Statistical and Qualitative Analyses

For Experiment 1, correct responses were analyzed using a mixed two-way analysis of variance (ANOVA) with presentation format as the between-participants factor and chunk number as the within-participants factor. For Experiment 2, RSES scores were analyzed using mixed two-way ANOVAs with confectionery type and time as factors. The two DIY Candy Kit (Chiiku-Gashi®) groups were compared on the study-specific scale using independent-samples t tests; Cohen's d was reported for these comparisons. For Experiment 3, observation records and contemporaneous utterance/comment notes were organized into five descriptive categories: encountering difficulty, trial and error/creative modification, task execution, completion/achievement, and behaviors suggesting positive self-evaluation. Because Experiment 3 was exploratory and involved only 14 participants, category frequencies were interpreted descriptively rather than as population-level product differences.

Results

Experiment 1

Figure 3 shows the number of correct quiz responses by stimulus presentation method and number of chunks. In the text-plus-figure condition, the mean numbers of correct responses for 2-6 chunks were 2.44, 2.29, 1.98, 2.09, and 2.09, respectively. In the text-only condition, the corresponding means were 2.68, 2.68, 2.16, 1.80, and 1.80. Performance generally decreased as the number of chunks increased, with a more pronounced decrease at five and six chunks in the text-only condition.

A two-way mixed ANOVA showed no significant main effect of presentation format, $F(1, 87) = 0.191$, ns. The main effect of chunk number was significant, $F(4, 348) = 18.4$, $p < 0.001$, as was the presentation format ×

chunk number interaction, $F(4, 348) = 5.10$, $p < 0.001$. Follow-up comparisons indicated that at three chunks the text-only condition produced significantly more correct responses than the text-plus-figure condition ($p < 0.01$). At five chunks, the text-plus-figure condition showed a nonsignificant trend toward a higher score ($p < 0.10$). No significant differences were found at two, four, or six chunks.

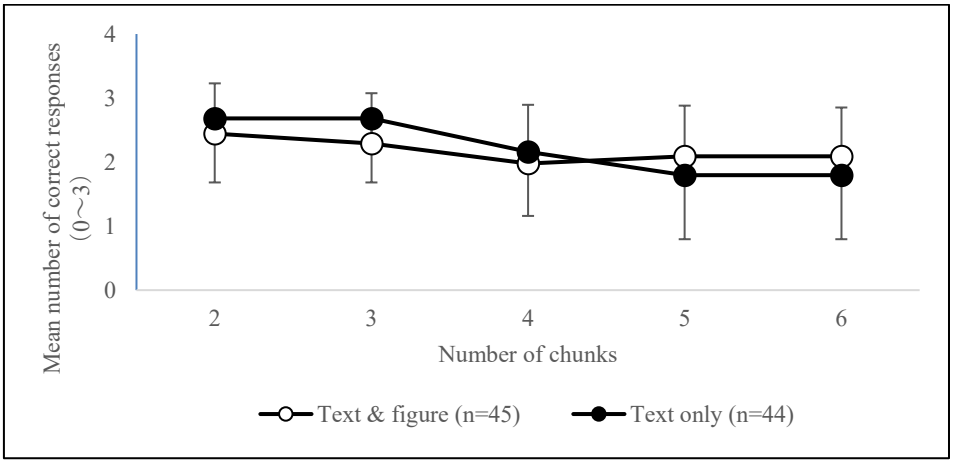


Figure 3. Mean number of correct responses by presentation format and number of chunks. Error bars indicate standard deviations. The two plotting symbols correspond to the presentation conditions shown in the legend.

Experiment 2

Self-esteem. Table 1 shows the mean self-esteem scale scores for each group and the results of the two-way analysis of variance (ANOVA). The mean score across the eight RSES items increased from 3.45 to 3.64 in the Neruneruneruneru® group, from 3.67 to 3.85 in the Oekaki Gummy Land® group, and from 3.50 to 3.60 in the conventional-confectionery group. The ANOVA for the overall mean showed a significant main effect of time ($p < 0.01$), whereas neither the main effect of confectionery type nor the confectionery type × time interaction was significant. Thus, the overall pre-post increase cannot be attributed specifically to one confectionery type.

Table 1

Mean Self-Esteem Scores and Two-Way ANOVA Results

RSES item	Neruneruneruneru®		Oekaki Gummy Land®		Conventional confectionery		F: Type	F: Time	F: Interaction
	Pre	Post	Pre	Post	Pre	Post			
1. I am generally satisfied with myself.	3.3	3.9	3.9	4.3	4.1	4.0	2.85†	6.64*	2.55†
2. I think I have some good qualities.	3.7	3.9	4.2	4.2	3.7	3.8	3.63*	0.39	0.10
3. I can do many things about as well as my friends.	3.6	3.9	3.6	3.9	3.7	3.2	0.71	0.17	4.43*
4. There are not many things I am good at. (R)	3.8	3.8	3.6	3.6	3.4	3.6	0.61	0.24	0.45
5. I sometimes feel that I am not useful. (R)	3.0	3.2	3.1	3.6	2.8	3.3	0.73	7.02*	0.66
6. I think I am a person of value, at least as much as other people.	3.4	3.2	3.3	3.2	3.6	3.3	0.20	1.34	0.09
7. I sometimes think that I will fail no matter what I do. (R)	2.7	3.4	3.6	3.4	2.9	3.5	1.82	7.09**	4.47*
8. I think I will be able to do many things in the future.	4.0	3.9	4.1	4.4	3.9	4.0	0.96	1.37	1.40
Mean of all 8 items	3.4	3.6	3.7	3.8	3.5	3.6	1.78	11.2**	0.39

Notes. R = reverse-scored item. † $p < 0.10$. * $p < 0.05$. ** $p < 0.01$.

Item-level analyses showed several significant or marginal effects. For Item 1, the main effect of time was significant ($p < 0.05$), and the interaction approached significance ($p < 0.10$); follow-up tests indicated significant post-activity increases in both DIY Candy Kit (Chiiku-Gashi®) groups but not in the conventional-confectionery group. For Item 2, only the main effect of confectionery type was significant ($p < 0.05$). For Item 3, the interaction was significant ($p < 0.05$); the Oekaki Gummy Land® group showed a nonsignificant trend toward a higher post-activity score ($p < 0.10$), whereas the conventional-confectionery group showed a significant change ($p < 0.05$). For Item 5, the main effect of time was significant ($p < 0.05$), and the Oekaki Gummy Land® group showed significant improvement ($p < 0.05$). For Item 7, both the main effect of time ($p < 0.01$) and the interaction ($p < 0.05$) were significant; follow-up tests showed significant improvement in the Neruneruneruneru® and conventional-confectionery groups (both $p < 0.01$).

Study-specific DIY Candy Kit (Chiiku-Gashi®) evaluation questionnaire. Table 2 shows the results of the study-specific DIY Candy Kit (Chiiku-Gashi®) evaluation questionnaire. The mean of the 10 study-specific items was 3.92 for Neruneruneruneru® and 4.34 for Oekaki Gummy Land®, with a significant difference between groups, $t = -2.75$, $p < 0.01$. Oekaki Gummy Land® scored significantly higher on Item 5 ($p < 0.05$) and Items 9 and 10 ($p < 0.01$), while Item 6 showed a nonsignificant trend toward a higher score ($p < 0.10$).

Table 2

Mean Scores on the Study-Specific DIY Candy Kit (Chiiku-Gashi®) Evaluation Questionnaire

Item	Neruneruneruneru®	Oekaki Gummy Land®	Cohen's d	t
1. I think I can make it successfully.	4.5	4.6	-0.096	-0.37
2. I think I can do the mixing well.	4.3	4.6	-0.378	-1.38
3. I think I can do it by myself if I look at the instructions.	3.8	4.3	-0.436	-1.64
4. I think I can be creative with the colors and shapes.	4.5	4.4	0.170	0.64
5. I want to keep trying even if it is difficult.	3.9	4.3	-0.564	-2.14*
6. If I make it myself, I think I will feel, "I did it!"	4.1	4.5	-0.452	-1.73†
7. I can think of myself as capable.	4.0	4.1	-0.095	-0.36
8. I think I did my best today.	4.3	4.7	-0.442	-1.63
9. I would be willing to show what I made to someone.	3.0	4.1	-0.869	-3.32**
10. I think I could explain to someone how to make it.	2.9	3.9	-0.765	-2.91**
Mean of all 10 items	3.9	4.3	-0.725	-2.75**

Notes. † $p < 0.10$. * $p < 0.05$. ** $p < 0.01$.

Experiment 3

Figure 4 shows the temporal progression of preparation steps for the two products. For Neruneruneruneru®, the median start times were 0.07 min for picking up the product, 0.33 min for opening it, 0.57 min for detaching the cup from the tray, 1.50 min for mixing powder 1 with water, 2.87 min for adding and mixing powder 2, and 4.46 min for adding the topping. For Oekaki Gummy Land®, the corresponding median start times were 0.07 min for picking up the product, 0.17 min for opening it, 0.80 min for preparation, 5.20 min for making colored water, 10.56 min for making gummies, and 20.67 min for removing the gummies. Thus, later steps began substantially later for Oekaki Gummy Land®, and the original data also showed greater between-participant variability in the later stages.

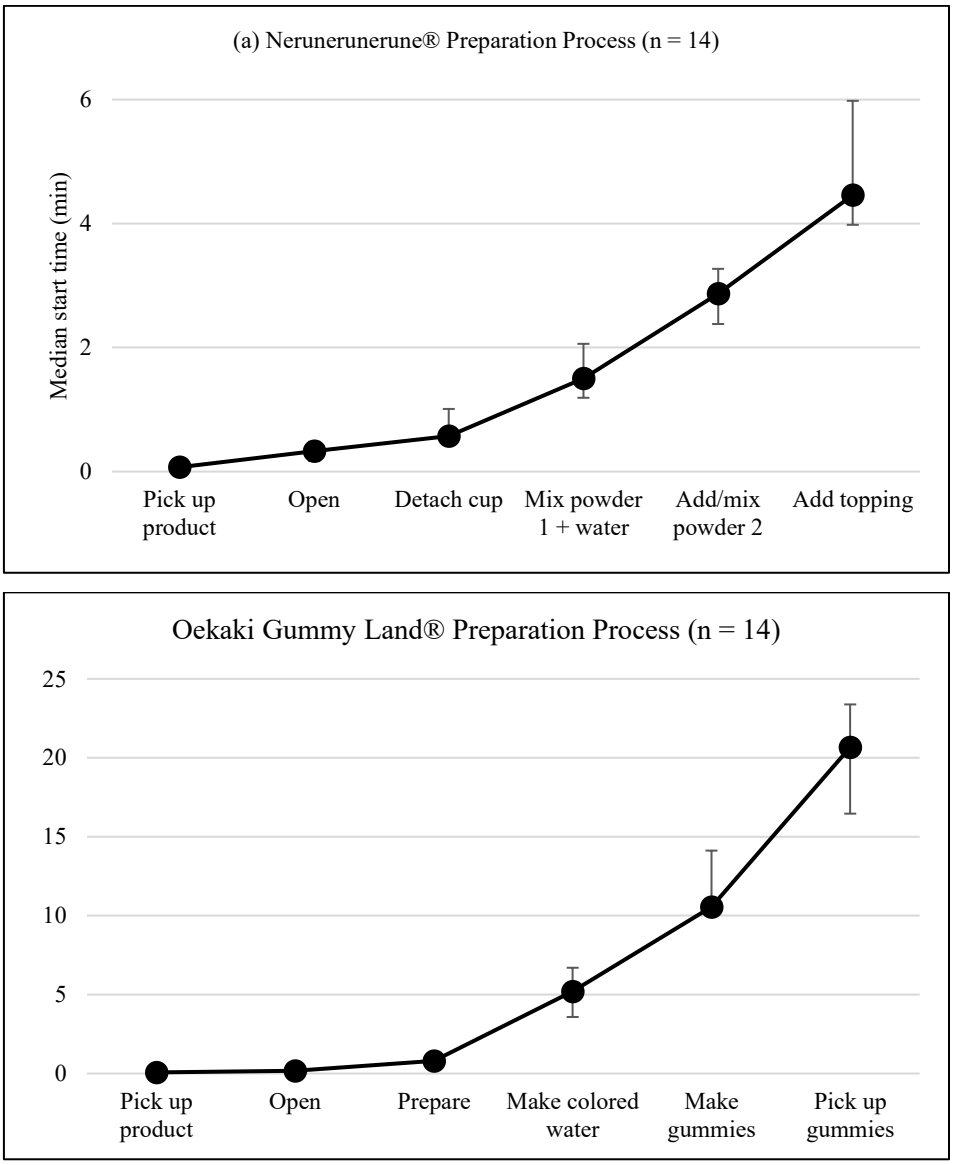


Figure 4. Temporal progression of preparation-step start times for (a) Neruneruneruneru® and (b) Oekaki Gummy Land®. Points represent median start times for each step; error bars indicate the interquartile range (Q1-Q3).

Table 3 shows categories and operational definitions used in Experiment 3. Observation records and contemporaneous utterances/comments were organized into five categories: encountering difficulty, trial and error/creative modification, task execution, completion/achievement, and behaviors suggesting positive self-evaluation.

Table 3

Categories and Operational Definitions Used in Experiment 3

Category	Operational definition	Main behavioral indicators/examples
Encountering difficulty	A problem occurred during a procedure, operation, or material adjustment, requiring self-correction or assistance from another person.	Incorrect sequence; inability to remove the product from a mold; excessive material; uncertainty about how to proceed; receiving parental advice or assistance.

Table 3 to be continued

Trial and error/creative modification	Behavior in which the child went beyond the prescribed procedure by changing a method or trying a new combination, shape, color, or preparation strategy.	Mixing colors; combining molds; reusing leftover materials; creating an original shape; trying a more efficient method.
Task execution	Behavior in which the child independently continued the required steps using the instructions or prior experience.	Checking instructions; following the procedure; working from prior experience without instructions; sustaining concentration.
Completion/achievement	Completion of the sequence and production of at least one edible item.	Removing the completed item from the mold; eating the finished item; completing multiple items; continuing until materials were used.
Behavior suggesting positive self-evaluation	Behavior or speech suggesting that the child evaluated the outcome positively following completion or success.	Showing the product to family; explaining the method or a creative feature; expressing "I did it"; appearing satisfied or proud.

Table 4 shows number of participants showing each behavioral category by product. Task execution and completion/achievement were observed in all 14 participants (100%) for both products. Encountering difficulty was observed in 1 participant (7.1%) for Neruneruneruneru® and 5 (35.7%) for Oekaki Gummy Land®. Trial-and-error/creative modification was not observed for Neruneruneruneru® but was observed in 12 participants (85.7%) for Oekaki Gummy Land®. Behaviors suggesting positive self-evaluation were observed in 3 participants (21.4%) during Oekaki Gummy Land® and in none during Neruneruneruneru®.

Table 4

Number of Participants Showing Each Behavioral Category by Product

Category	Neruneruneruneru®, n (%)	Oekaki Gummy Land®, n (%)	Descriptive pattern
Encountering difficulty	1 (7.1%)	5 (35.7%)	Observed more often with Oekaki Gummy Land®
Trial and error/creative modification	0 (0%)	12 (85.7%)	Observed more often with Oekaki Gummy Land®
Task execution	14 (100%)	14 (100%)	Observed in all participants for both products
Completion/achievement	14 (100%)	14 (100%)	Observed in all participants for both products
Behavior suggesting positive self-evaluation	0 (0%)	3 (21.4%)	Clearly observed only with Oekaki Gummy Land®

Notes. A category was counted as present when at least one clearly corresponding behavior was recorded during preparation of that product. Positive self-evaluation was not directly measured; this category was based on behavioral indicators such as showing, explaining, or expressing satisfaction or pride.

Discussion

Instructional Information Design and Working Memory

Experiment 1 showed that comprehension declined as the amount of information in the preparation instructions increased and that this effect depended on presentation format. At five chunks, the text-plus-figure condition showed a nonsignificant trend toward a higher score than the text-only condition ($p < 0.10$). Because visuospatial working memory develops during childhood and visual information can facilitate comprehension (Oka et al., 2010; Doyama et al., 2014), adding visual representations may support the maintenance and processing of procedural information when information load is relatively high.

Nevertheless, performance declined with increasing chunk number even when figures were provided. Consistent with previous research on procedural text (Kubodera et al., 2008), illustrations may support

comprehension and execution but cannot eliminate working-memory constraints. Instructional design should therefore consider not only whether visual information is present, but also how much information is presented at one time, how it is segmented, and how closely text and visual information correspond.

Confectionery-Making Experiences and Self-Esteem: Integrating Experiments 2 and 3

In Experiment 2, the overall eight-item self-esteem score increased significantly from pre- to post-activity. However, neither the main effect of confectionery type nor the confectionery type × time interaction was significant. Accordingly, the results do not support the conclusion that a particular DIY Candy Kit (Chiiku-Gashi®) product uniquely increased self-esteem. By contrast, on the study-specific evaluation questionnaire, Oekaki Gummy Land® received higher overall ratings than Neruneru nerune® and higher ratings on items concerning persistence and sharing or explaining outcomes. Together with previous studies showing that cooking experiences can increase children's confidence and self-efficacy (Jarpe-Ratner et al., 2016; Cunningham-Sabo & Lohse, 2014; Sakamoto et al., 2019; Kondo et al., 2021; Policastro et al., 2023), these findings suggest that even a brief making-and-eating activity may be accompanied by short-term positive self-evaluation.

Experiment 3 helps clarify what may occur during such activities. Task execution and completion/achievement were observed for all children with both products, whereas trial-and-error and creative modification were especially common during Oekaki Gummy Land®. The temporal data also showed that Neruneru nerune® progressed through a relatively short, structured sequence, whereas later stages of Oekaki Gummy Land® took longer and varied more across children. Thus, the two products appeared to provide different activity structures: one relatively guided and sequential, and the other more open to experimentation and self-directed modification.

The preparation process was not a single linear sequence shared by all children. Rather, task execution formed a base from which children sometimes encountered difficulty, engaged in trial and error, and progressed toward completion; in some cases, completion was followed by showing the product to family members or explaining creative choices. The correspondence between the higher Experiment 2 ratings for showing/explaining the product and the analogous behaviors observed in Experiment 3 provides descriptive convergence between quantitative self-report and behavioral observation.

These observations are compatible with the possibility that understanding instructions, solving problems, making creative choices, and successfully completing a product can contribute to feelings of achievement or competence. However, self-esteem was not directly measured in Experiment 3, and the observed creative or sharing behaviors should not be interpreted as evidence of a generalized increase in self-esteem.

Educational Implications Across the Three Experiments

Taken together, the three experiments suggest that the educational value of interactive confectionery may lie in combining several processes within one activity: understanding instructions, executing procedures, modifying or experimenting with methods, completing a product, and recognizing or sharing the outcome. Experiment 1 demonstrated the importance of information load and presentation format for comprehension; Experiment 2 showed an overall pre-post increase in self-esteem and higher ratings of challenge and outcome sharing for the more open-ended product; and Experiment 3 showed that trial and error, creative modification, and outcome sharing can occur as observable behaviors.

These findings suggest that effective activity design may require a balance between clarity and openness. Basic steps can be presented in a concise and visually supportive manner that reduces unnecessary cognitive load,

while choices in color, shape, or combinations can preserve opportunities for autonomous exploration. Showing a finished product or explaining how it was made may also extend the activity from an individual experience into social interaction.

Importantly, the present findings do not establish that DIY Candy Kit (Chiiku-Gashi®) in general produces long-term improvements in self-esteem or cognitive ability. The educational value observed here is better interpreted as a possibility arising from the combination of appropriate information design and opportunities for children to act autonomously, experiment, complete a task, and share the result.

Limitations and Future Directions

Several limitations should be noted. First, although Experiments 1 and 2 included 89 children, the geographical and school contexts were limited, and Experiment 3 was an exploratory analysis with only 14 participants. Product-specific frequencies in Experiment 3 should therefore be interpreted as descriptive characteristics of the observed sample rather than estimates of population-level product differences.

Second, Experiment 1 did not directly assess working-memory capacity with a standardized measure; performance on the comprehension task should not be treated as a direct measure of individual working-memory capacity. Third, self-esteem in Experiment 2 was assessed immediately after the activity, so the persistence of the observed change is unknown. Moreover, because the confectionery type × time interaction was not significant for the overall score, the data do not show that the more open-ended product produced a larger increase in self-esteem.

Fourth, Experiment 3 relied primarily on structured behavioral observation, and the category of behavior suggesting positive self-evaluation was not a direct measure of self-esteem. Category assignment may also have been influenced by evaluator interpretation. Future studies should use multiple coders and report inter-rater agreement. Fifth, parents were permitted to provide advice and assistance, and parent-child interaction may therefore have influenced task execution and achievement experiences.

Future research should include broader age groups and settings, follow-up assessments, standardized working-memory measures, and psychological indicators such as self-efficacy. A useful next step would be to test the proposed sequence—comprehension of instructions → autonomous task execution → trial and error/creative modification → completion/achievement → competence or positive self-evaluation—using both quantitative and qualitative methods. Research on collaborative preparation with parents or peers may also clarify the educational significance of social interaction mediated by confectionery-making activities.

Acknowledgments

We thank the affiliated elementary school for hosting the study and the participating children for their cooperation. This study was conducted as part of a joint research project between Kracie, Ltd. and Kyoto Koka University concerning the effects of DIY Candy Kit (Chiiku-Gashi®) on children's self-esteem and the appropriate amount of information per preparation-instruction panel.

Declarations

Ethics approval. The study was approved by the Research Ethics Committee of Kyoto Koka University (Approval No. 25-40).

Consent to participate. Informed consent was obtained from guardians in accordance with the procedures described in the Method section.

Funding. This study was supported by research funding provided by Kracie, Ltd. to Kyoto Koka University for the joint research project.

Competing interests. Yuki Ishimaki is affiliated with the Foods Laboratory, Foods Company, Kracie, Ltd., which manufactures the DIY Candy Kit (Chiiku-Gashi®) products examined in this study.

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