Report

Preliminary research on paper rotor（*Kami-tombo*）as a craft teaching material : effect of wing width and length on rotor flight time

Kentaro Nozaki, Yuki Mori, Ayano Mori, Ayuko Mori, Shoko Ootake and Kumiko Iwasaki

Abstract

A paper rotor（*Kami-tombo*）, a craft teaching material, is generally introduced in textbooks of Life Environment Studies（*Seikatsuka*）in Japanese elementary school. The rotor was crafted using a piece from a milk carton and straw. Two wings were cut out from the milk carton using a scissors or knife. The wings were stapled to the straw using a stapler. Factors controlling the flight time of the paper rotor are not being well investigated in the field of education studies. Therefore, we examined the effect of wing width and length on the flight time of the rotor. The flight time of a rotor with 2-cm wing width was generally longer than that with a 1-cm wing width because the average flight time of around 2 seconds was obtained only at 11-, 12-, 15-, 16- and 18-cm wing lengths with 2-cm wing width. The rotor with a 11-16 cm wing length and 2 cm wing width was evaluated to be suitable as a craft teaching material in the Life Environment Studies. Results of this study were reported at a scientific meeting organized by the Nagoya Science Literacy Forum.

Key words：elementary school, Life Environment Studies, paper rotor（*Kami-tombo*）, teaching material.

1. Introduction

Children attending a Japanese elementary school are studying a subject, Life Environment Studies（*Seikatsuka*）, during their first two years（five and six years old）. The aim of the subject is composed of five elements : activities and experiences ; interests in human relation, society and nature ; plan and style of one's own life ; life skills ; and basis for independence（Japanese Ministry of Education, Culture, Sports, Science and Technology, 2008）. A handicraft using a scissors, knife and so on is an important teaching subject involving the element of life skills of children（Sasaki, 2011 ; Nozaki, 2012）. A paper rotor（*Kami-tombo*）, much like a paper helicopter, is a craft teaching material that is generally introducedin textbooks（*e.g.*

School of Education, Sugiyama Jogakuen University（Kentaro Nozaki, e-mail : ken@sugiyama-u.ac.jp）

Dainippon Tosho, 2011）and on web sites（*e.g.* Department of Life Environment Studies, Faculty of Education, Aichi University of Education : http : //crafts.step.aichi-edu.ac.jp/easy009.html, inspected in 27 December 2012）of the Life Environmental Studies. Elementary school teachers should encourage their students to find out some ideas to extend the flight time of the rotor. The paper helicopter is a quite well known teaching material among engineers and statisticians in both the academic and industrial sectors（Box, 1991 ; Anthony and Anthony, 2001 ; Takahashi, 2003）. However, factors controlling the flight time of the paper rotor are not being well investigated in the field of education studies. Therefore, we examined the effect of wing width and length on the flight time of the rotor.

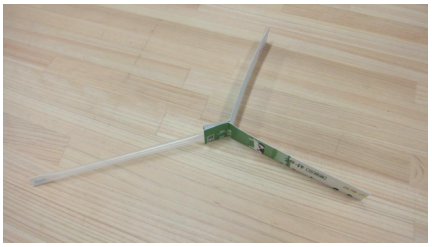

Fig. 1. Paper rotor（*Kami-tombo*）crafted in this study.

Fig. 2. Two wings stapled to straw using stapler.

2. Materials and Methods

The paper rotor was crafted from a milk carton and straw（Fig. 1）. Two wings were cut out from the milk carton using a scissors or knife. The rotor wing was adjusted to a 1-cm width with a 1-18 cm length（18 conditions）and a 2-cm width with a 1-19 cm length（19 conditions）. Two wings were stapled to a straw（3 mm diameter, 20 cm length）using a stapler（Fig. 2）. Flight time of the rotor was measured by a stopwatch five times at each conditionin the classroom（Figs. 3 and 4）. Measurements 185 times（18 conditions × 5 times + 19 × 5）per person were carried out by six researchers. The time of each rotor free fall from 150 cm above ground was measured by two researchers using the stopwatch.

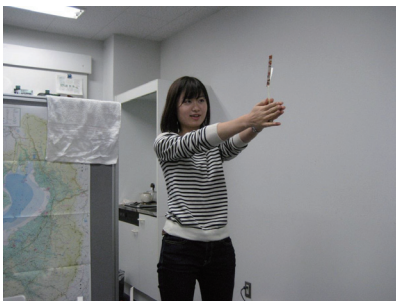

Fig. 3. Ready to fly the paper rotor（Yuki Mori）.

Fig. 4. Paper rotor experiment by Ayano Mori（right）and Aya Matsuoka（left）

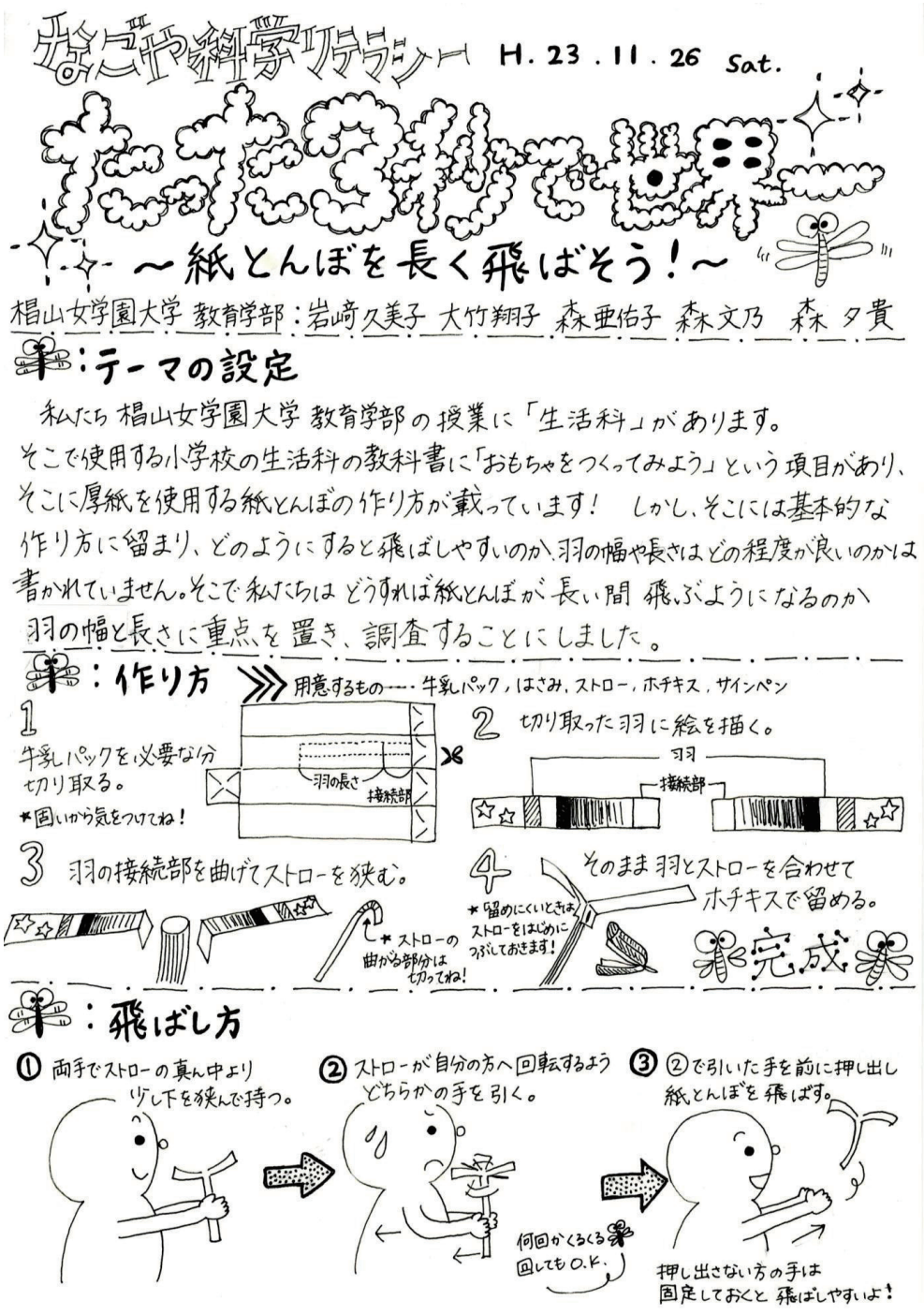

Fig. 5. A paper of procedure for crafting the rotor.

Results of this study were reported at a scientific meeting organized by the Nagoya Science Literacy Forum on 26 November, 2011. We also practiced crafting the paper rotor with participants. Figure 5 shows the procedure used to craft the rotor.

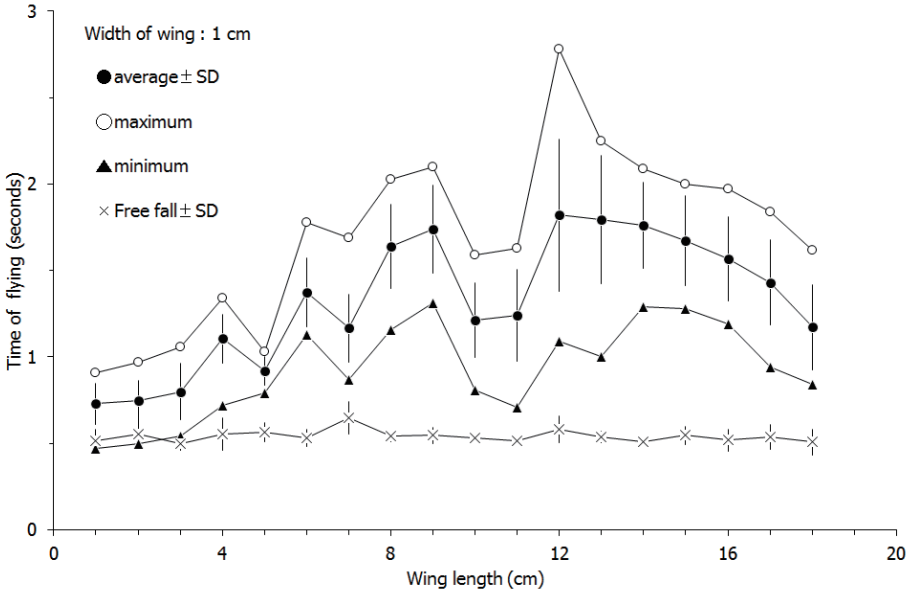

Fig. 6. Results of paper rotor experiment with 1-cm wing width.

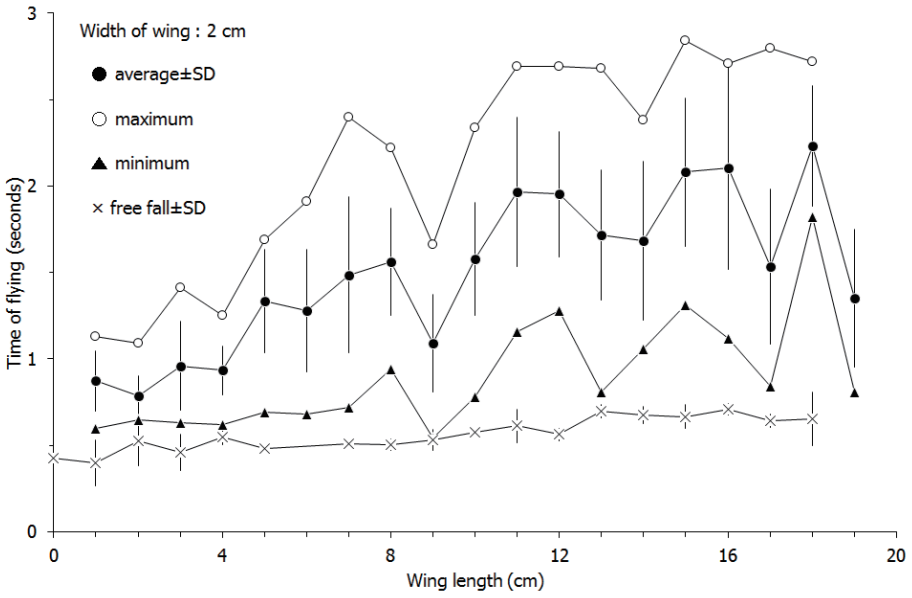

Fig. 7. Results of the paper rotor experiment with 2-cm wing width.

3. Results and Discussion

Changes in flight and free fall times with a 1-cm wing width were shown in Figure 6. Average time（± SD）in free fall at each wing length ranged from 0.43 ± 0.06（1-cm length）to 0.65 ± 0.09（7-cm length）seconds. Average flight time at each wing length ranged from 0.73 ± 0.12（1-cm length）to 1.82 ± 0.44（12-cm length）seconds. Maximum flight time was 2.78 seconds at 12-cm wing length. Changes in flight and free fall times at 2-cm wing width were shown in Figure 7. Time in free fall at each wing length ranged from 0.40 ± 0.13（2-cm length）to 0.71 ± 0.03（16-cm length）seconds. Average flight time at each wing length ranged from 0.79 ± 0.12（1-cm length）to 2.23 ± 0.35（18-cm length）seconds. Maximum flight time was 2.84 seconds at 15-cm wing length.

Longer wing length seemed to influence the fall velocity of the rotor due to the increase of weight and air resistance. However, almost no difference in the time of free fall was seen at a wing width of 1-cm and a wing width of 2-cm respectively. Thus, we decided that the wing length did not affect the fall velocity. Flight time of the rotor with a 2-cm wing width was generally longer than at 1-cm wing width because the average flight time of around 2 seconds was obtained only at wing length of 11-, 12-, 15-, 16- and 18- cm length with 2 cm wing width. Therefore, the rotor having a wing of 11-16 cm length with 2 cm width is evaluated to be suitable as a craft teaching material in the Life Environment Studies. The average, maximum and minimum flight times were for paper rotors with respective wing width of 1-cm and 10-11 cm wing length, and 2-cm wing width and 9-cm wing length, were a sharp simultaneously fall. We thought to be difficult the technique to fly the rotor at their conditions from researcher's expressions. However, that reason was not clear.

The Life Environment Studies which began in 1992 replaced the Science and Social Studies of the lower grades. However, opinions opposing its teaching continued for twenty years（*e.g.* Noda, 2004；Hyodo, 2010）. The group critical of the Life Environment Studies approach maintains that the learning content is not sufficiently scientific and makes too much of experience. From the results of our study, we suggest that the paper rotor experiment is indeed a possible scientific teaching material for children in the lower grades just as the paper helicopter experiment is in relation to quality control in the economic and engineering education field. Figures 8 and 9 show our presentation and practice scenes at a meeting of the Nagoya Science Literacy Forum. The forum participants appreciated the results of our study, and enjoyed paper rotor craft and play.

Fig. 8. Presentation of our study in scientific meeting of the Nagoya Science Literacy Forum on 26 November, 2011 by Ayano Mori, Shoko Ootake, Kumiko Iwasaki and Yuki Mori (right to left).

Fig. 9. Paper rotor flying by meeting participants.

Acknowledgments

The authors are grateful to Aya Matsuoka of the School of Education, Sugiyama Jogakuen University, and Tomohiro Yoshiike of the Graduate School of Engineering, Nagoya University for their generous assistance in this study. They also wish to thank Professor Dr. Yukihiko Namikawa of the School of Education, Sugiyama Jogakuen University, Professor Hiroshi Kawakatsu of Meijo University and Dr. Jun-ichiro Yasuda of Gifu University for their useful discussions and criticisms. This research was supported by a Grant-in-Aid for Scientific Research (C) from The Japan Society for the Promotion of Science (No. 24501114) to Kentaro Nozaki.

References

Anthony, J. and F. J. Anthony (2001) Teaching the Taguchi method to industrial engineers. Work Study, 50(4): 141-149.

Box, G.(1991) Teaching engineers experimental design with a paper helicopter. Quality Engineering, 4(3): 453-459.

Dainippon Tosho (2011) Textbook of the Life Environment Studies part 2 (*Seikatsuka-Hakken*). p.81, Dainippon Tosho Publishing Co., Ltd., Tokyo (*in Japanese*).

Hyodo, T.(2010) What of the curriculum guidance is a problem? Kagaku (*Iwanami Shoten*), 80(5): 502-509 (*in Japanese*).

Japanese Ministry of Education, Culture, Sports, Science and Technology (2008) Commentary on the curriculumguidance of the Life Environment Studies (*Seikatsuka*). p.10, Toyokan, Tokyo (*in Japanese*).

Noda, A.（2004）Research for the improvement of the Life Environment Studies. Bulletin of Aichi University of Education, Education Sciences, 53 : 1-8（*in Japanese*）.

Nozaki, K.（2012）Learning of food and life education in *Seikatsuka* studies（Life Environment Studies）on a training course of nursery and primary school teachers at the School of Education, Sugiyama Jogakuen University, Nagoya, Japan. Journal of Sugiyama Jogakuen University, Natural Science, 43 : 1-12（*in Japanese*）.

Sasaki, H.（2011）Importanceof teaching contents of life environment studies in the Japanese elementary school. *Rikakyoushitsu*（The Journal of Science Education）, 54（4）: 16-19（*in Japanese*）.

Takahashi, T.（2003）Robust design for mass production. Journal of Materials Processing Technology, 143/144 : 786-791.

実践報告

工作の教材としての紙とんぼの予備的研究

―紙とんぼの飛行時間に及ぼす羽の幅と長さの効果―

野崎健太郎・森　夕貴・森　文乃・森　亜佑子・大竹翔子・岩﨑久美子

摘　　要

工作の教材である紙とんぼは，生活科の教科書に良く紹介されている。紙とんぼは，牛乳パックとストローでつくることができる。2 枚の羽は牛乳パックからはさみやナイフで切り取られ，ホッチキスでストローに固定される。しかしながら，教育学の分野で紙とんぼの飛行時間に影響する要因を研究した事例は見当たらない。そこで，本研究では，羽の幅と長さが紙とんぼの飛行時間に及ぼす効果を検討した。紙とんぼの飛行時間の最大値は，幅 2 cm，長さ 15 cm で得られた 2. 84 秒であった。全体としては，羽の幅が 2 cm のものが，幅 1cm のものより長い傾向であった。なぜならば，飛行時間の平均値が 2 秒程度であった紙とんぼは，幅 2 cm で長さ 11，12，15，16，18 cm のみであったからである。したがって，生活科の授業で工作の教材として適している条件は，幅 2 cm，長さ 11～16 cm の紙とんぼであると評価された。本研究の結果は，名古屋科学リテラシーフォーラムが主催する科学交流会で報告された。

キーワード：小学校，生活科，紙とんぼ，教材