

## Psychological effects of learner-autonomy-oriented motor skill learning using ICT teaching materials: Perceived physical competence in junior high school apparatus gymnastics classes

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### Abstract:

The GIGA School concept aims to realize Proactive, Interactive, and Deep Learning by combining conventional education with ICT. However, in physical education, the effective use of ICT remains challenging because many teachers report difficulties and insufficient training in ICT utilization. Consequently, concrete approaches for improving lessons through ICT often depend on individual teachers' competencies and experiences. To address this issue, we developed ICT learning materials that emphasize learner individuality and autonomy, allowing each learner to practice and acquire skills of their choice at their own pace. These materials incorporate two learning methods, the kinesthetic experiential method and the model mastery method, as studied by Matsuura et al. (2018). The purpose of this study was to examine the effects of gymnastics classes using these ICT learning materials on junior high school students' enjoyment of learning and intrinsic motivation. The ICT materials were implemented during the skill acquisition phase of mat exercise lessons. Before and after classes, students completed self-evaluations of flow, intrinsic motivation, confidence in mat exercises, and perceived progress. In addition, perceived physical competence was assessed before the classes. The results showed significant increases in intrinsic motivation, enjoyment of mat exercise activities, sense of control over the technique, confidence in mat exercises, and self-evaluated progress after the classes compared with before the classes. The findings also suggest that classes using these ICT learning materials were more enjoyable and encouraged more proactive engagement in gymnastics activities than previous classes. Overall, ICT learning materials that emphasize learner individuality and autonomy can effectively support skill acquisition in junior high school apparatus gymnastics classes while enhancing enjoyment and intrinsic motivation. Such materials may provide a practical approach for promoting individualized learning in physical education classes.

**Key Words:** Gymnastics, Perceived physical competence, Enjoyment, Intrinsic motivation

### Introduction

In the report released in 2021 by the Central Council for Education, the ideal vision of Japanese school education for a new era was described as “the realization of individualized learning and collaborative learning that draws out the potential of all children” (MEXT, 2021). From the perspective of educational digital transformation (DX), information and communication technology (ICT) has been positioned as a foundational tool for promoting these forms of learning in an integrated manner (MEXT, 2021). However, in the fields of physical education, and health and physical education, numerous teachers report difficulties in using ICT and perceive insufficient opportunities for professional training. Consequently, concrete approaches for improving lessons through ICT continue to depend largely on individual teachers' competencies and instructional expertise (Japan Sports Agency, 2022).

Within this context, Apparatus Gymnastics represents one of the most instructionally challenging content areas in school physical education. Although a compulsory component of the physical education curriculum in both elementary and junior high schools in Japan (MEXT, 2017a, 2017b, 2018), surveys consistently report a large proportion of teachers who lack of confidence in teaching Apparatus Gymnastics (Hasegawa et al., 2018; Shimizu et al., 2019). Furthermore, due to its inherent characteristics, Apparatus Gymnastics make differences in students' skill levels particularly salient. Therefore, for learners to experience enjoyment associated with successful skill performance, it is essential to provide tasks and goals tailored to each learner's proficiency level, rather than adopting uniform task settings (Mizushima, 2004). From this perspective, there is a high degree of alignment between the educational policy emphasis on realizing individualized learning and the instructional challenges inherent in Apparatus Gymnastics.

In recent years, under the GIGA School Initiative promoted by the Ministry of Education, Culture, Sports, Science and Technology, efforts have been made to integrate conventional educational practices with ICT to realize individualized learning, maximize teachers' instructional potential, and improve lessons by fostering proactive, interactive, and deep learning (MEXT, 2020). Given that Apparatus Gymnastics is a content area that presents instructional challenges across school levels and requires careful consideration of individual differences in learners' skill levels, the use of ICT in Apparatus Gymnastics can be regarded as a potentially effective approach.

However, several challenges related to the use of ICT in health and physical education in Japan have been identified. Specifically, ICT applications are often limited to video recording and viewing, and approaches that incorporate big data or advanced technologies have been insufficiently examined (Sato et al., 2022). Additionally, declines in physical activity associated with ICT use have been reported (Sato et al., 2022). With regard to the application of ICT in Apparatus Gymnastics, many studies have been conducted with university students as participants (e.g., Nakano & Tamura, 2017; Miyazaki et al., 2022), whereas investigations at the elementary and junior high school levels remain limited. Although some practical examples exist at these levels, they primarily involve filming students' performances or viewing demonstration videos, followed by verbalization and analysis (e.g., Tamagoshi et al., 2024; Takayanagi et al., 2014). Moreover, it has been suggested that observing and analyzing movements on a screen at the initial stages of learning may hinder learners' ability to grasp movements introspectively (Asaoka, 2012). Thus, whether the use of ICT for reviewing one's own movements in physical education classes is effective for motor learning remains an open question (Watanabe, 2021).

To address these issues, we developed ICT-based teaching materials that enable each learner to practice skills of their choice and progress at their own pace (Matsuura et al., 2025). The system incorporates two instructional methods: kinesthetic-experiential learning (KEL), which is associated with implicit learning, and model mastery learning (MML), which is associated with explicit learning; both have been validated in previous studies (Matsuura et al., 2023a). KEL is an instructional approach based on the Global Dynamics Approach, originally developed as a motor learning framework for humanoid robots modeled on human movement (Yamamoto & Kuniyoshi, 2002). By effectively accumulating rich movement-related sensory experiences acquired through interactions between the learner and the environment, KEL facilitates the emergence of motor skills. In contrast, MML is based on multiple instructional manuals and systematically presents methods and key points for acquiring ideal body movements in a step-by-step manner. Learners can select either of these two learning approaches according to their preferences and proceed with their learning accordingly. When university students participated in Apparatus Gymnastics classes using this ICT teaching material, no differences were observed between groups with high and low levels of perceived motor competence in terms of either the number of skills attempted or the number of new skills acquired. Furthermore, regardless of learners' level of perceived physical competence or their learning style as classified by Felder (1995), the ICT material was found to be effective for both skill acquisition and practice aligned with individual ability (Matsuura et al., 2023b).

Given that Apparatus Gymnastics is a compulsory component of the physical education curriculum in both elementary and junior high schools in Japan (MEXT, 2017a, 2017b, 2018), it is important to examine whether the present teaching material can be used by junior high school students for practice aligned with their individual abilities, regardless of differences in perceived physical competence. Building on these findings, the present study aimed to implement Apparatus Gymnastics lessons using ICT teaching materials with junior high school students and to examine their psychological effects, with particular attention to differences related to levels of perceived physical competence.

## **Material & methods**

### ***Participants***

Participants were 144 first-year junior high school students (four classes of 36 students each) from a national university-affiliated school in Japan. An eight-lesson unit on Apparatus Gymnastics was conducted, during which ICT teaching materials were used during the mat exercise skill acquisition phase. All instruction was delivered by a full-time physical education teacher at the junior high school. This study was conducted in accordance with relevant ethical guidelines and was approved by the Research Ethics Committee for Human Subjects Research at the Principal Investigator's institution (approval no. H23-0002).

### ***Measurement***

#### ***Perceived physical competence***

The Perceived Physical Competence Scale (Okazawa et al., 1996) was used to measure learners' perceived motor competence. This scale consists of 12 items across three subscales: (1) sense of physical competence, (2) sense of control, and (3) sense of acceptance, with four items per subscale. Responses were rated on a five-point Likert scale.

#### ***Sport Flow Scale***

The Sport Flow Scale (SFS; Yagi & Sakairi, 2009) was used to assess enjoyment of activities during mat exercise practice. This scale comprises six items representing six subfactors: (1) merging of action and

awareness, (2) concentration on the task at hand, (3) sense of control, (4) loss of self-consciousness, (5) transformation of time, and (6) autotelic experience. Responses were rated on an 11-point scale.

#### *Intrinsic motivation*

To assess intrinsic motivation toward the learning content, the short form of the Intrinsic Motivation Scale (Sakurai & Takano, 1985) was employed, following the procedure of Matsuura et al. (2018). This scale consists of 12 items across six subscales: (1) challenge, (2) curiosity, (3) mastery, (4) perceived locus of causality (internal causality), (5) endogenous–exogenous attribution (endogenous attribution), and (6) enjoyment, with two items per subscale. Responses were rated on a five-point scale. Subscale (4) measures the extent to which the intention to act is perceived as being initiated by the individual, whereas subscale (5) assesses the degree to which the behavior itself is recognized as having an inherent purpose.

#### *Self-confidence in mat exercises and self-evaluation of skill improvement*

To assess students' self-confidence in mat exercises, they evaluated their own confidence before and after the class using a five-point scale ranging from 1 (not confident at all) to 5 (very confident). In addition, to assess students' self-evaluation of progress in mat exercise skills, they evaluated their perceived progress before and after class using a five-point scale ranging from 1 (no progress at all) to 5 (significant progress).

#### *Learning steps and difficulty level of the learning steps*

The number of learning steps completed and the proficiency levels achieved by each student in each lesson were extracted from the data recorded in the ICT teaching materials.

#### *Contents and learning methods*

The ICT teaching materials used in this study were the same as those used by Matsuura et al. (2025). These materials incorporate KEL (implicit learning) and MML (explicit learning), as examined by Matsuura et al. (2018). As an implicit learning approach, KEL emphasizes attention to kinesthetic sensations that predict movement outcomes and encourages learners to implicitly establish links between sensations and performance through diverse experiential opportunities (Matsuura et al., 2023a). Its instructional design aims to promote self-discovery of effective techniques in mat exercises. By contrast, MML represents an explicit approach in which skill acquisition is guided step by step through instructional materials and tips for body control, drawing on multiple reference texts (Kaneko, 1974, 1982; Miki et al., 2006).

The skills included in the ICT materials were consistent with those specified in the national course of study (MEXT, 2017b, 2018). Learners selected a learning method (KEL or MML) and a skill from the list, accessed videos and textual explanations appropriate to their level, and began practice at the corresponding “learning step” (proficiency stage). Figure 1 shows examples of the learner interface. In the mat exercise lessons, students practiced techniques of their choice using tablet devices while being guided by the application's prescribed learning method. The instructor monitored the class, ensured safety, and addressed student inquiries.

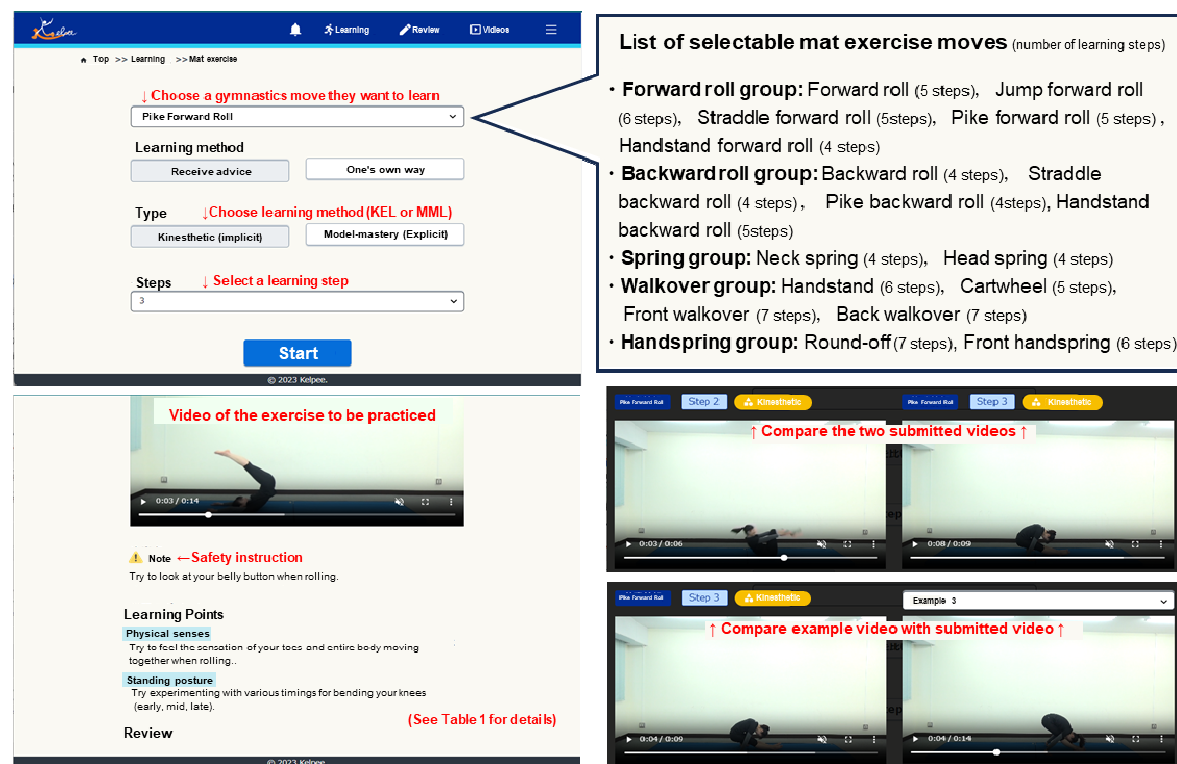


**Figure 1.** A part of the screen used by learners for the ICT teaching materials used in this study (Partially modified, Matsuura et al., 2025)

### Instructional format and procedure

The unit plan is presented in Table 1. Of the eight lessons, ICT teaching materials were used during lessons 2–6 for skill acquisition. Each class of 36 students (18 boys and 18 girls) was divided into six groups: three groups of six boys and three groups of six girls. In forming the groups, students of similar heights were placed together to facilitate mutual support during skill practice. For the practice setting, each group was provided with one long mat, and students were allowed to freely arrange the practice area so that they could work on the skills they wished to practice. Figure 2 shows an example of a practice setting. Video recordings were conducted by members of the same group, and students were permitted to move to other groups' practice areas depending on the skills they intended to practice.

As part of the survey, participants completed a questionnaire on perceived physical competence (Okazawa et al., 1996) prior to the start of the lessons. In addition, during the first and eighth lessons, data were collected regarding students' experiences with mat exercise classes using the SFS (Yagi & Sakairi, 2009), the short form of the Intrinsic Motivation Scale (Sakurai & Takano, 1985), and self-evaluations of confidence in mat exercises and perceived improvement.

**Table 1.** Instructional unit plan

| Time | 1                                                                              | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 3                                                                                                                                                                               | 4 | 5 | 6                                                                                                                                                                                                                                      | 7 | 8 |
|------|--------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|
| 0    | <b>Orientation</b>                                                             | Review of learning content, Preparation of equipment, Warm-up                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                 |   |   |                                                                                                                                                                                                                                        |   |   |
| 10   | • Sequence of learning                                                         | <b>Practice of Skills Using the ICT Teaching Material 1</b><br><br>Students engaged in practicing selected skills at their own pace. The instructional objectives allowed for two options: either (a) to challenge a variety of different skills, or (b) to advance through successive steps of the same skill with the aim of achieving mastery. Ultimately, students were informed that the overarching goal was to acquire the ability to perform movements that integrate multiple skills in sequence. | <b>Practice of Skills Using the ICT Teaching Material 2</b><br><br>Students practiced individual skills with a particular focus on connecting one skill to another in sequence. |   |   | <b>Assignment: Performance and Submission of a Multi-Skill Routine</b><br><br>Students were instructed to perform a routine consisting of three or more skills in continuous sequence, record the performance on video, and submit it. |   |   |
| 20   | • Usage of ICT teaching materials                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                 |   |   |                                                                                                                                                                                                                                        |   |   |
| 30   | • Pre-lesson survey                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                 |   |   |                                                                                                                                                                                                                                        |   |   |
| 40   | Review of basic skills (forward roll, backward roll, assisted handstand, etc.) | Post-lesson survey                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                 |   |   |                                                                                                                                                                                                                                        |   |   |
| 50   | Lesson reflection                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                 |   |   |                                                                                                                                                                                                                                        |   |   |

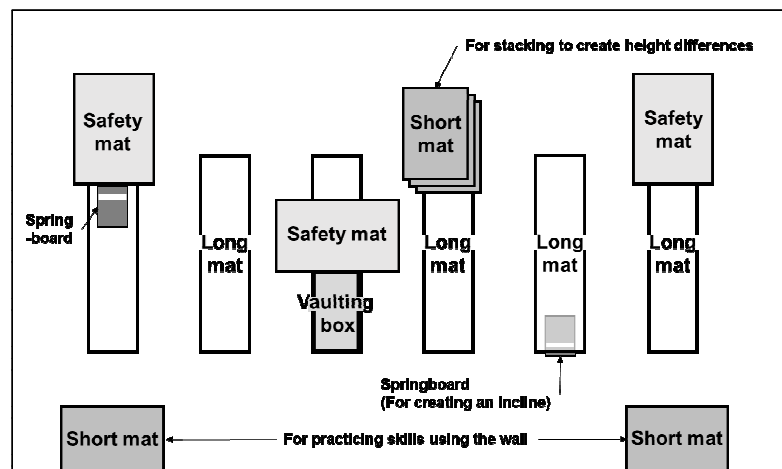


**Figure 2.** Example of practice setting

### Analysis

The mean total score for perceived physical competence was calculated ( $M = 41.31$ ,  $SD = 10.13$ ). Participants scoring above the mean were classified into the high perceived physical competence group (hereafter, the PPC High group), and those scoring below the mean were classified into the low perceived physical competence group (hereafter, the PPC Low group; see Table 4). A two-way analysis of variance (ANOVA) was conducted for each measurement index with group (PPC High vs. PPC Low) and time (pre- vs. post-class) as factors. Pearson correlation analyses were performed to examine the relationships between enjoyment, intrinsic motivation, and post-class self-evaluations of confidence and perceived improvement in mat exercise skills. For the number and difficulty of learning steps, independent-samples t-tests were used to compare the High and Low groups. Only valid responses with no missing data were used for each measure. The level of statistical significance was set at  $p < .05$ , and IBM SPSS Statistics 28 was used for the analyses.

## Results

### Sport Flow Scale

For the total SFS score, the interaction effect was not significant ( $F(1, 123) = 0.651, p = .421$ ); however, significant main effects were observed for time ( $F(1, 123) = 8.419, p = .004$ ) and condition ( $F(1, 123) = 6.367, p = .013$ ). For the sense of control subscale, the interaction was not significant ( $F(1, 123) = 0.007, p = .934$ ), but significant main effects were found for time ( $F(1, 123) = 24.368, p < .001$ ) and condition ( $F(1, 123) = 6.225, p = .014$ ). Significant main effects of condition were also found for merging of action and awareness ( $F(1, 123) = 7.353, p = .008$ ), concentration on the task at hand ( $F(1, 123) = 4.745, p = .031$ ), and autotelic experience ( $F(1, 123) = 6.867, p = .010$ ). In contrast, no significant effects were observed for loss of self-consciousness or transformation of time (Table 2).

### Intrinsic motivation

For the total intrinsic motivation score, neither the interaction ( $F(1, 122) = 0.181, p = .671$ ) nor the main effect of condition ( $F(1, 122) = 3.367, p = .069$ ) was significant, whereas the main effect of time was significant ( $F(1, 122) = 6.833, p = .010$ ). For the subscales, curiosity showed a significant interaction ( $F(1, 122) = 7.115, p = .009$ ). Multiple comparisons revealed that, before the lessons, the PPC High group scored significantly higher than the PPC Low group ( $p < .001$ ), and only the PPC Low group demonstrated a significant increase from pre- to post-class ( $p = .028$ ). For enjoyment, the interaction was not significant ( $F(1, 122) = 2.675, p = .105$ ). However, significant main effects were observed for time ( $F(1, 122) = 12.250, p < .001$ ) and condition ( $F(1, 122) = 3.974, p = .048$ ). Significant main effects of the condition were also found for challenge ( $F(1, 122) = 5.776, p = .018$ ), mastery ( $F(1, 122) = 12.474, p < .001$ ), and perceived locus of causality (internal causality) ( $F(1, 122) = 6.879, p = .010$ ). No other significant differences were observed between groups (Table 2).

### Self-confidence in mat exercises and self-evaluation of skill improvement

For self-confidence in mat exercises, the interaction effect was not significant ( $F(1, 122) = 1.558, p = .214$ ); however, significant main effects were found for condition ( $F(1, 122) = 10.443, p = .002$ ) and time ( $F(1, 122) = 12.899, p < .001$ ). Similarly, for the self-evaluation of skill improvement, the interaction was not significant ( $F(1, 122) = 0.738, p = .392$ ), whereas significant main effects were observed for condition ( $F(1, 122) = 4.511, p = .036$ ) and time ( $F(1, 122) = 47.716, p < .001$ ) (Table 2).

**Table 2.** Comparison of the PPC High and PPC Low groups on SFS, intrinsic motivation, self-confidence, and self-evaluation of skill improvement scores

|                      |                                      | Perceived physical competence |               |          |               |           |               |          |               |                         |                  |                       |
|----------------------|--------------------------------------|-------------------------------|---------------|----------|---------------|-----------|---------------|----------|---------------|-------------------------|------------------|-----------------------|
|                      |                                      | High group                    |               |          |               | Low group |               |          |               | Main effects            |                  |                       |
|                      |                                      | Pre                           |               | Post     |               | Pre       |               | Post     |               | Interaction<br><i>F</i> | Time<br><i>F</i> | Condition<br><i>F</i> |
|                      |                                      | <i>M</i>                      | ( <i>SD</i> ) | <i>M</i> | ( <i>SD</i> ) | <i>M</i>  | ( <i>SD</i> ) | <i>M</i> | ( <i>SD</i> ) |                         |                  |                       |
| SFS                  | Merging of action and awareness      | 6.344                         | (2.418)       | 6.594    | (2.821)       | 5.033     | (2.683)       | 5.820    | (2.553)       | 0.994                   | 3.707            | 7.353 **              |
|                      | Concentration on the task at hand    | 7.390                         | (2.216)       | 7.880    | (2.278)       | 6.740     | (2.523)       | 7.020    | (2.439)       | 0.181                   | 2.485            | 4.745 *               |
|                      | Sense of control                     | 5.670                         | (2.247)       | 6.770    | (2.068)       | 4.770     | (2.636)       | 5.900    | (2.406)       | 0.007                   | 24.368 ***       | 6.225 *               |
|                      | Loss of self-consciousness           | 5.980                         | (3.109)       | 6.020    | (2.920)       | 5.620     | (3.147)       | 4.930    | (3.270)       | 1.421                   | 1.185            | 2.377                 |
|                      | Transformation of time               | 5.030                         | (2.532)       | 6.000    | (2.520)       | 5.410     | (2.991)       | 5.250    | (2.656)       | 3.485                   | 1.759            | 0.256                 |
|                      | Autotelic experience                 | 7.330                         | (2.720)       | 7.580    | (2.435)       | 5.970     | (3.114)       | 6.690    | (2.802)       | 0.896                   | 3.806            | 6.867 *               |
|                      | Sport Flow (total)                   | 37.170                        | (11.128)      | 40.830   | (10.309)      | 33.540    | (11.813)      | 35.610   | (11.719)      | 0.651                   | 8.419 **         | 6.367 *               |
| Intrinsic motivation | Challenge                            | 5.860                         | (1.595)       | 5.840    | (1.405)       | 5.180     | (1.432)       | 5.410    | (1.575)       | 0.759                   | 0.576            | 5.776 *               |
|                      | Curiosity                            | 7.984                         | (1.827)       | 7.603    | (2.332)       | 6.492     | (2.314)       | 7.049    | (2.291)       | 7.115 **                | 0.252            | 8.366 **              |
|                      | Mastery                              | 7.190                         | (1.830)       | 7.380    | (1.887)       | 6.030     | (1.888)       | 6.330    | (2.249)       | 0.101                   | 2.172            | 12.474 ***            |
|                      | Perceived locus of causality         | 7.016                         | (1.980)       | 7.127    | (2.159)       | 5.918     | (2.347)       | 6.361    | (2.331)       | 0.889                   | 2.481            | 6.879 *               |
|                      | Endogenous-exogenous attribution     | 5.492                         | (1.401)       | 5.635    | (1.744)       | 5.541     | (1.822)       | 5.607    | (1.791)       | 0.080                   | 0.584            | 0.001                 |
|                      | Enjoyment                            | 7.670                         | (1.901)       | 7.950    | (1.764)       | 6.770     | (2.291)       | 7.560    | (1.996)       | 2.675                   | 12.250 ***       | 3.974 *               |
|                      | Intrinsic motivation (total)         | 38.970                        | (2.929)       | 40.020   | (3.761)       | 38.070    | (3.855)       | 38.820   | (4.225)       | 0.181                   | 6.833 *          | 3.367                 |
|                      | Self-confidence in mat exercises     | 2.680                         | (1.013)       | 2.900    | (1.201)       | 2.020     | (0.975)       | 2.480    | (1.120)       | 1.558                   | 12.899 ***       | 10.443 **             |
|                      | Self-evaluation of skill improvement | 3.370                         | (1.021)       | 3.950    | (0.771)       | 2.980     | (1.025)       | 3.740    | (0.964)       | 0.738                   | 47.716 ***       | 4.511 *               |

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

Correlation analyses were conducted separately for the PPC High and PPC Low groups (Table 3). In the PPC High group, self-confidence showed little association with the total intrinsic motivation score, but a moderate correlation with the total SFS score was observed ( $r = .480, p < .001$ ). Self-evaluation of skill improvement showed only weak associations with any of the indicators. In the PPC Low group, self-confidence likewise showed little association with intrinsic motivation but demonstrated a moderate correlation with the total SFS score ( $r = .422, p < .001$ ). However, unlike the PPC High group, self-evaluation of skill improvement in the PPC Low group showed a moderate correlation with the total SFS score ( $r = .673, p < .001$ ). In particular, strong correlations were found between self-evaluation of skill improvement and the SFS autotelic experience

subscale ( $r = .728, p < .001$ ; Figure 3-1) as well as the intrinsic motivation enjoyment subscale ( $r = .735, p < .001$ ; Figure 3-2). Enjoyment was also moderately correlated with self-confidence ( $r = .469, p < .001$ ). Furthermore, the sense of control subscale of the SFS showed moderate correlations with both self-confidence ( $r = .414, p = .001$ ) and self-evaluation of skill improvement ( $r = .614, p < .001$ ).

**Table 3.** Correlations of self-confidence and self-evaluation of skill improvement scores with SFS and intrinsic motivation scores in the PPC High and PPC Low groups

| Perceived physical competence | SFS             |                                 |                                   |                  |                            |                        |                      |                    | Intrinsic motivation |           |         |                              |                                  |                              |
|-------------------------------|-----------------|---------------------------------|-----------------------------------|------------------|----------------------------|------------------------|----------------------|--------------------|----------------------|-----------|---------|------------------------------|----------------------------------|------------------------------|
|                               |                 | Merging of action and awareness | Concentration on the task at hand | Sense of control | Loss of self-consciousness | Transformation of time | Autotelic experience | Sport Flow (total) | Challenge            | Curiosity | Mastery | Perceived locus of causality | Endogenous-exogenous attribution | Intrinsic motivation (total) |
| High group                    | Self-confidence | 0.453                           | 0.220                             | 0.432            | 0.152                      | 0.253                  | 0.502                | 0.480              | 0.301                | 0.520     | 0.427   | 0.631                        | -0.090                           | 0.446                        |
|                               | <i>p</i>        | 0.000                           | 0.076                             | 0.000            | 0.223                      | 0.041                  | 0.000                | 0.000              | 0.014                | 0.000     | 0.000   | 0.000                        | 0.471                            | 0.000                        |
|                               | Self-evaluation | -0.015                          | 0.26                              | 0.312            | -0.188                     | 0.321                  | 0.311                | 0.214              | 0.067                | 0.265     | 0.259   | 0.338                        | 0.247                            | 0.359                        |
| Low group                     | <i>p</i>        | 0.905                           | 0.035                             | 0.011            | 0.132                      | 0.009                  | 0.011                | 0.084              | 0.594                | 0.032     | 0.036   | 0.006                        | 0.046                            | 0.003                        |
|                               | Self-confidence | 0.299                           | 0.247                             | 0.414            | 0.35                       | 0.218                  | 0.308                | 0.422              | 0.077                | 0.394     | 0.248   | 0.38                         | 0.020                            | 0.469                        |
|                               | <i>p</i>        | 0.019                           | 0.055                             | 0.001            | 0.006                      | 0.092                  | 0.016                | 0.001              | 0.557                | 0.002     | 0.054   | 0.003                        | 0.878                            | 0.000                        |
| Low group                     | Self-evaluation | 0.441                           | 0.533                             | 0.614            | 0.29                       | 0.377                  | 0.728                | 0.673              | 0.171                | 0.594     | 0.448   | 0.591                        | -0.051                           | 0.735                        |
|                               | <i>p</i>        | 0.000                           | 0.000                             | 0.000            | 0.023                      | 0.003                  | 0.000                | 0.000              | 0.188                | 0.000     | 0.000   | 0.000                        | 0.696                            | 0.000                        |
|                               |                 |                                 |                                   |                  |                            |                        |                      |                    |                      |           |         |                              |                                  | 0.012                        |

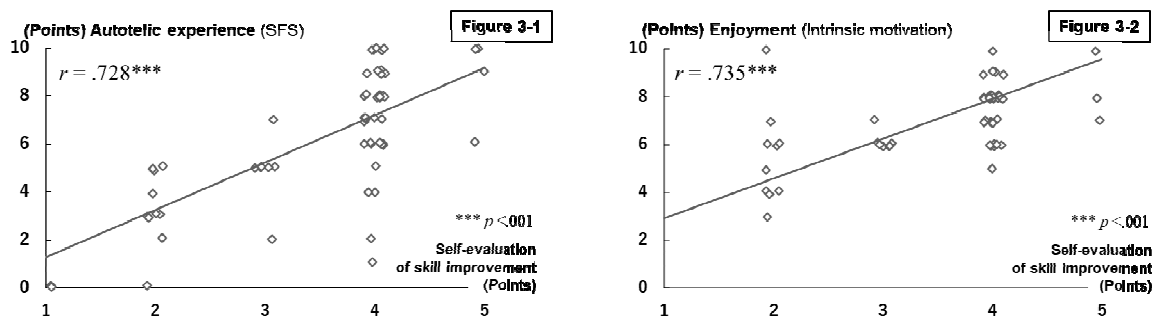


**Figure 3.** Figure 3-1: Scatterplot of autotelic experience scores and self-evaluation of skill improvement scores in the PPC Low group. Figure 3-2: Scatterplot of enjoyment scores and self-evaluation of skill improvement scores in the PPC Low group. In the PPC Low group, self-evaluation of skill improvement showed strong associations with both enjoyment and autotelic experience.

#### Learning steps and difficulty level of the learning steps

For both the number of learning steps performed by each student in each lesson ( $t(127) = 0.741, p = .230$ ) and the difficulty level of the learning steps ( $t(127) = 0.259, p = .398$ ), no significant differences were observed between the PPC High group and the PPC Low group (Table 4).

**Table 4.** Comparison of the PPC High and PPC Low groups in perceived physical competence scores, learning steps, and difficulty level of the learning steps

|                               |                                        | Perceived physical competence |               |           |               |          |          |
|-------------------------------|----------------------------------------|-------------------------------|---------------|-----------|---------------|----------|----------|
|                               |                                        | High group                    |               | Low group |               |          |          |
|                               |                                        | <i>M</i>                      | ( <i>SD</i> ) | <i>M</i>  | ( <i>SD</i> ) | <i>t</i> | <i>p</i> |
|                               | Learning Steps                         | 5.32                          | (3.57)        | 5.79      | (3.72)        | -0.741   | 0.460    |
|                               | Difficulty level of the learning steps | 2.57                          | (1.13)        | 2.52      | (1.00)        | 0.259    | 0.796    |
| Perceived physical competence | Sense of physical competence           | 14.56                         | (3.08)        | 7.38      | (2.68)        | 13.904   | <.001    |
|                               | Sense of control                       | 17.98                         | (1.90)        | 12.20     | (3.55)        | 11.532   | <.001    |
|                               | Sense of acceptance                    | 16.91                         | (2.29)        | 12.83     | (3.21)        | 8.256    | <.001    |
|                               | Perceived physical competence (Total)  | 49.45                         | (4.79)        | 32.42     | (6.78)        | 16.402   | <.001    |

## Discussion

### Summary of results

For both the total SFS score, which represents enjoyment, and the total intrinsic motivation score, significant increases were observed from pre- to post-class, regardless of the level of perceived physical competence. Among the subscales, significant improvements were also found in the SFS sense of control subscale and the intrinsic motivation enjoyment subscale, irrespective of perceived physical competence. Furthermore, both self-confidence in mat exercises and self-evaluation of skill improvement significantly increased from pre- to post-class regardless of competence level. In contrast, no significant differences between

the PPC High and PPC Low groups were observed in either the number or the difficulty level of the learning steps performed. Taken together, these findings indicate that, compared to before the class, students perceived mat exercises as more enjoyable after the class and reported higher levels of self-confidence and self-evaluated improvement, regardless of their perceived physical competence.

#### ***Enjoyment and intrinsic motivation***

Regardless of the level of perceived physical competence, a likely reason for the observed increases in enjoyment and intrinsic motivation is the design of the ICT teaching materials, which emphasize learner autonomy and individuality. These materials allow learners to choose the skills they wish to practice, the starting level of difficulty, and the preferred learning method. Satisfaction of autonomy has been shown to enhance curiosity and initiative toward learning and to predict positive learning attitudes and willingness to take on new challenges (Rowicka & Postek, 2023). Autonomy-supportive learning environments have also been associated with reduced cortisol responses, thereby enhancing emotional safety and facilitating the experience of enjoyment (Hogue et al., 2013). Within the framework of self-determination theory, autonomy support positively influences intrinsic motivation through the provision of opportunities for choice (Deci & Ryan, 1985, 1987; Patall et al., 2008). In particular, opportunities to select both learning content and learning methods are linked to higher intrinsic motivation (Fujii, 2020). Taken together, the key feature of the present ICT materials, which enable learners to freely select their practice content, starting level, and approach to learning, likely supported autonomy and self-determination and subsequently contributed to increased enjoyment and intrinsic motivation.

#### ***Self-confidence and enjoyment***

Analysis of the relationships among confidence, enjoyment, and intrinsic motivation showed that, regardless of the level of perceived physical competence, increases in confidence were only weakly associated with intrinsic motivation but were moderately associated with the total SFS score, which reflects enjoyment. At the subscale level, both the PPC High and PPC Low groups demonstrated moderate correlations with the SFS sense of control subscale, which reflects the perception of being able to control one's skills, as well as with the intrinsic motivation enjoyment subscale. Regarding the link between enjoyment and confidence, previous research suggests that perceiving learning activities as enjoyable facilitates the recognition of successful experiences and feelings of accomplishment, which in turn enhances self-efficacy (Lu et al., 2023). Taken together, these findings suggest that, irrespective of perceived physical competence, experiencing enjoyment in activities may contribute to greater self-confidence in those activities.

#### ***Self-evaluation of skill improvement and enjoyment***

The relationships among self-evaluation of skill improvement, enjoyment, and intrinsic motivation differed according to the level of perceived physical competence. In the PPC High group, only weak associations were observed across indicators. In contrast, in the PPC Low group, moderate to strong associations were found not only with the total SFS score, sense of control, and enjoyment but also with several other subscales. In particular, strong relationships emerged between self-evaluation of skill improvement and both enjoyment and autotelic experience, the latter referring to enjoyment derived from the activity itself. Several mechanisms may account for why greater enjoyment is associated with higher self-evaluations of skill improvement. Enjoyment can attract and sustain attentional resources, which facilitates understanding and retention of learning content and fosters a sense of progress (Kang & Wu, 2022). Enjoyment may also reduce threat appraisals and anxiety, which in turn decreases overly negative self-evaluations (Hogue et al., 2013).

### **Conclusions**

In mat exercise classes for first-year junior high school students, the use of ICT teaching materials that emphasized learner individuality and autonomy led students to perceive mat exercises as more enjoyable after the lessons than before, regardless of their level of perceived physical competence. Additionally, both self-confidence in mat exercises and self-evaluation of skill improvement increased. Satisfaction of autonomy and competence has been shown to foster curiosity about new learning and to support the long-term development of confidence by sustaining intrinsic motivation through enjoyment (Rowicka & Postek, 2023). Research on junior high school students has also indicated that recognizing enjoyment enhances immersion in sports activities and strengthens motivation for continued participation (Joung et al., 2024). Taken together, the present findings suggest that the ICT teaching materials supported learners' autonomy and self-determination, which made it easier for them to enjoy the learning process. Greater awareness of enjoyment was likely associated with stronger feelings of improvement and confidence, which in turn, may have contributed to higher intrinsic motivation.

The value of these ICT learning materials lies in their instructional design, which strongly emphasizes learner individuality and autonomy. The materials allow learners to select the skills they wish to practice, choose among learning methods, and determine their starting level according to their current abilities and goals. This flexible structure removes the need to follow a single uniform learning pathway and instead supports the construction of personalized learning experiences based on individual needs and preferences. Consequently, even within the same lesson, learners can engage in different self-selected activities, such as consolidating basic techniques, attempting more advanced skills, or repeatedly practicing movements that require further refinement. This diversity of learning experiences suggests that the ICT materials can function as a platform accommodating

differences in skill level and learning approach, rather than imposing one instructional model on all students. Future research should examine how the use of these materials interacts with learner characteristics, such as physical competence, motivation, and preferred learning styles. Refining instructional strategies that align ICT use with learners' developmental stages and skill levels may help achieve not only greater individuality and autonomy but also optimized learning tailored to each student. Such refinement has the potential to promote inclusive and effective physical education practices that support diverse learners.

### Conflict of Interest

The authors declare that this study was conducted in the absence of any commercial or financial relationships that could be construed as potential conflicts of interest.

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