Original Research Article

Implementing Japanese Origami in STEAM Education: A Report From an International Astronomical Youth Camp

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ABSTRACT

This study examined the potential of Japanese origami for STEAM education through questionnaires and two 90-minute hands-on origami workshop sessions conducted at the International Astronomical Youth Camp (IAYC), with each participant attending one session. In the pre-camp survey (N=45), 76% reported prior origami experience, and overall interest was high, although many participants were uncertain about its educational usefulness in astronomy. Among the 19 workshop participants who completed the post-workshop survey, 74% reported being very satisfied with the workshop, and "concentration" was the most frequently identified cultivated skill. Among the 18 participants whose pre-camp and post-workshop responses were successfully matched, both interest in origami ($p<0.001$) and perceived educational usefulness in astronomy ($p=0.002$) increased significantly after the workshop. Free-text responses frequently included engineering-related terminology such as "deployment" and "folding," suggesting a strong conceptual connection between origami and space-related contexts. Despite limitations including a small sample size and short intervention duration, the findings indicate that origami can enhance motivation and educational understanding in multicultural and time-constrained learning environments. These results support the integration of origami into interdisciplinary STEAM education, particularly in astronomy-related contexts.

Keywords: Origami; STEAM education; Astronomy education; Workshop; International youth; Experiential learning

INTRODUCTION

Origami is a traditional Japanese cultural art, the term combining the words "to fold" and "paper." Typically, abstract or realistic subjects are folded from an uncut square sheet to complete the work. The oldest extant Japanese manual is the Hiden Senbazuru Orikata (Secret of One-Thousand Cranes Origata), dated 1797 (1). In the twentieth century, origami spread internationally, heavily influenced by the work of origami artist Akira Yoshizawa (2). More recently, the field has advanced toward mathematization, giving rise to the interdisciplinary area of "origami engineering" (3). In aerospace, the Miura-ori folding pattern has been applied to deployable structures such as solar sails and satellite components (4-6), and folding technologies are incorporated into the James Webb Space Telescope (JWST) (7). National Aeronautics and Space Administration (NASA) and European Space Agency provide educational origami models for primary and secondary students based on JWST structures (8, 9), and in 2021 NASA hosted the youth-oriented Webb Origami Challenge, demonstrating that "origami and space engineering" can attract strong interest among

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young people (10). However, little is known about origami awareness and experience among international youth engaged with astronomy, or about the educational effects of origami in this population. Therefore, in this study we administered questionnaires and conducted workshops on origami and astronomy at the International Astronomical Youth Camp (IAYC) (11, 12), which brings together multinational teenagers and young adults, with the aim of clarifying participants' perceptions and experiences of origami and the changes observed after the workshop.

METHODS AND MATERIALS

Participants

This study targeted 45 respondents to an origami-and-space questionnaire, out of a total of 72 IAYC participants. The camp was held in De Klonie, the Netherlands, from 1 to 21 August 2025. Since its inception in 1969, IAYC has run more than 50 camps. Historically, 55% of participants study or work in STEM fields and 26% have gone on to work in astronomy/astrophysics (13).

Survey Procedure

Pre-camp and post-workshop questionnaires were administered via Google Forms without collecting participants' real names. The pre-camp survey collected country of origin, age, gender, and nickname. In the post-workshop survey, participants were first asked to re-enter the same anonymous ID (nickname) used in the pre-camp survey. If they had forgotten their nickname, they were asked to enter their country of origin, age, and gender instead. The pre-camp survey also included yes/no items on prior origami experience, a perceived origami-space connection, and the presence of traditional paper-craft in the respondent's home country, as well as two five-point Likert items on (a) interest in origami and (b) the perceived educational usefulness of origami in astronomy. If respondents answered "yes" to prior origami experience or to a perceived origami-space connection, they provided free-text responses describing their first encounter with origami and what "origami and space" brought to mind. The post-workshop survey re-administered the exact same two Likert items used in the pre-camp survey, (a) and (b), as the primary outcomes and additionally included five-point Likert questions on workshop satisfaction and perceived difficulty. A single-choice item asked which skill origami could cultivate (creativity, concentration, spatial awareness, or dexterity).

Ethical Considerations

This study was conducted with approval from the IAYC organizing committee. Participants were informed of the study purpose before completing the questionnaire, and completion of the questionnaire was taken as informed consent. Data used for analysis were anonymized to protect participant confidentiality.

Origami Workshops

Each workshop was conducted in a hands-on format for 90 minutes, twice in total, and each participant attended one session. The instructor had 10 years of origami experience. Sessions were announced via social media during the camp. The instruction emphasized enabling each participant to complete at least one model. Fifteen-centimeter TANT color paper was used. The source text was The Complete Book of Origami: A Beginner's Guide to the Most Popular Folded Paper Models (14). Participants freely selected models (Classic Traditional Models; Animals, Fish, Insects; Vehicles; Toys; Envelopes and Box) from a pool of 85. A total of 19 participants attended one of the two workshop sessions, and all completed the post-workshop survey (100%).

Statistical Analysis

Statistical analyses included baseline group comparisons, descriptive summaries of post-workshop responses, and paired pre-post comparisons. The full sample (N=45) was divided into the workshop group (N=19) and the non-workshop group (N=26). Pre-camp survey items were summarized and compared between groups using the chi-square test and Fisher's exact test. Post-workshop responses from all 19 workshop participants were also summarized descriptively. For the paired pre-post comparisons, pre-camp and post-workshop survey responses were matched primarily using nickname. No duplicate nicknames were identified among the workshop participants. When nickname was missing, responses were matched using country of origin, age, and gender. No duplicate combinations of these variables were identified among the relevant participants. Eighteen of the 19 workshop participants were successfully matched and included in the paired analyses. Pre-camp and post-workshop scores for interest in origami and perceived educational usefulness of origami in astronomy were compared using the Wilcoxon signed-rank test. Statistical analyses were performed using JMP Pro 18.0.2 for Mac. A p-value < 0.05 was considered statistically significant. Free-text responses were analyzed exploratorily using inductive coding.

One author read all responses and developed categories based on participants' wording and contextual meaning. Similar responses were grouped into the same category, and category labels were defined to concisely represent the main ideas expressed in the responses. Because coding was conducted by a single author, independent coding and inter-rater reliability assessment were not performed. Therefore, the free-text analysis was used to provide descriptive and exploratory context for the quantitative findings rather than as a formal qualitative analysis.

RESULTS

Table 1 summarizes the pre-camp survey (N=45). Comparing workshop and non-workshop groups, no pre-camp survey item showed a significant difference. Participants' origins were Europe N=33 (Germany 8, Spain 6, Italy 4, UK 3, Croatia 2, Czech Republic 2, Ukraine 2, Greece 1, Malta 1, Albania 1, Belgium 1, Georgia 1, Sweden 1), North America N=5 (USA 3, Canada 2), South America N=4 (Argentina 2, Trinidad and Tobago 2), and Asia N=3 (Mongolia 1, Kazakhstan 1, India 1), indicating a multinational cohort. Table 2 shows that first encounters with origami most often occurred in family or home contexts. Among the 19 participants who reported a perceived connection between origami and space, deployable or foldable spacecraft structures were identified in 11 responses (58%), specific examples such as JWST or Hubble in 9 (47%), academic or engineering associations in 6 (32%), and conceptual analogies in 2 (11%) (Table 3). Because duplicate coding was permitted, the percentages do not sum to 100%. Among the 19 workshop participants who completed the post-workshop survey (Table 4), all reported being "Satisfied" or "Very satisfied" with the workshop. The difficulty of origami was most frequently rated "Difficult" (42%), and "concentration" was the most frequently endorsed cultivated skill (53%). In the matched pre-post analysis (N=18, Figures 1 and 2), interest in origami increased from a median of 4.0 (IQR: 4.0–4.0) before the workshop to 4.5 (IQR: 4.0–5.0) after the workshop (Wilcoxon signed-rank test, $p<0.001$). Perceived educational usefulness of origami in astronomy increased from a median of 3.0 (IQR: 3.0–4.0) before the workshop to 4.0 (IQR: 3.25–5.0) after the workshop (Wilcoxon signed-rank test, $p=0.002$).

Table 1. *Baseline characteristics and pre-camp perceptions of workshop and non-workshop groups (N=45) This table compares demographic characteristics, prior origami experience, perceived origami-space connection, interest in origami, perceived educational usefulness of origami in astronomy, and the presence of traditional paper-craft in the home country between workshop and non-workshop groups before the intervention. Values are shown as N (%). Chi-square tests were used for Age (years) and Perceived educational usefulness of origami in astronomy; Fisher's exact test was used for all other variables. No statistically significant baseline differences were observed between groups. For some categorical variables, categories were collapsed for statistical comparison as indicated in parentheses in the P-value column.*

Variable	Category	Total (N=45), N (%)	Workshop group (N=19), N (%)	Non-workshop group (N=26), N (%)	P-value
Age (years)	16-18	17 (38)	8 (42)	9 (35)	0.731
	19-22	15 (33)	5 (26)	10 (38)	
	≥23	13 (29)	6 (32)	7 (27)	
Gender	Male	17 (38)	4 (21)	13 (50)	0.067 (female vs. male and no response)
	Female	25 (56)	14 (74)	11 (42)	
	No response	3 (7)	1 (5)	2 (8)	
Country of origin	Europe	33 (73)	15 (79)	18 (69)	0.517 (Europe vs. all other regions)
	North America	5 (11)	2 (11)	3 (12)	
	South America	4 (9)	1 (5)	3 (12)	
	Asia	3 (7)	1 (5)	2 (8)	

Continued Table 1. *Baseline characteristics and pre-camp perceptions of workshop and non-workshop groups (N=45) This table compares demographic characteristics, prior origami experience, perceived origami-space connection, interest in origami, perceived educational usefulness of origami in astronomy, and the presence of traditional paper-craft in the home country between workshop and non-workshop groups before the intervention. Values are shown as N (%). Chi-square tests were used for Age (years) and Perceived educational usefulness of origami in astronomy; Fisher's exact test was used for all other variables. No statistically significant baseline differences were observed between groups. For some categorical variables, categories were collapsed for statistical comparison as indicated in parentheses in the P-value column.*

Variable	Category	Total (N=45), N (%)	Workshop group (N=19), N (%)	Non-workshop group (N=26), N (%)	P-value
Prior origami experience	Yes	34 (76)	15 (79)	19 (73)	0.736
Perceived origami-space connection	Yes	19 (42)	9 (47)	10 (38)	0.761
Interest in origami	Very interested	8 (18)	1 (5)	7 (27)	1.000 ("Very interested" and "Somewhat interested" vs. "Neutral")
	Somewhat interested	28 (62)	14 (74)	14 (54)	
	Neutral	9 (20)	4 (21)	5 (19)	
	Not very interested	0 (0)	0 (0)	0 (0)	
	Not interested at all	0 (0)	0 (0)	0 (0)	
Perceived educational usefulness of origami in astronomy	Definitely yes	3 (7)	0 (0)	3 (12)	0.954 ("Definitely yes" and "Yes" vs. "Not sure" and "Not really")
	Yes	11 (24)	6 (32)	5 (19)	
	Not sure	26 (58)	11 (58)	15 (58)	
	Not really	5 (11)	2 (11)	3 (12)	
	No	0 (0)	0 (0)	0 (0)	
Traditional paper-craft in home country	Yes	6 (13)	3 (16)	3 (12)	0.686

Table 2. *Coding of free-text responses regarding participants' first encounters with origami among those with prior origami experience (N=34). This table summarizes where or how participants first experienced origami, stratified by workshop participation. Responses were coded according to the context described in the free-text answers: family or home, school, social media or videos, books/manuals/kits, workshops, and other/unclear. Values are shown as N (%). Because some responses included more than one context, duplicate coding was permitted; therefore, percentages do not sum to 100%.*

Question	Coded category	Total (N=34), N (%)	Workshop group (N=15), N (%)	Non-workshop group (N=19), N (%)
Prior origami experience (Duplicates included)	Family/Home	16 (47)	9 (60)	7 (37)
	School	11 (32)	6 (40)	5 (26)
	Book/Manual/Kit	5 (15)	3 (20)	2 (11)
	Social media or Videos	3 (9)	1 (7)	2 (11)
	Workshop	2 (6)	1 (7)	1 (5)
	Other/Unclear	6 (18)	0 (0)	6 (32)

Table 3. *Coding of free-text responses regarding perceived connections between origami and space among participants who reported an origami–space connection (N=19). This table summarizes the concepts participants associated with origami and space, stratified by workshop participation. Responses were coded into four exploratory categories: deployable or foldable structures of spacecraft, recall of specific examples such as JWST or Hubble, academic or engineering associations, and conceptual analogies. JWST indicates the James Webb Space Telescope. Values are shown as N (%). Because some responses included more than one concept, duplicate coding was permitted; therefore, percentages do not sum to 100%.*

Question	Coded category	Total (N=19), N (%)	Workshop group (N=9), N (%)	Non-workshop group (N=10), N (%)
Perceived origami-space connection (Duplicates included)	Deployable/foldable structures of spacecraft	11 (58)	7 (78)	4 (40)
	Recall of specific examples (JWST/Hubble)	9 (47)	4 (44)	5 (50)
	Academic/engineering associations	6 (32)	4 (44)	2 (20)
	Conceptual analogies	2 (11)	0 (0)	2 (20)

Table 4. *Post-workshop survey responses among workshop participants (N=19). This table summarizes workshop satisfaction, perceived difficulty, and the single-choice item on skills that participants believed could be cultivated through origami after the 90-minute workshop. Values are shown as N (%).*

Survey item	Response	Total (N=19), N (%)
Workshop satisfaction	Very satisfied	14 (74)
	Satisfied	5 (26)
	Neutral, Dissatisfied, Very dissatisfied	0 (0)
Difficulty of origami	Very difficult	0 (0)
	Difficult	8 (42)
	Neither easy nor difficult	6 (32)
	Easy	4 (21)
	Very easy	1 (5)
Skills potentially cultivated through origami	Concentration	10 (53)
	Spatial awareness	4 (21)
	Dexterity	3 (16)
	Creativity	2 (11)

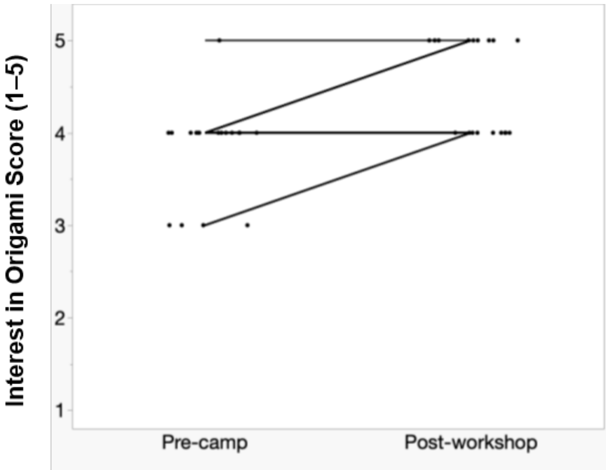

Figure 1. Individual changes in interest in origami before and after the origami workshop among the 18 successfully matched participants. Each line connects the pre-camp and post-workshop scores of the same participant; points were horizontally jittered to reduce overlap. Interest in origami was rated on a five-point ordinal scale: 1=Not interested at all, 2=Not very interested, 3=Neutral, 4=Somewhat interested, and 5=Very interested. The median score increased from 4.0 (IQR: 4.0–4.0) before the workshop to 4.5 (IQR: 4.0–5.0) after the workshop. Paired scores were compared using the Wilcoxon signed-rank test (p<0.001).

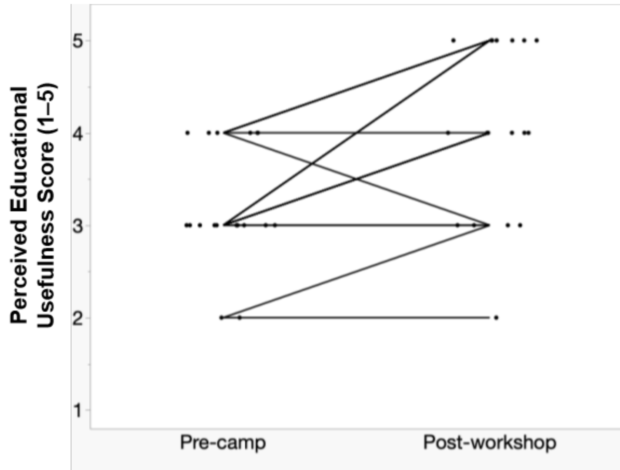

Figure 2. Individual changes in the perceived educational usefulness of origami in astronomy before and after the origami workshop among the 18 successfully matched participants. Each line connects the pre-camp and post-workshop scores of the same participant; points were horizontally jittered to reduce overlap. Perceived educational usefulness was rated on a five-point ordinal scale: 1=No, 2=Not really, 3=Not sure, 4=Yes, and 5=Definitely yes. The median score increased from 3.0 (IQR: 3.0–4.0) before the workshop to 4.0 (IQR: 3.25–5.0) after the workshop. Paired scores were compared using the Wilcoxon signed-rank test (p=0.002).

DISCUSSION

The novelty of this study lies in assessing origami experience and interest among multinational youth at an astronomy camp and demonstrating that, even under constraints of short duration and multicultural composition, a workshop can enhance interest in origami and recognition of its educational value. This improvement may be partly explained by the hands-on and visually engaging nature of origami, which may facilitate intuitive understanding of spatial and engineering concepts. Prior reviews of origami as an educational tool in elementary and secondary education have documented improvements in geometric skills, spatial awareness, fine motor skills, and relaxation (15); furthermore, university-level implementations show that origami activities can cultivate design thinking, leadership, and teamwork, supporting creativity and problem-solving. Thus, origami appears applicable across a wide learner spectrum, from early grades through university (16). At a Finnish university, an origami workshop was conducted for a multinational group of international students; although roughly 30% of participants were Japanese, all gave positive evaluations, which aligns with the present study (17). In Japan, paper-folding activities are positioned within the national Course of Study for elementary mathematics (18), implying many Japanese encounter origami early in life; yet quantitative data on experience and interest outside Japan remain scarce. Notably, in our study, most astronomy-oriented young adults reported prior origami experience and interest, suggesting strong affinity between astronomy and origami. This investigation has several limitations. First, the intervention consisted of a brief workshop program offered only twice, which prevented assessment of long-term educational effects. Second, the sample size was small. Third, workshop participation was voluntary, and recruitment was conducted through social media announcements during the camp. Therefore, participants who chose to attend may have had greater pre-existing interest in origami, hands-on activities, or STEAM education than those who did not participate, resulting in potential selection bias. Although no statistically significant baseline differences were observed between the workshop and non-workshop groups, the small sample size limited our ability to rule out meaningful pre-existing differences. This self-selection may have influenced both the high post-workshop satisfaction ratings and the observed pre-post changes. Fourth, instruction was provided by a single instructor, which may have limited individualized support and difficulty calibration. Fifth, because the free-text responses were coded by a single author and inter-rater reliability was not assessed, the reproducibility of the qualitative categorization is limited. Future studies should conduct multiple iterations of origami activities, include larger and more diverse samples, use recruitment procedures that reduce self-selection, incorporate more rigorous qualitative coding procedures, and examine sustained educational effects.

CONCLUSION

This study suggests that origami-based astronomy activities can function not only as cultural craft experiences but also as accessible STEAM activities that connect traditional Japanese paper folding with modern spatial thinking and space engineering. In a multinational astronomy camp, most participants already had some prior origami experience and interest, but many were uncertain about its educational usefulness in astronomy. After a single 90-minute hands-on workshop, both interest in origami and perceived educational usefulness in astronomy increased significantly among successfully matched participants, and satisfaction with the workshop was high. These findings indicate that origami may help learners recognize links between cultural practice, geometry, design, and deployable space structures in a short, inclusive, and low-resource educational format. The study is limited by the small sample size, short intervention duration, single-instructor format, and exploratory qualitative coding without inter-rater reliability assessment. Nevertheless, the results support the integration of origami into international, astronomy-linked STEAM curricula and outreach workshops. Future research should evaluate repeated or longer interventions, compare different instructional approaches, and assess whether origami-based activities lead to durable gains in spatial reasoning, engineering understanding, and intercultural engagement.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest related to this work.

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