ICT-Based Instructional Materials and Butterfly Stroke Skill Acquisition in Junior High School Students: A Pre–Post Evaluation

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Abstract

Butterfly is considered particularly challenging to learn in Japanese junior high school physical education, and reduced swimming opportunities during the COVID-19 pandemic may have further intensified this difficulty. This study examined whether butterfly swimming skills improved over a nine-lesson unit supported by ICT-based instructional materials. Participants were 75 Grade 9 students from a junior high school in Nagoya, Japan. Students who were absent for three or more lessons were excluded, resulting in 66 participants. In Lessons 1 and 9, students performed a maximal-effort 25 m butterfly swim (water start; permitted to stop if breathless). Swimming movements were recorded from an above-water lateral view using a tablet device (approximately 3 m; 60 fps). Two trained raters evaluated the videos using a 12-point scale comprising four components (posture, kick, pull, and breathing; 1–3 points each). Inter-rater reliability was high (ICC(2,1) = 0.881; ICC(2,2) = 0.937). Total skill scores increased from 6.33 ± 2.76 at pre-test to 8.05 ± 2.59 at post-test (Wilcoxon signed-rank test, $p < .001$, $r = .78$; $N = 66$). All component scores also increased ($p < .001$; $r = .62$–$.73$). After the unit, 58 of 66 students (87.9%) managed to complete a 25 m butterfly swim. Although the lack of a control group limits causal inference, the findings suggest that ICT-based materials may support butterfly skill acquisition in school-based swimming instruction, even under restrictions on device use at the poolside.

Keywords: ICT-based learning materials, butterfly stroke, physical education, skill acquisition

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Introduction

In Japanese junior high school physical education, students are expected to acquire proficiency in the four competitive strokes—front crawl, breaststroke, backstroke, and butterfly (Ministry of Education, Culture, Sports, Science and Technology [MEXT], 2017). The curriculum also requires students to understand key technical elements of each stroke and fitness components that can be developed through swimming. Although swimming is a whole-body activity that may contribute to improvements in cardiorespiratory fitness and endurance, it is also a unit in which large inter-individual differences in swimming ability can make lesson design and instruction challenging. Butterfly is considered difficult for many learners because it requires simultaneous coordination of undulatory body motion, upper- and lower-limb actions, and breathing timing. In addition, in a class setting, it may be difficult for teachers to demonstrate movements in detail underwater or provide immediate feedback, which can further constrain instruction.

In recent years, the COVID-19 pandemic led many schools to restrict or suspend swimming lessons. Consequently, opportunities for students to practice aquatic skills decreased, and practitioners reported that, even after lessons resumed, some students continued to show reduced swimming ability and increased reluctance or anxiety toward swimming. In addition, many teachers have expressed concerns about how to structure stepwise learning while ensuring safety and fostering skill development in classes that include such learners. Under these circumstances, in addition to securing sufficient practice time during lessons, support may be needed to help learners form clear movement images and select appropriate practice methods.

The use of ICT-based learning materials and video-based instruction may help address these issues. Because movement images can be difficult to develop through verbal explanation alone, visual support using above- and underwater videos may facilitate students' understanding of swimming techniques. However, the pool environment poses substantial constraints on device use and safety management, and research on ICT implementation in school-based physical education remains limited. Kretschmann (2017) examined the use of tablet-based video feedback in elementary school swimming lessons and highlighted the feasibility of ICT-supported learning in pool settings. However, the targeted skills were mainly front crawl. Empirical evidence focusing on butterfly—an especially challenging stroke that may also be difficult for teachers to demonstrate—remains scarce. Scurati et al. (2019) reported that supplementary feedback delivered via mobile devices significantly improved stroke evaluation in breaststroke among university students specializing in sport science. However, further evidence is required across strokes and age groups. Taken together, the extent to which stepwise learning support using ICT-based materials is associated with learning outcomes in butterfly in school-based swimming instruction remains unclear. Moreover, there is a need for implementation studies that examine not only one-off video presentations or feedback but also the instructional design of ICT materials tailored to learners' skill stages (i.e., what to present, in what sequence, and from which viewpoints).

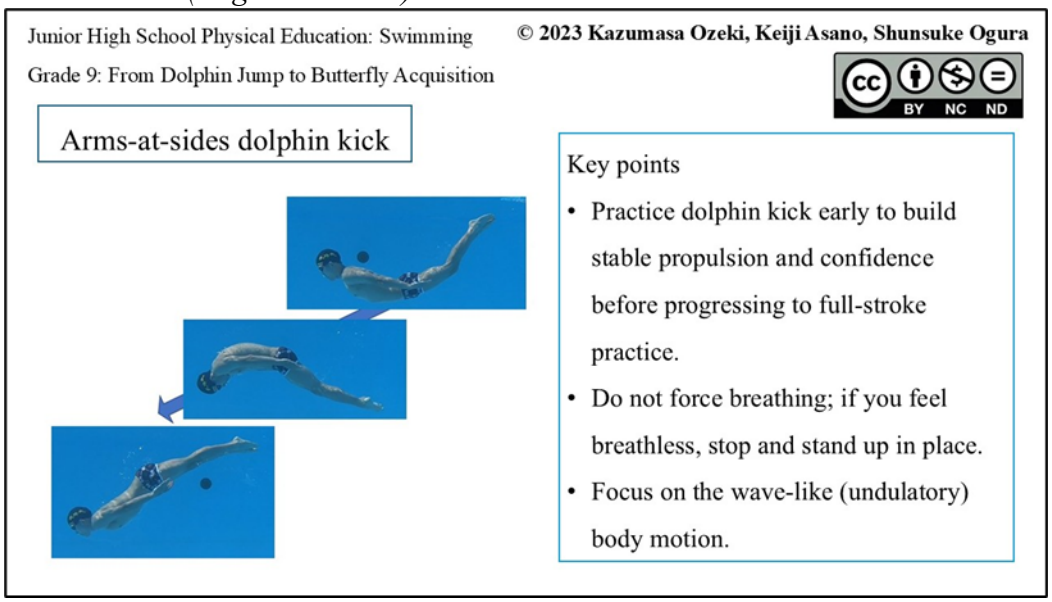
In this study, we developed ICT-based learning materials using LoiLoNote (LoiLo Inc.), a platform currently used in educational settings in Nagoya, Aichi Prefecture, Japan. The materials were designed to facilitate visual understanding of fundamental swimming movements and to support systematic, practical learning by presenting videos and photographs in a stepwise manner according to skill level (Figure 1). In addition, considering that some students may have had limited learning experience in upper elementary school with front crawl,

breaststroke, and safety-related aquatic skills, the program was structured to connect safety-oriented learning with subsequent stroke acquisition. The materials were intended to support teachers in delivering stepwise instruction in classes that include students with reduced swimming ability and/or negative attitudes toward swimming.

This study aimed to examine changes in butterfly swimming skill (total score and component scores) over a nine-lesson unit among Grade 9 students at a junior high school that implemented these ICT-based materials, using a pre–post design. The findings are intended to provide foundational evidence on the implementation of ICT-based learning materials in school-based swimming instruction, with a particular focus on butterfly skill acquisition.

Figure 1

Example Screen From the ICT-Based Learning Material Illustrating Key Points for Dolphin Kick Practice (English Version)



Source: Ozeki et al., 2023. (CC BY-NC-ND).

Methods

ICT-Based Learning Materials

In many Japanese junior high schools, swimming instruction typically covers front crawl in Grade 7, breaststroke in Grade 8, and backstroke in Grade 9. Butterfly is often not taught in class. Therefore, the current ICT-based learning materials were structured to enable stepwise learning toward butterfly acquisition.

In Grade 7, the materials prioritized the development of aquatic self-preservation skills, with an emphasis on safety-related skills such as floating and breathing. Specifically, the materials included elementary backstroke—selected because it facilitates a transition from supine floating and allows breathing in a stable, face-up posture—and "butterfly-style swimming" and "Clione backstroke" as learning tasks. Hamagami et al. (2015) reported that acquiring backstroke before front crawl may lead to greater improvements in swimming skills, partly because the breathing demand is relatively lower in backstroke. Consistent with this rationale, the materials were intended to reduce the fear of water through backstroke (or backstroke-like

activities) and to create a learning environment in which students can engage more proactively in swimming instruction.

In Grades 8 and 9, the materials included instructional videos required for acquiring breaststroke and butterfly, building on the safety-related skills developed in Grade 7. For breaststroke, to address "whip kick with excessive abduction" (a common stumbling point in skill acquisition), the materials also presented a land-based drill (Hira-kick exercises; Ikuta et al., 2021) to encourage self-directed practice outside class. Because butterfly is difficult to acquire and for teachers to demonstrate sufficiently, the materials included extensive above- and underwater model videos. In addition, multiple-practice-method videos were provided so that students could identify their own challenges and obtain cues for improvement through trial and error.

Use of the ICT-Based Material

At the target school, students were not allowed to view or record videos using learning tablets at the poolside. Accordingly, the materials were used before and after pool practice.

During the first half of the unit, the materials were used to help students form a target movement image and understand key technical points. After viewing the videos and sharing key points in the classroom, students moved to the pool and practiced while confirming the technical points and practice methods introduced in the videos.

During the second half of the unit (problem-solving learning), the materials were used as a resource to help students select practice methods based on their individual goals for the lesson. Students were supported in selecting and modifying practice methods for their own challenges while referring to the videos.

Participants and Study Design

Participants were 75 Grade 9 students (38 boys and 37 girls) from a junior high school in Nagoya, Aichi Prefecture, Japan. Changes in the butterfly swimming skill over a nine-lesson unit were examined using a pre–post design. Students who were absent for three or more lessons (n = 9) were excluded, resulting in 66 participants.

Swimming Task and Video Recording

In Lessons 1 and 9, students were instructed to perform a maximal-effort 25 m butterfly swim. A water start was used, and students were permitted to stop mid-trial if they experienced difficulty breathing. Swimming movements were recorded from above water using a tablet device positioned laterally to the swimmer at an approximate distance of 3 m, with a recording rate of 60 fps.

Skill Assessment and Reliability

Butterfly skill was evaluated by two trained raters after sharing scoring criteria and conducting pilot scoring (one university faculty member specializing in swimming and one junior high school physical education teacher with experience in swimming instruction and lesson study). A 12-point scale was developed based on previous studies (Yasuda et al., 2023). The scale

comprised four domains—posture, kick, pull, and breathing—each scored on a 3-point scale (total score range: 0–12).

Inter-rater reliability was assessed using the intraclass correlation coefficient (ICC) based on a two-way random-effects model with absolute agreement. The ICC for single measures (ICC(2,1)) was 0.881 (95% CI [0.828, 0.921]), whereas that for average measures (ICC(2,2)) was 0.937 (95% CI [0.906, 0.959]).

Statistical Analysis

Statistical analyses were conducted using IBM SPSS Statistics version 27.0 (IBM, Armonk, NY, USA). Pre–post differences were tested using the Wilcoxon signed-rank test. Effect size was calculated as $r = |Z|/\sqrt{N}$, where N denotes the number of participants. Statistical significance was set at $p < .05$.

Results

The total butterfly swimming scores increased from $M = 6.33$ ($SD = 2.76$) at pre-test to $M = 8.05$ ($SD = 2.59$) at post-test (Wilcoxon signed-rank test, $p < .001$, $r = .78$; $N = 66$) (Figure 2). Component scores for posture, kick, pull, and breathing also increased from pre-test to post-test ($p < .001$), with effect sizes ranging from $r = .62$ to .73 (Table 1). After the unit, 58 of the 66 students (87.9%) managed to complete a 25 m butterfly swim.

Figure 2

Total Butterfly Swimming Skill Scores at Pre-test and Post-test (N = 66)

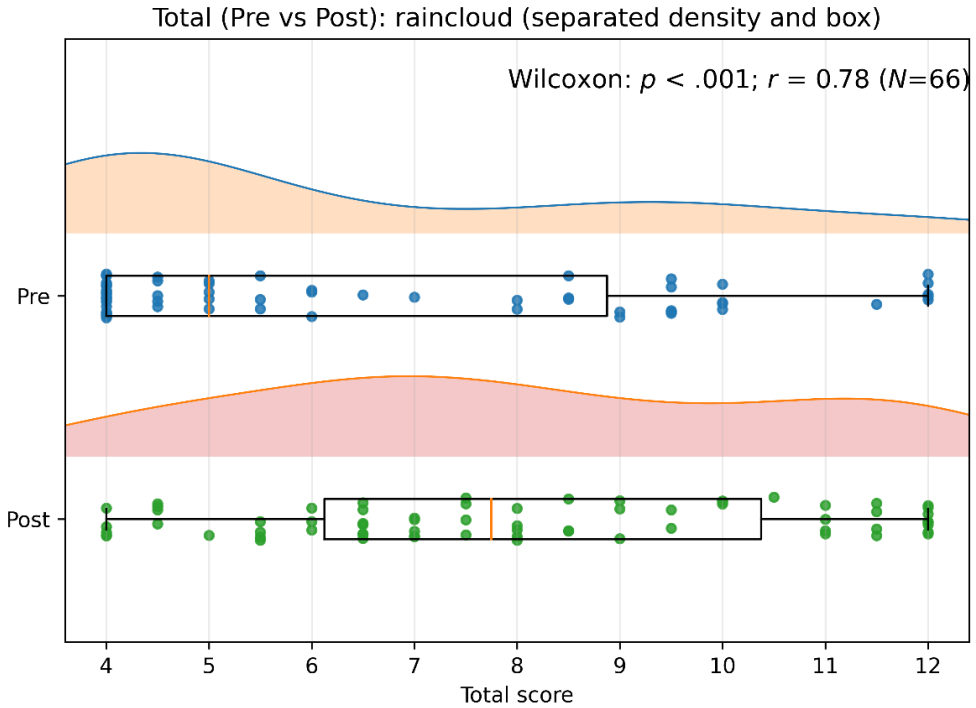


Table 1

Component Scores (0–3 Points) at Pre-test and Post-test (N = 66)

Component	Pre (mean ± SD)	Post (mean ± SD)	Pre median [IQR]	Post median [IQR]	*p*	*r*	Ties (Δ=0)
Posture	1.48 ± 0.71	1.98 ± 0.71	1.0 [1.0–2.0]	2.0 [1.5–2.5]	< .001	0.71	24
Kick	1.67 ± 0.75	2.02 ± 0.76	1.5 [1.0–2.0]	2.0 [1.5–2.75]	< .001	0.68	32
Pull	1.54 ± 0.69	2.01 ± 0.67	1.0 [1.0–2.0]	2.0 [1.5–2.5]	< .001	0.73	21
Breathing	1.64 ± 0.73	2.04 ± 0.70	1.5 [1.0–2.5]	2.0 [1.5–2.5]	< .001	0.62	24

Discussion

This study examined whether the butterfly swimming skills of Grade 9 students improved over a nine-lesson unit supported by ICT-based learning materials. The total skill scores increased significantly from pre-test to post-test, and all component scores (posture, kick, pull, and breathing) also improved. These findings suggest that visually supported instruction using ICT materials may be associated with skill learning in junior high school swimming lessons.

Swimming skills can be difficult to represent mentally through verbal instruction alone. Butterfly imposes a high cognitive and motor demand because it requires coordinated movements and precise breathing timing. The ICT materials used in this study included above- and underwater model videos with key technical points, which may have facilitated observational learning and clarified the instructional focus. Kretschmann (2017) reported the use of tablet-based video feedback in elementary school swimming classes, suggesting that video-supported learning can be feasible in pool settings. The present findings extend this perspective by indicating that learning support may still function under constraints that prevent device use at the poolside, through short viewing sessions before and after pool practice.

In the latter half of the unit, students selected practice methods while referring to the videos, which may have supported self-regulated learning through identifying individual issues and choosing appropriate drills. Scurati et al. (2019) reported that supplementary feedback delivered via mobile devices improved stroke evaluation in breaststroke among university students. Although the participants and stroke differed, the present results are consistent with the notion that video- and device-mediated information can contribute to skill improvement.

Effect sizes for the components ranged from $r = .62$ to .73, indicating that the magnitude of improvement differed across elements. Posture and pull may be more readily recognized and imitated from video due to their visible movement characteristics, whereas breathing involves timing control and may also be influenced by discomfort or resistance to water, potentially resulting in smaller short-term gains. In addition, the 3-point component scale likely produced tied scores and may have reduced sensitivity to small changes.

Conclusion

A nine-lesson unit using ICT-based learning materials built on LoiLoNote was associated with improvements in butterfly swimming skills (both total and component scores) among Grade 9

students. Even in school settings where device use is restricted at the poolside, brief viewing sessions before and after pool practice may allow practical implementation. Stepwise presentation of above- and underwater videos may help standardize instruction and support learners' understanding, particularly for butterfly, which can be difficult for teachers to demonstrate.

This study had two key limitations. First, because a pre–post design without a control/comparison group was used, the observed improvements cannot be attributed uniquely to the ICT-based materials; practice volume, instructional strategies, maturation, and familiarity with the lessons may also have influenced the outcomes. Second, participants were drawn from a single junior high school (Grade 9); therefore, generalizability to other grades and school contexts should be interpreted cautiously.

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Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

The author declares that ChatGPT 5.2 (OpenAI) was used as an AI-assisted tool for proofreading and language refinement, including translation support. The use was limited to improving clarity and academic writing style. The research ideas, design, procedures, findings, analyses, and discussion are the author's original work.

References

Hamagami, Y., Kitsukawa, M., Sawamura, S., Shimizu, S., & Shimizu, S. (2015). Oyogi no shūjukudo kara miru seoyogi to kurōru no gakushū shidō no junjosei ni kansuru kentō [A study of the instructional ordering for the backstroke and the crawl from a perspective of proficiency levels of swimming]. *Iwate Daigaku Kyouikugakubu Fuzoku Kyouiku Jissen Sougou Sentā Kenkyū Kiyou* [Journal of the Clinical Research Center for Child Development and Educational Practices], *14*, 211–217.

Ikuta, Y., Mori, H., Nakauchi, Y., & Ikuta, M. (2021). Issei shidou no taiiku no jugyou no naka de, aori-ashi no kyousei wa kanou darouka?—Hira-kikku taisou no kouka kenshou [Is it possible to correct a breaststroke kick fault in a physical education class under a group teaching environment? An investigation on the effect of "Hira-kick exercise"]. *Nihon Suiei Suichuu Undou Gakkai 2021 Nenji Taikai Ronbunshuu* [Japanese Society of Sciences in Swimming and Water Exercise 2021: Program & Proceedings], 60–63.

Kretschmann, R. (2017). Employing Tablet Technology for Video Feedback in Physical Education Swimming Class. *Journal of E-Learning and Knowledge Society*, *13*(2). https://doi.org/10.20368/1971-8829/143

Ministry of Education, Culture, Sports, Science and Technology (MEXT). (2017). *Chūgakkō gakushū shidō yōryō (Heisei 29-nen kokuj) kaisetsu: Hoken taiiku-hen* [Junior high school curriculum guidelines (2017 revision): Commentary on health and physical education], 102–117. https://www.mext.go.jp/component/a_menu/education/micro_detail/__icsFiles/afieldfile/2019/03/18/1387018_008.pdf

Scurati, R., Michielon, G., Signorini, G., & Invernizzi, P. L. (2019). Towards a safe aquatic literacy: Teaching the breaststroke swimming with mobile devices' support. A preliminary study. *Journal of Physical Education and Sport, 19*(Suppl. 5), 1999–2004. https://doi.org/10.7752/jpes.2019.s5298

Yasuda, J., Fukami, E., Yoshinaga, T., & Kanazawa, S. (2023). Shougakkou taiikuka no suiei undou ni okeru dai 4 gakunen no jidou o taishou to shita menkaburi kurōru no kansatsuteki dousa hyouka kijun no sakusei to sono shinraisei·datousei no kenshou [Developing for Criterion of Observational Movement Evaluation for No-Breath Front Crawl in 4th Grade Children of Swimming Classes in Elementary School of Physical Education and Its Verification for Reliability and Validity]. *Japanese Journal of Sport Education Studies, 43*(1), 33–53. https://doi.org/10.7219/jjses.43.1_33

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