A Study on Constructing the Order of the Teaching Materials on Apparatus Gymnastics to Learn “Spring Motion”: Focusing on the Relation between “Forward Roll Bridge” and “Spring Motion from a Higher Level”*

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The purpose of this study was to develop effective teaching plans for learning how to “spring” by creating lesson plans using a “forward roll bridge (FRB)” as the teaching material and analyzing the effectiveness of the lesson plans through their execution in classes. These lessons of “spring motion from a higher level (SMH)”, which were taught over 6 school hours in total, were carried out as a part of the unit on apparatus gymnastics spanning from April 15th to the 28th, 2016. Participants were 5th grade students (32 male, 31 female, 2 classes) of the F elementary school, which is located in Hiroshima prefecture. These lessons were followed by the “FRB (10 school hours in total)” lessons developed for this study, in which the students learned “the spring motion with hip subduction, from forward roll (SHF)” and aimed to do the “SMH”, landing on the ground. The F elementary school employs a subject teacher system throughout the elementary school, and the students had already learned the “antenna bridge (AB)” and the “FRB” in the previous year.

The results of this study were as follows;

(1) An improvement of the students’ athletic skills for doing all of the moves, “AB”, “FRB”, and “SMH”, was observed after the 6 school hour lessons. It expressly indicates that the lesson plans were effective for teaching “SMH”.

(2) A correlation of the achievements of “FRB” and “SMH” was found in the first lesson (|r| ≦ 0.700, p < 0.0001). This result indicates that “FRB” should be learned before “SMH”, to produce a higher achievement rate. After the 6th lesson, the correlations between “AB” and “FRB” (|r| ≦ 0.348, p < 0.006) and between “FRB” and “SMH” (|r| ≦ 0.440, p < 0.0001) were found. This might show that effectiveness of “FRB” as a move connecting the learning of “AB” and “SMH”.

(3) The qualitative analysis of the students’ movements indicated that there were two types of students who were not able to do “SMH”, those students who achieved “SHF” but could not do the spring, and those students who had not achieved “SHF”. This differs from former studies that showed only the latter type of students existing. This indicates that the difficulties of “SMH” were that 1) the students first need to achieve two skills, “SHF” and “pushing with hands”, and 2) the students need to adapt themselves for another situation in order to be able to do the move.

Keywords: lesson plan, elementary school, mat exercise, vault exercise
1. Where the problem lies

1.1. “Kick up” and “spring” in elementary school curriculum guidelines (hereafter, curriculum guidelines)

Teaching materials used for lessons were changed following revisions to the curriculum guidelines. The “kick up” in mat exercise and “spring” in vault exercise were first presented in the 1989 revision of the Elementary School Instructional Documents, Physical Education (Ministry of Education, 1989). In this document, as shown in Table 1, “head kick up” was presented as one technique for rotating during mat exercises and “head spring” presented as a technique for the rotation system in vault exercise. Note that the “head spring” was only given as an example in the sixth-grade vault exercise. Later, in the 1998 revision of the elementary school curriculum guidelines, physical education (Ministry of Education, 1998), “kick up” was removed from examples of mat exercises and “neck spring” was presented as a technique for a forward roll on the vault as examples of supportive jumping in vault exercise. Additionally, in the current curriculum guidelines, physical education (MEXT, 2008), “neck spring” and “head spring” are presented as further development techniques for a forward roll on the vault in the presentation of skills in the rotation system for vault exercise.

“A Study on the Achievement Status of Apparatus Gymnastic Techniques in Elementary and Middle School (Kobayashi et al., 2010)”, which examined the degree to which content in the current curriculum guidelines had been established, showed the following results regarding achievement levels of the skills “kick up” and “spring”. Achievement rates for “neck spring” and “head spring” in vault exercise fell below 50% for both elementary and middle school and was only 5% in middle school for “neck kick up” and “head kick up”. As one cause for this, Takahashi (2012) noted that, “Although the achievement gap ratio between schools was remarkable in all apparatus gymnastic events and achievement rates were relatively high in schools that were devotedly working on this, achievement rates in schools in general were extremely low even for ‘basic skills’”. Furthermore, Takahashi states “standards can be reached by applying an appropriate instruction program, allotting an appropriate amount of time, and implementing classes” (Takahashi, 2010). Elementary schools are generally schools that have classroom teachers in charge of physical education classes. Therefore, it is speculated that there were many teachers who did not understand the unit planning and teaching methods when the curriculum guidelines were revised and new skills and events were adopted. Regarding the fact that “spring” was taken on as a teaching material with the 1989 curriculum guidelines revision, Shiraishi (1991) wrote that “many elementary school teachers said that they were unable to hide their surprise. That’s because most of the current teachers had never actually done those skills personally nor taught them”. Looking at the survey results from Kobayashi et al. (2010), we can guess that even today there has not been great improvement. Therefore, developing lesson plans for learning the exercise skills “kick up” and “spring” can have great significance.

1.2. Practical cases seen in previous research

On the other hand, there is a lot of research on the “neck spring”. Taking research classes held at Fukushima University-attached elementary school as an example, Shiraishi (1991) wrote that the “action of swiftly opening of the bent body” and the “timing” of this action are the instructional points for the “neck spring”. Then, as lower-level materials for learning the “neck spring”, Kamiya et al. (1992) studied an array of low-level teaching materials for learning the “neck spring”, and suggests a lesson plan of (1) forward roll on a vault, (2) knee extension forward roll on a vault, (3) launching up to feet from a knee extension forward

Table 1 Revisions to curriculum guidelines and “kick ups” and “springs”.

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Mat Exercise</td>
<td>Head Kick Up</td>
<td>Not presented</td>
<td>Not presented</td>
</tr>
<tr>
<td>Vault Exercise</td>
<td>Head Spring</td>
<td>Head Spring/ Neck Spring</td>
<td>Head Spring/ Neck Spring</td>
</tr>
</tbody>
</table>

90
roll on a vault, (4) neck spring, and (5) head spring. Then, as the learning and teaching phases of the “neck spring”, they showed a (1) spring motion from a higher level, (2) neck spring from a forward roll on two connected vaults of the same height, (3) neck spring from the low vault on two connected vaults of different heights, and (4) neck spring from a normal vault. Kitagawa (1994) considered building sensory awareness to be very important for learning the “neck spring”, and emphasized that (1) neck inversion, (2) bending and opening of the body from a neck inversion (hereafter referred to as “sandwich”), and (3) bridge from a neck inversion (antenna bridge) should be performed as preparation exercises at the beginning of each class. Sato et al. (2009) established the learning phases of “neck spring” to be basic learning, foundational learning, and developmental learning. Basic learning includes as low-level teaching materials (1) ton-ton forward roll, (2) jump forward roll, (3) “sandwich”, (4) antenna bridge, and (5) spring motion from a higher level”. For foundational learning, “forward roll on a vault” and “big forward roll on a vault” were established as common tasks and worked on. An activity place was devised aimed at mastery of skills students were able to do and where they could challenge themselves to practice. Furthermore, as small steps toward neck springs in development training, (1) neck spring from a higher level on a two connected vaults of the same height, (2) neck spring from a lower vault, and (3) neck spring from a regular vault were established.

In these studies, antenna bridge and spring motion from a higher level (and spring motion from the same height) were often used as low-level teaching materials for the neck spring. However, as introduced previously in Kobayashi et al.’s (2010) survey, we can infer that there is also a problem in the array of these teaching materials, which may be contribute to the low degree of achievement for “kick ups” and “springs”. Actually, in Sato et al. (2009)’s study, researchers stated that “the low-level teaching materials currently adopted cannot be considered effective for all students and it is necessary to further develop basic low-level teaching materials”.

1.3. The system of techniques for “kick ups” and “springs”

1.3.1. “Spring motion”

Kaneko (1982) cited “spring up” and “rotation acceleration” as required skills for “neck springs”. The “spring up skill” is said to be made of three factors and the position of this stance must be reversed in an instant. The second required factor is an “energetic lifting motion by raising the feet”. The third required factor is “pressing and release the hands on the mat”. “Skill of rotation acceleration”, Kaneko says, “consists of movement that warps the body and creates dorsiflexion of the head; however, both are synchronized with the spring up third factor of pressing and releasing the hands”. Therefore, we believe the third factor is connected both to “spring up skill” and “rotation acceleration skill”. In this research, we define the combined actions of factors one and two as a “spring motion”.

1.3.2. Systemization of Akitomo Kaneko’s work

Kaneko (1982, 1987) systematized mat exercise and vault exercise work as shown in Figures 1 and 2.

A “kick up” in mat exercise is placed in the group of “kick ups” that are part of the turnover skills in the rolling system. Kaneko (1982) stated that a characteristic of “kick up” is that it “requires energy to perform the bending motion that produces the lateral axis rotation”. Therefore, a “kick up” is includes everything in the process of shifting from a form that does not complete a full rotation on the lateral axis to a form that rotates, including the overhead aspect”. However, a “spring” in the vault exercise is not found in the system of rotations. In Kaneko’s systematization (1987), “spring” is placed only in the “handspring preparation practice”. Handspring preparation practices include rolling down from the vault, vault forward rolls, “neck springs”, “head springs”, and “bent-arm springs” and lead to bent-arm handsprings.

1.3.3. A study on the teaching system for rotations on the vault by Shojiro Shindo

Shindo (1988) presented an understanding of Kaneko’s theory while also critically reflecting on it in a study on the teaching system for rotations on
Shindo (1988) explained that Kaneko’s theory (1987) contains the following contradictions. Kaneko (1987) places rotating down from a higher level in tasks 1 through 5 in “handspring preparation practice”. Kaneko explains this is because with rotation skills for vault exercise, it is necessary to first remove the fear that accompanies the movement of going upside-down on the vault. However, Shindo (1988) states that since vault exercises have the order of feet-hands-feet, it cannot be determined that rotating down from the vault serves as training for a movement coordination skill. In other words, even if a student can rotate down from the vault, it cannot be said that this connects to the “movement coordination skill” in vault exercises that is performed in the sequence of jumping, placing hands, and rotating down.

Kaneko (1987) also places “forward roll on the vault” as task 6. This is the mat exercise “forward roll” performed on the vault and “is a gymnastics skill that requires arm support (placing and removing) and entirely different movement forms and skills” (Shindo, 1988). Regarding this issue, even within Kaneko’s systematization, the contact skill group and the spring skill group are distinguished as
Structuring the Order of Teaching Materials for Learning the “Spring”

1.4. Teaching materials & forward roll bridge

Many previous studies have used the “antenna bridge” and “spring motion from a higher level” as low-level teaching materials for the “spring motion” (Kamiya et al., 1992; Kitagawa, 1994; Sato et al., 2009; Shiraishi, 1991). This is because the “antenna bridge” is teaching material for moving from the stationary state of an antennae to a bridge using the “spring motion”, and it is a necessary skill for the “neck kick up” and therefore appropriate for mastering the “spring motion”. The “spring motion from a higher level” is different from the vault’s “neck spring”, and the movement begins from a vault of the same height and the aerial phase appears as a result of the spring motion using the drop in height difference and is therefore appropriate for learning “spring motion” techniques and “pressing and releasing hands on the mat”. If we compare the movements in these two low-level teaching materials, can adding an overhead roll and an aerial phase to the “antenna bridge” not be called a “spring motion from a higher level”? Compared with the antenna bridge, after adding two new exercise techniques, the “spring motion from a higher level”, which adds another fear from the height drop, is a difficult motor skill that students should master. Therefore, as a preliminary phase in developing from “antenna bridge” to “spring motion from a higher level”, we believed it is necessary to have students experience a “spring including an overhead roll” that does not have an aerial phase on a flat floor mat. However, in the current curriculum guidelines, regardless of the fact that skills for “kick ups” during mat exercise are not presented in elementary school, for vault exercises, “neck spring” and “head spring” are presented as development skills for “forward rolls on the vault”. Therefore, students cannot progress from “forward rolls on the vault” immediately to “neck springs” and “head springs”, rather it is necessary to position teaching materials in mat exercises that lead to learning a “spring including overhead rolls”. Thus, we developed lesson plans that incorporate teaching materials such as the “forward roll bridge” that includes an “antennae bridge” with an overhead roll.

In this study, as shown in the movement process in Figure 3, the “forward roll bridge” is defined as performing a “spring motion” and moving into a bridge stance in the middle of a forward roll when

separate skills from different systems. Therefore, Shindo (1988) stated that “for ‘rotation sensory awareness’, there should be more preparation on other apparatus as well, such as arm-support rotations in mat exercises’”.

Furthermore, Kaneko (1987) noted that there were also differences regarding the runway portion. For the runway portion in a “spring”, there is the “problem of having to intentionally limit the degree to which support is placed on the neck and head in order to perform the ‘spring motion’” (Kaneko, 1987). However, Shindo (1988) explains that for the runway portion in a “forward spring”, based on this movement structure, the “faster speed on the runway and a stronger jump is more beneficial to the rotation and so you don’t have to ‘intentionally limit’ [these]”. That is, Shindo (1988) indicates that for “springs”, rather than intentionally limiting the runway and jump in order to perform the rotation acceleration of the spring motion, in the “forward spring”, to perform the rotation acceleration of “instantly jumping up action” from the springboard, you “don’t have to ‘intentionally limit’” the runway speed and jump and the “technical components are fundamentally different”. Therefore, Shindo (1988) states that in vault exercises, the “spring skills” and the “handspring skills” should be taught separately as two different support (arm/limb) skills within the rotation skills group”, and it has a “very close affinity structurally to mat exercise arm-supported rotation apparatus and sequential structuring of teaching materials based on a recognition of the relationship with mastery of these techniques and skills in mat exercises must be considered”.

The rotation skills group in vault exercises involves fear in coming down from the vault and also fear in jumping up onto the vault. In such circumstances, by developing skills to go from a “forward roll on the vault” to a “neck spring”, which “requires completely different movement form and technique”, is acquiring the new skill “spring motion” difficult to achieve for students? As Shindo (1988) states, considering the “very close affinity structurally” between mat and vault exercises, we believe it will be necessary to proceed to learning the “neck spring” on the vault after achieving the “spring motion” on the mat.
the waist moves above the head.

Therefore in this study, we created lessons plans placing the “forward roll bridge” as additional low-level teaching material for acquiring the “spring motion”, which is technical content shared by both the “kick up” on mat exercise and “spring” on vault exercise in apparatus gymnastics, and we aimed to develop effective lesson plans for acquiring the “spring motion” by analyzing the effectiveness of low-level teaching materials from classroom practice using these lesson plans.

2. Research method

2.1. Explanation of subjects

Classes on “spring motion from a higher level” (6 hours total) were conducted for an elementary school’s fifth-grade apparatus gymnastics (mat exercise and vault exercise). This research was conducted with the approval of the Hiroshima University Ethics Review Committee.

2.1.1. Implementation period, number of students, teacher characteristics

The classes were held from April 15 to April 28, 2016, implemented in units (6 hours total) on the spring motion from a higher level with two classes of fifth graders (32 boys, 31 girls) at Hiroshima F Elementary School. F Elementary School adopts the system where different teachers teach different subjects, and the targeted students had been learning the forward roll bridge since fourth grade (10 hours total) and had experience doing the antenna bridge and forward roll bridge. The teacher responsible for instructing classes on both the forward roll bridge and the spring motion from a higher level had 16 years of teaching experience (12 years in a public elementary school and 4 years in the physical education department of a national university-affiliated elementary school).

2.1.2. Unit planning, learning process

Unit planning was performed where the pre-unit “forward roll bridge” (10 hours total) had been and there is a leveled-step for the “spring including an overhead rotation”, and it was created as shown in Table 2 with the aim of creating an aerial phase and a landing.

With this unit, class began with the “neko-chan exercise (partial teacher change)” (Yamauchi, 2007), and the movement of the trunk was explained. We reshuffled the order of the “bridge” and “antenna” and “antenna” was switched to sandwich and completed 10 times. Then “bridge” was switched to “antenna bridge” and the “spring motion” was reviewed. Since there were students who were able to do it in fourth grade but then lost the skill, students who never acquired the skill, and students who moved between schools this year and had no experience with “antenna bridge” or “forward roll bridge”, during this period, we aimed at mastery of “spring including an overhead rotation” on a flat mat.

The learning tasks were to learn the skills “press and release the hands” and “dorsiflexion of the head” to create the aerial phase of the “spring motion from a higher level” and to learn the timing and feeling to perform a stronger, better “spring motion”.

The activity location had three places (70 cm drops) of thick safety mats (30 cm) from the stage (100 cm), and we prepared two places (70 cm drops) of thin safety mats (15 cm) from the stack of regularly used mats (85 cm). In both places the drops were made equal so that there was no difference in motor skills due to location differences. However, since it was anticipated that there would be students afraid of the height of the stage, when shooting the video, we made it possible for each student to choose either place.

2.1.3. Collection of resources

A digital video camera was installed so that the
Structuring the Order of Teaching Materials for Learning the “Spring” movement from beginning to landing could be captured for all students and stationary video recording was taken. The movement for each student at each hour was evaluated following the created achievement criteria and was collected as quantitative data. Image processing was performed for the recorded data so that individuals could not be identified and the data was used as documentation.

In this study, to judge the degree of learning outcomes from the implemented lesson plans based on the learners’ motor skills, the students’ motor skills from the video recordings were targeted for analysis; for Hour 1 and Hour 6, this was “antenna bridge”, “forward roll bridge”, and “spring motion from a higher level”, and for Hour 2 and Hour 5, this was “spring motion from a higher level”.

### Analysis method

#### 2.2.1. Creating achievement criteria

In previous research, students’ movements were divided into four phases from four perspectives.
Table 3 “Antenna bridge” achievement criteria.

<table>
<thead>
<tr>
<th>Achievement Level 3</th>
<th>After moving her waist, she reactivity lifts her waist up and bends her upper body.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achievement Level 2</td>
<td>Without moving her waist, she lifts her waist up and bends her upper body.</td>
</tr>
<tr>
<td>Achievement Level 1</td>
<td>Without moving her waist, she does not lift her waist up and after her feet land on the floor, she bends her body.</td>
</tr>
</tbody>
</table>

Table 4 “Forward roll bridge” achievement criteria.

<table>
<thead>
<tr>
<th>Achievement Level 3</th>
<th>After moving her waist, she reactivity lifts her waist and bends her upper body.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achievement Level 2</td>
<td>In the middle of the roll, her waist lifts up but it does not lift up reactivity and the waist angle is open.</td>
</tr>
<tr>
<td>Achievement Level 1</td>
<td>Her waist does not lift up in the middle of the roll, and she lifts her waist after her feet have landed.</td>
</tr>
</tbody>
</table>

Table 5 “Spring motion from a higher level” achievement criteria.

<table>
<thead>
<tr>
<th>Achievement Level 3</th>
<th>After moving her waist, she reactivity lifts her waist and bends her body, thereby creating the aerial phase.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achievement Level 2</td>
<td>Her waist lifts in the middle of the roll but it does not lift up reactivity and the waist angle is open.</td>
</tr>
<tr>
<td>Achievement Level 1</td>
<td>Her waist does not lift up in the middle of the roll and the waist angle is small as she lands.</td>
</tr>
</tbody>
</table>

(waist-bend angle, spring timing, press off, landing), and Sato et al. (2009) used all four perspectives as achievement criteria; Osedo et al. (2009) set five perspectives of the students’ movement based on preparation phase, main phase, and ending phase, and for each perspective, they set three stages based
on each phase. In this study, we adopted the standards from Osedo et al. (2009) and as shown in Tables 3-5, created achievement criteria for the "spring motion" in "antenna bridge", "forward roll bridge", and "spring motion from a higher level" as action that combined Kaneko’s (1982) kick-up technique points "lumbar movement and leg dropping" and "leg lifting".

These achievement criteria were created by two people, a male teacher in charge of the class and a university professor with experience in an elementary school’s physical education department. Then, to increase the validity of the criteria, in the university’s school teacher training course, we sought the opinions of university professors in charge of apparatus gymnastics classes and made revisions. Note that for each achievement criteria, an achievement degree of 3 was considered to show mastery of the "spring motion". For the final unit hour in fourth grade, the achievement rate for a "spring motion" in a "forward roll bridge" was 83.6% for achievement criteria 3 in Table 4.

2.2.2. Analysis reliability

To investigate the reliability of achievement evaluations for the students’ three teaching materials, kappa coefficients were found for all (n=618) evaluations performed individually by classroom teachers and university professors in charge of apparatus gymnastics classes in the university’s school teacher training course. A high kappa coefficient considered to be substantially consistent, k = .77, was confirmed. Then, the inconsistent items were examined and targeted for analysis by both people simultaneously.

2.2.3. Statistical processing

In this study, to investigate the relationship between the "antenna bridge" and "forward roll bridge" learned in fourth grade and the teaching materials for the "spring motion from a higher level" learned in this unit, we examined the relationship between the achievement degrees for the three teaching materials in Hour 1 by calculating correlation analysis (Pearson’s correlation coefficient). Then, to investigate how effective the lesson plans are for the achievement degree of teaching materials, we conducted a paired t-test on the before/after unit teaching materials achievement degree and confirmed teaching material mastery from Hour 1 and Hour 6. Additionally, we conducted effect size (ES) analysis. To study whether or not there were associations between the three teaching materials in Hour 6, we examined the relationship between achievement degrees for "spring motion from a higher level", "antenna bridge", and "forward roll bridge" by calculating Pearson analysis (Pearson’s correlation coefficient).

2.2.4. Movement analysis

Based on the video recordings from each hour of class, through qualitative analysis of students who were able to perform the "spring motion from a higher level" and students who were unable to, we investigated the contributing factors for mastering or not mastering a "spring including an overhead rotation" in the "spring motion from a higher level".

3. Results and discussion

3.1. Correlation of achievement levels for antenna bridge, forward roll bridge, and spring motion from a higher level the first time

Table 6 shows the relationship of the achievement levels for antenna bridge, forward roll bridge, and spring motion from a higher level the first time.

Based on these results, a significant positive correlation was observed for the relationship between achievement degrees for "antenna bridge" and "spring motion from a higher level", which was also reported in Sato et al. ‘s (2009) research. However, there was a low correlation (|r| ≠ 0.270, p < 0.32) between the two teaching materials. For the "forward roll bridge" dealt with in this study, a significant positive correlation was observed in the relationships between achievement degrees for
“antenna bridge” and “forward roll bridge” and “forward roll bridge” and “spring motion from a higher level”. Although there was a low correlation (\(|r| \leq 0.384, p < 0.02\)) between “antenna bridge” and “forward roll bridge”, there was a high correlation (\(|r| \leq 0.700, p < 0.0001\)) between “forward roll bridge” and “spring motion from a higher level”. Based on these results, it was speculated that “forward roll bridge” has a higher correlation with “spring motion from a higher level” than “antenna bridge” does.

3.2. The shift in achievement rates of teaching materials from Hour 1 to Hour 6

Table 7 shows the achievement rates for “spring motion from a higher level” at each class hour as a result of conducting this unit. The percentage of students with an achievement degree of 3 for “spring motion from a higher level” was 47.6% at Hour 1, 58.7% at Hour 2, 69.8% at Hour 3, 75% at Hour 4 and the achievement rate increased by approximately 10% with the learning of a new task and was 83.6% by the final hour of the unit. We conducted a paired t-test on “spring motion from a higher level” achievement degrees from Hour 1 to Hour 6 and found a significant improvement (t (61) = 6.416, p < 0.001). Additionally, a high effect size (ES = 0.98) was calculated. In other words, it was suggested that this unit was effective for mastering “spring motion from a higher level”.

Table 8 shows the achievement rates for “antenna bridge” and “forward roll bridge” in Hour 1 and Hour 6. This unit focused on “spring motion from a higher level”; however, significant increases achievement rates (t (61) = 2.880, p < 0.01, t (61) = 4.803, p < 0.001) for “antenna bridge” and “forward roll bridge” were observed. In this unit, aiming for mastery of the “spring motion”, the “antenna bridge” was performed during “neko-chan
exercise (partial instructor change)” (Yamauchi, 2007), and time to practice the “forward roll bridge” was established with the goal of acquiring a “spring including an overhead rotation”. However, the achievement rates for “antenna bridge” and “forward roll bridge” were lower than the rate for “spring motion from a higher level”. The following two points are thought to be factors for this. First, “spring motion from a higher level”, which is a “spring including an overhead rotation” performed with a height difference, was established as the main teaching material in this unit, and the low-level teaching materials were “antenna bridge” and “forward roll bridge”. That is, in this unit, the goal was to learn a movement that created the appearance of an aerial phase through “spring including an overhead rotation”. Although “antenna bridge” and “forward roll bridge” include the “spring motion” and “spring including an overhead rotation” as shared technical content, the aerial phase did not appear in this unit as teaching material to master. Therefore, in this unit, the achievement rate was low for “antenna bridge” and “forward roll bridge”, which do not have an aerial phase; however, within the unit’s study of “spring motion from a higher level”, there was mastery of “spring including an overhead rotation”, which has an aerial phase, and it is thought that may be why the achievement rates were high. Second, it is thought that the length of time committed to the teaching materials in this unit may have been influential. The “antenna bridge” was only addressed as a part of the neko-chan exercises, and the “forward roll bridge” was only addressed for approximately five minutes at the beginning of class, and therefore, we think that skill improvement was observed in “spring motion” acquisition during “spring motion from a higher level” was a result of learning the “spring motion” during these two teaching materials.

3.3. Correlation of achievement rates for “antenna bridge”, “forward roll bridge”, and “spring motion from a higher level” in Hour 6

Table 9 shows the relationship between achievement rates for “antenna bridge”, “forward roll bridge”, and “spring motion from a higher level”. Based on these results, we observed a significant positive correlation between achievement rates for “antenna bridge” and “forward roll bridge” (|r| = 0.348, p < 0.006) and “forward roll bridge” and “spring motion from a higher level” (|r| = 0.440, p < 0.0001). A correlation between achievement rates for “antenna bridge” and “spring motion from a higher level” was not observed (|r| = 0.233, p < 0.07). It is guessed that it is a large task for students to develop from an “antenna bridge” that focuses on mastery of the “spring motion” to “spring motion from a higher level”, which requires mastery of “hand pressing and release” and “head dorsiflexion” to achieve the second aerial phase of a “spring including overhead rotation”.

3.3.1. Achievement rates for “antenna bridge” and “forward roll bridge” in Hour 1 and the achievement rate for “spring motion from a higher level” in Hour 6

We compared achievement rates for “antenna bridge” and “forward roll bridge” in Hour 1 to the achievement rate for “spring motion from a higher level” in Hour 6. Obtained results are shown in Tables 10 and 11. As shown in Table 10, two students with an achievement level 3 for “antenna bridge” in Hour 1 had achievement levels 2 and 1 for “spring motion from a higher level” in Hour 6. The student who had an achievement level 2 for “spring motion from a higher level” in Hour 6 also had an achievement level 2 for “forward roll
Table 10 Relationship between achievement rates for “antenna bridge” in Hour 1 and “spring motion from a higher level” in Hour 6.

<table>
<thead>
<tr>
<th>Achievement Level of “Antenna Bridge” in Hour 1</th>
<th>Achievement Level of “Spring Motion from a Higher Level” in Hour 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achievement Level 3</td>
<td>Achievement Level 3</td>
</tr>
<tr>
<td>Achievement Level 2</td>
<td>Achievement Level 2</td>
</tr>
<tr>
<td>Achievement Level 1</td>
<td>Achievement Level 1</td>
</tr>
</tbody>
</table>

Table 11 Relationship between achievement levels of “forward roll bridge” in Hour 1 and “spring motion from a higher level” in Hour 6.

<table>
<thead>
<tr>
<th>Achievement Level of “Forward Roll Bridge” in Hour 1</th>
<th>Achievement Level of “Spring Motion from a Higher Level” in Hour 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achievement Level 3</td>
<td>Achievement Level 3</td>
</tr>
<tr>
<td>Achievement Level 2</td>
<td>Achievement Level 2</td>
</tr>
<tr>
<td>Achievement Level 1</td>
<td>Achievement Level 1</td>
</tr>
</tbody>
</table>

Table 12 Relationship between achievement levels for “forward roll bridge” in Hour 1 and “spring motion from a higher level” in Hour 1.

<table>
<thead>
<tr>
<th>Achievement Level of “Forward Roll Bridge” in Hour 1</th>
<th>Achievement Level of “Spring Motion from a Higher Level” in Hour 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achievement Level 3</td>
<td>Achievement Level 3</td>
</tr>
<tr>
<td>Achievement Level 2</td>
<td>Achievement Level 2</td>
</tr>
<tr>
<td>Achievement Level 1</td>
<td>Achievement Level 1</td>
</tr>
</tbody>
</table>

bridge” in Hour 6. The following points are thought to be factors for this. There is no “spring including an overhead rotation” in an “antenna bridge”. Therefore, although the student achieved a “spring motion” with an “antenna bridge”, the student did not master the “spring including an overhead rotation” that is required for the “forward roll bridge” and “spring motion from a higher level”. In other words, it was suggested that the degree of difficulty for mastering the movement would be increased simply by including “overhead rotation”.

The student who had an achievement level 1 for “spring motion from a higher level” in Hour 6 had an achievement level 3 for “forward roll bridge” in Hour 1. It is thought this is because the student was also able to do a “spring motion from a higher level” in the “spring including an overhead rotation” during the “forward roll bridge” learned in grade four. That is, we surmise it effective to learn “spring including an overhead rotation” in the “forward roll bridge” unit as a preliminary phase of “spring motion from a higher level”.

3.3.2. Analysis of movement in the high-level group for “forward roll bridge” in Hour 1

As shown in Table 12, among the students with an achievement level 3 for “forward roll bridge” in Hour 1, eight students had achievement levels of 1 or 2 for “spring motion from a higher level” in Hour 1. The following characteristics were obtained through analysis of these students’ movements.

As shown in Figure 4, despite having an achievement level 3 for “spring motion” in the “forward roll bridge”, for students with an achievement level 1 for “spring motion” in “spring motion from a higher level”, the opening of the waist bend was not observed and they ended up “rolling down”. The following factor is thought to explain why a “spring motion” was not observed in the “spring motion from a higher level” although it was seen in the “spring motion” in “forward roll bridge”. Analysis of the students’ movements showed that students A, B, and D stretched their arms upward during the second half of the movement. We suspect this is because there was such a strong awareness of “pressing and releasing hands”, which was instructed to the students as a new task during “spring motion from a higher level”. Therefore, it seems it has become impossible to consciously perform the
Figure 4  Movements of students with an achievement Level 3 for “forward roll bridge” in Hour 1 and achievement level 1 for “spring motion from a higher level”.

<table>
<thead>
<tr>
<th>Student A</th>
<th>Student B</th>
<th>Student C</th>
<th>Student D</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Images" /></td>
<td><img src="image2" alt="Images" /></td>
<td><img src="image3" alt="Images" /></td>
<td><img src="image4" alt="Images" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Student E</th>
<th>Student F</th>
<th>Student G</th>
<th>Student H</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5" alt="Images" /></td>
<td><img src="image6" alt="Images" /></td>
<td><img src="image7" alt="Images" /></td>
<td><img src="image8" alt="Images" /></td>
</tr>
</tbody>
</table>

Figure 5  Students’ movement who had achievement level 3 for “forward roll bridge” in Hour 1 and achievement level 2 in “spring motion from a higher level”.

<table>
<thead>
<tr>
<th>Student E</th>
<th>Student F</th>
<th>Student G</th>
<th>Student H</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image9" alt="Images" /></td>
<td><img src="image10" alt="Images" /></td>
<td><img src="image11" alt="Images" /></td>
<td><img src="image12" alt="Images" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Student E</th>
<th>Student F</th>
<th>Student G</th>
<th>Student H</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image13" alt="Images" /></td>
<td><img src="image14" alt="Images" /></td>
<td><img src="image15" alt="Images" /></td>
<td><img src="image16" alt="Images" /></td>
</tr>
</tbody>
</table>
“spring motion” as the supposed “major achievement” (Kaneko, 1982) in the original “spring motion from a higher level” and it has instead become a “rolling down”-type movement.

As shown in Figure 5, there were four students who opened up the waist bend yet the flexing of the body was not observed and they did not lift their waist. These students also had an achievement level 3 in the “spring motion” with the waist lifted in the “forward roll bridge”. However, when the movement became “spring motion from a higher level”, their waist did not lift and they had an achievement level 2. A characteristic of these students’ movements is that in the latter half of the movement “spring motion from a higher level”, “dorsiexion of the head” as a way to see the landing was not observed. It is thought that students subconsciously restricted the “spring motion” as a result of the aerial phase and not being used to the height difference with the steps.

These characteristics resemble the actions indicated by Jinka et al. (1992) “stumbling block (1) not understanding the timing of the execution” and “stumbling block (2) opening up the waist and bending the legs”. However, viewing these eight students’ movements, we thought that the “timing of the execution” was learned in the “forward roll bridge”. That is, these students’ movements suggested that they lost the “spring motion” they had acquired by focusing strongly on “pressing and releasing the hands” as a task in the “spring motion from a higher level” and by getting used to the aerial aspect that appears in the location with the steps. After acquiring the “spring motion” in the “spring motion from a higher level” performed on the location with steps in Hours 2 through 6, these students had an achievement level 3 each class hour. Therefore, it is thought to be necessary to include time to get used to performing the “spring motion” on location with steps after learning the “spring” on the flat floor mat.

3.3.3. The low-level group for “forward roll bridge” in Hour 1

In this unit, sixteen students had an achievement level 3 for “forward roll bridge”. Twelve of these students also had an achievement level 3 for “spring motion from a higher level” in Hour 6.

In student I’s “antenna bridge” movement in Hour 1, waist movement was not observed, yet waist-bend opening was and the student had an achievement level 2. Since the “spring motion” in the “antenna bridge” was not achieved, the student’s achievement level for “forward roll bridge” in Hour 1 was 1 and also 1 for “spring motion from a higher level”, as shown in Figures 6 and 7.

Student I mastered the “spring including an overhead rotation” in “forward roll bridge” during the time for learning “forward roll bridge” in Hour 2 with the teacher’s assistance and group friends’ involvement. However, though the student mastered “spring including an overhead rotation” in “forward roll bridge”, the student was not able to immediately master the “spring including an overhead rotation” in “spring motion from a higher level”. Afterward, proceeding with the learning in this unit, the student was able to master the “spring
Structuring the Order of Teaching Materials for Learning the “Spring”

3.3.4. The effectiveness of low-level teaching materials for forward roll bridge
As seen in Student B in Figure 4 and Student I in Figure 7, the movement of the first time in the “spring motion from a higher level” appears the same. However, it is thought there are different reasons these two students did not reach an achievement level 3. The student practicing “spring including an overhead rotation” in “forward roll bridge” had a problem with the “spring motion” based on the difference in the location. Student I had a problem with learning the “spring with an overhead rotation”. Thus it is suggested that the difficulty level for students increases when they move from a “forward roll bridge” with a “spring” on a uniform, level surface to a “spring motion from a higher level” on a location with a step. As presented in Sato et al.’s study (2009), one of the reasons for developing teaching materials to progress from an “antenna bridge” to a “spring motion from a higher level” is that in addition to learning two more new techniques, “spring including an overhead rotation” and “pressing and releasing hands”, students must simultaneously overcome difficulties associated with conditions changes in the location where they perform the movement. Therefore, it is suggested that the “forward roll bridge”, presented in this study, is an effective teaching materials to link “antenna bridge” and “spring motion from a higher level”.

3.4. Students who were unable to master the “spring motion from a higher level” in this unit
In this unit, there were three students who were unable to perform a “spring including an overhead rotation” even once during the “spring motion from a higher level”. Among these students, Student J and Student K were unable to perform a “spring including an overhead rotation” in the “forward roll bridge” unit in fourth grade. Therefore, they were unable to perform a “forward roll bridge” even in Hour 1 of this unit. However, during the foundational learning phase, they were able to perform the “forward roll bridge” in Hour 6 with the guidance and assistance from group friends and the teacher, as shown in Figure 10.

Student L mastered the “spring including an overhead rotation” during the final Hour 10 of the
fourth-grade “forward roll bridge” unit. The student also mastered the “spring” in “antenna bridge”. Therefore, in this unit, Student L had an achievement level 3 for “antenna bridge” in both Hour 1 and Hour 6; however, the student had an achievement level 2 for Hour 1 in “forward roll bridge”. Similar to Students J and K, this student was unable to perform a “forward roll bridge” in Hour 6 after proceeding with the learning in this unit. Similar to Students A and I, who were mentioned earlier, these three students were unable to immediately perform “spring motion from a higher level” even though they were able to perform the “forward roll bridge”. The movement in Figure 11 suggests the condition “waist opens and then the legs bend”, which was indicated as a stumbling block in Jinka et al. (1992). The presumed reason for this is “due to fear, the student cannot recognize what he/she needs to do with his/her body”. However, since both students were able to perform the “spring including an overhead rotation” on the flat floor mat, if there were a little more time in this unit and they were able to get used to the location with steps, we think they might have been able to master the “spring including an overhead rotation” in the “spring motion from a higher level” as well.

4. Summary

This study aimed to develop effective lesson plans for mastering the “spring” by creating lesson plans incorporating the “forward roll bridge” as further low-level teaching materials for learning the “spring” in apparatus gymnastics and analyzing the effectiveness of low-level teaching materials based on classroom practices using these lesson plans. A total of 6 hours of lessons were implemented targeting two classes of fifth graders who had studied the “antenna bridge” and “forward roll bridge” the previous year, and video recordings were taken of the motor skills “antenna bridge”, “forward roll bridge”, and “spring motion from a higher level”. Recordings of the students’ movements were evaluated by one teacher and one university professor based on achievement criteria established from prior research. Relationships between achievement levels for each skill and the lesson plans’ effectiveness were verified. Analysis of these results revealed the following points.

(1) All six hours of the unit plan were conducted and motor skills improvement was seen with all teaching materials for “antenna bridge”, “forward roll bridge”, and “spring motion from a higher level”. However, there were differences in these results, and it was clear that these were effective lesson plans especially for “spring motion from a higher level”.

(2) An investigation of the correlation between achievement levels of the three teaching materials revealed a significant correlation between “antenna bridge” and “spring motion from a higher level” in Hour 1, which was consistent with prior research (|r| ≤ 0.270, p < 0.32). However, the correlation between “forward roll bridge” and “spring motion from a higher level” was even higher (|r| ≤ 0.700, p < 0.0001) and this suggested the need to learn “forward roll bridge” first. An investigation of the correlation between achievement levels of the three teaching materials in the final Hour 6 of this unit revealed no significant correlation between “antenna bridge” and “spring motion from a higher level”. However, a significant correlation was found between “antenna bridge” and “forward roll bridge” (|r| ≤ 0.348, p < 0.006) and between “forward roll bridge” and “spring motion from a higher level” (|r| ≤ 0.440, p < 0.0001).

These results suggest the effectiveness of “forward roll bridge” as a teaching material linking “antenna bridge” and “spring motion from a higher level”.

(3) Qualitative analysis of the students’ movements suggested the following points. It was...
surmised that there is more than one cause of the movement noted in prior research as a stumbling block, and there were children who could not perform “spring motion from a higher level” despite having learned a “spring including an overhead rotation”. It is thought the reason for this is that since students are not used to the aerial phase of the “spring motion from a higher level” or the height difference in the location with steps, they subconsciously restrict the “spring motion”. Another reason, however, is that students displaying this same movement did not master the “spring including an overhead rotation” movement itself. That is, in addition to learning two new techniques, the “spring including an overhead rotation” and an aerial phase by pressing and releasing hands, having to simultaneously overcome fear and difficulty accompanying changes to the location conditions where the skill is performed are considered factors when developing teaching materials for moving from an “antenna bridge” to “spring motion from a higher level”. Therefore, the necessity of learning a “spring including an overhead rotation” on the flat floor mat was suggested.

Based on the results above, learning the “spring including an overhead rotation” on a flat floor mat in the “forward roll bridge” unit is thought to be effective for learning the “spring motion from a higher level”. However, it was suggested that time for proficiency on the location with steps is needed and that this is a factor applicable to all students unable to master the “spring including an overhead rotation”. Therefore, we think it is necessary to get used to the location with steps starting from the lower grades and the number of hours for the lesson plans must be examined.

Future challenges include performing a continuous survey on the student subjects and continuing further research on structuring the order of teaching materials. To have these lesson plans widely practiced in other schools, it is necessary to create lesson plans including location set-up and instructional plans and then to verify their effects.

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