Validity and Reliability of a Volleyball Common Content Knowledge Test for Japanese Physical Education Preservice Teachers

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Abstract

Common content knowledge (CCK) includes the knowledge of (a) rules, safety, and etiquette, (b) techniques, and (c) tactics of movement forms (e.g., sports, dance and yoga; Ward, 2009) and has been established as critical knowledge for teachers to provide quality instruction. The purpose of this study was to evaluate the validity and reliability of a volleyball CCK test of preservice teachers in Japan. The test was developed using three steps: (a) content experts developed the questions, (b) ten experienced secondary school physical education teachers established face and content validity, and (c) the test was pilot tested with eight preservice teachers to secure concurrent validity. Following this, the test was given to 126 physical education preservice teachers. Data were analyzed using Rasch modeling (Rasch, 1980). The data fit the model for 29 of 30 questions. The analysis provides evidence to support the validity and reliability of the volleyball CCK test for Japanese physical education preservice teachers. The test can be confidently used to assess the knowledge of preservice teachers and the effectiveness of teacher education programs.

Keywords: Physical education, teacher education, pedagogy
1. Introduction

Pedagogical content knowledge (PCK) is the knowledge that teachers use to help students learn a subject matter (Shulman, 1987; Ward and Ayvazo, 2016). Ward and colleagues (2015, p.2) defined PCK that “PCK is a focal point, a locus, defined as such as an event in time (and therefore specific contextually) where teachers make decisions in terms of content based on their understanding of a number of knowledge bases (e.g., pedagogical, learning, motor development, students, contexts, and curriculum).” Among different knowledge bases impacting PCK, content knowledge has been shown to be influential on teacher effectiveness (Kim et al., 2018). Content knowledge consists of two sub-categories, common content knowledge (CCK) and specialized content knowledge (SCK; Ball et al., 2008). In the context of physical education, Ward (2009) defined CCK as the knowledge and skills that one needs to perform a task, specifically, knowledge of rules, safety, and etiquette, techniques, and tactics of a sport/activity. SCK was defined as the knowledge and skills that are needed to teach, which involves the knowledge of student errors and of instructional tasks and task progressions (Ward, 2009).

The importance of CCK and SCK for quality instruction has been validated by a series of intervention studies that compared teachers’ and students’ behaviors before and after the teachers received training on CCK and SCK (Kim et al., 2018). The results consistently showed that after teachers acquired more in-depth content knowledge, their instruction improved, and there were significant and meaningful gains in student learning. The conclusion from this line of inquiry is “when content knowledge is weak, PCK is weak, and conversely, when content knowledge is strong, PCK is strong” (Ward and Ayvazo, 2016, p. 200). Recent studies have reported that preservice teachers acquire only minimum levels of CCK and SCK from their K-12 physical
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education and extracurricular activities prior to entering the university and that CCK and SCK
need to be taught during teacher education programs (Tsuda et al., 2019; Ward et al., 2018).

A weakness of this line of literature is that while SCK has reliable and well-validated
instruments (Ward et al., 2017), measurements of CCK are only content validated. The field
lacks valid and reliable measures of CCK that can be used to assess preservice teacher
knowledge. Tests of CCK both clarify and define the scope of what teachers should know about
each content area (He, Ward, and Wang, 2018).

Researchers in China (He, Ward, and Wang, 2018) and Turkey (Devrilmez et al., 2018) have
begun to develop CCK measures for soccer and gymnastics, respectively. It is clear from these
studies that CCK is culture-specific. For example, Chinese scholars developed a test using CCK
questions from the United States (U.S.) as a foundation. However, for the Chinese context, the
questions were to be too easy for Chinese physical educators (He, Ward, and Wang, 2018).

Teachers in China specialize in sports and receive considerably more training than teachers in the
U.S. and the expectation for school physical education is higher because units of instruction are
longer than in the U.S. (He et al., 2018). Thus, an important conclusion is that the depth of CCK
needed in each country’s context varies due to the different physical education demands in each
country.

At present, there are some content validated measures for teachers’ knowledge in a sport in
Japan (Onizawa et al., 2012; Ogiwara et al., 2010). However, those tests are only content
validated and not psychometrically validated. They also were not framed as within the CCK
framework. To further understand teachers’ knowledge bases from the content knowledge
framework, it is important to develop a test underpinned by this concept. The purpose of this
study was to evaluate the validity and reliability of the test of volleyball CCK among preservice
teaching who are in the physical education licensure programs using Rasch modeling (Rasch, 1980).

2. Method

2.1. Settings

The institutional review board of the lead author approved the study, and informed consent was solicited and obtained from all participants. Three physical education licensure programs were the sites of the study. One program was from a public university, and two other programs were from private universities. Volleyball was selected as a content area for developing the CCK test because it is a commonly taught sport in Japan (Fukuhara and Suzuki, 2005) and a content that meets the net/wall game category of the curriculum (Ministry of Education, Culture, Sports, Science and Technology [MEXT], 2018). In practice, teachers choose a sport to teach the game concept and to teach those concepts, and teachers’ understanding of the sport and obtaining the knowledge is essential to provide effective instruction and produce student learning (Kim et al., 2018).

2.2. Participants

The convenience sampling approach was used to recruit preservice teachers from three universities. The participants were emailed and invited to complete the test online. A total of 126 (male $n = 75$; female $n = 51$; $M_{age} = 21.52$, $SD = 2.03$) Japanese secondary physical education preservice teachers participated in the study.

2.3. Test Development

Three steps were used to develop the test. First, a panel of experts developed questions. Second, the content of the test was validated by five experienced inservice teachers in volleyball.
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Last, the test was pilot tested by preservice teachers who had different levels of knowledge in volleyball to establish concurrent validity.

2.3.1. Step one: Experts developing questions

In this step, three volleyball content experts were asked to develop a 30-questions multiple-choice test with four choices for answers appropriate for secondary school physical education. In selecting experts, we used three criteria: Individuals who (a) taught secondary physical education courses in a physical education teacher education program at a university, (b) knew the course of study for Japanese schools (MEXT, 2017), and (c) played volleyball at the college level and coached a college team. The experts were instructed that the test must meet the categories of CCK identified by Ward (2009) that are: (a) rules, safety, and etiquette, (b) techniques, and (c) tactics of volleyball at the level that is needed to teach secondary physical education in Japan.

One expert developed a set of questions using the Japanese course of study (MEXT, 2018) and three books (Japan Volleyball Association, 2012, 2017; Toyoda, 2004). The questions were shared with a second content expert assessed the questions to ensure the alignment with the course of study. The test was further revised based on feedback. Finally, a third content expert reviewed the test. The questions were revised until all three experts were satisfied.

2.3.2. Step two: Establishing content and face validity for secondary school settings

In this step, five experienced middle and high school physical education teachers who had taught volleyball for more than five years reviewed the test for establishing face and content validity. The teachers were asked if; (a) the items in the test were appropriate to expect teachers to know for teaching volleyball in secondary physical education lessons, and (b) the questions were understandable. Based on their feedback, the test was further revised by the experts identified in step one. If those experts judged that a comment from teachers was inappropriate
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with the considerations of their knowledge in physical education teacher education programs, the course of study, and volleyball, the comment was not reflected on the test. At this point, the questions were entered into the online questionnaire software, Qualtrics®, to move to the online setting.

2.3.3. **Step three: Securing concurrent validity among preservice teachers**

In step three, the test was given to eight preservice teachers. A faculty member at a data collection site selected two high knowledge, four medium, and two low knowledge levels preservice teachers in volleyball. Though experience levels are not always correlated with knowledge levels, this was the best criterion we could find for this assessment. There were two purposes in this step. The first was to ensure that the test could differentiate among the various knowledge levels of preservice teachers (i.e., concurrent validity). The second was to check the functionality of the Qualtrics® software. After one round of test implementation with preservice teachers, it was determined that the test was too easy and did not differentiate among the knowledge levels. Accordingly, the test was returned to the content expert for a revision to increase the difficulty of some questions.

In the second round, the test was given to six preservice teachers who were identified in the same way as in the first pilot testing. The results demonstrated that the test discriminated among the different knowledge levels. The final test consisted of 30 questions - 10 questions on the rules, safety and etiquette, 11 questions on the techniques, and nine questions on the tactics of volleyball.

2.4. **A demographic questionnaire**

A demographic questionnaire consisting of 16 questions was designed to determine the backgrounds of the test takers: participants’ university, gender, age, playing experiences,
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teaching/coaching experiences, and formal class experiences. However, the total number of questions that each participant responded to were varied depending on their response and ranged from six to 16. For example, if preservice teachers answered that they played volleyball outside of K-12 physical education, they were asked further questions including their experiences in elementary, middle, and high schools and how many years in each school level, respectively. Conversely, if preservice teachers answered that they did not play volleyball outside of K-12 physical education, no further detailed questions were asked. Table 1 shows the participants’ responses to the demographic questionnaire. Because only limited answers were acquired from specific questions such as elementary, middle and high schools, any playing, teaching/coaching experiences in different age levels were combined into overall playing, and teaching/coaching experiences (see Table 1).

[Insert Table 1 here]

2.5. Procedures

Data were collected over a six-week period. The participants completed the demographic questionnaire and the test approximately within 20 to 40 minutes according to the record collected by Qualtrics®. The online directions asked students to complete the test without using any resources. The data were entered into an excel spreadsheet. Logits (responses to the items) were scored either right or wrong in the spreadsheet.

2.6. Data Analysis

The Rasch measurement model (Rasch, 1980) was used to analyze the volleyball CCK test to examine the validity and reliability of the test using the Winstep software version 4.3.3. (Linacre, 2011). Unlike item response theory models where the model shapes to “fit the data,” the Rasch model requires the data to “fit the model” (Linacre, 2011).
Rasch model is that the probability of a person’s response to a question depends on the difficulty of the item (i.e., the question) and the person’s ability (Linacre, 2011). The results of this study were analyzed in four ways: (a) unidimensionality, (b) model data fit, (c) item/person reliability and separation, and (d) a wright map.

2.6.1. Unidimensionality

The fundamental assumption of the Rasch model is unidimensionality (Linacre, 2011). Unidimensionality refers to the existence of one underlying measurement construct (dimension) that accounts for variation in examinee responses (Bond and Fox, 2010). Violating this assumption could severely bias item and ability parameter estimation (Bond and Fox, 2010). The unidimensionality of the data was analyzed in two ways. First, standardized residual variance in eigenvalue was calculated. Score 2.0 is a criterion to represent unidimensionality (Linacre, 2011). Second, a standardized residual contrast plot was produced to examine if the clusters of items truly measure different aspects of the knowledge. In this analysis, items are clustered into three categories and de-attenuated correlation results indicate how each cluster is correlated with each other. If the correlation values are close to 1.00, it indicates questions in a test look at the same construct (Linacre, 2011).

2.6.2. Model data fit

The item fit analysis determines how well the data fits the model (Bond and Fox, 2007). Item fit statistics include the mean square residual (MNSQ) and the standardized mean square residual (ZSTD) based on the difference between what is observed and what is expected by the Rasch model (Liu, 2010). The MNSQ is a squared residual based on the difference between the observed response patterns and the predicted response patterns and is a chi-square calculation (which measures the level of association) for the outfit and infit statistics. The ZSTD is a
normalized t-score of the residual and provides a t-test statistic measuring the probability of the MNSQ calculation occurring by chance. (Liu, 2010). Since the ZSTD value is based on the MNSQ, the MNSQ values were examined first for evaluating the fit of the test to the Rasch model (Linacre, 2012). Only when MNSQ values lie outside of an acceptable range, ZSTD values were considered.

For the analyses, the data is analyzed in two ways, infit and outfit statistics. Infit statistics are sensitive to where the model would expect the response to be. For example, if a participant with high knowledge in volleyball answered difficult questions well, this would indicate a good fit with the model. Outfit statistics are sensitive to unexpected patterns in the data. For instance, if a participant with no experience in volleyball was able to answer difficult questions, this indicates a poor fit with the model. Both infit and outfit statistics, ranging from 0.5 (little variation in responses) to 1.5 (large variation in responses) indicate that the instrument is in a good fit for the model (Linacre, 2011).

2.6.3. Separation and reliability index

The separation index is calculated for person and item, respectively. Item separation is used to verify the questions exist on a low to higher difficulty hierarchy and provides the construct validity of the instrument. Person separation is used to classify respondents to distinguish between high and low performers. An item or person separation index of 1.5 represents an acceptable level of separation, and index of 2.0 indicates a good level of separation, and an index of 3.00 illustrates an excellent level of separation (Bond and Fox, 2007). A reliability index indicates the “reproductivity of relative measure location” (Linacre, 2011). Reliability close to 1.00 demonstrates a high degree of confidence for either item or person (Bond and Fox, 2007).

2.6.4. Wright map
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Wright maps, also called person-item maps, show person measures and item measures plotted along the same common scale in logits (Linacre, 2011). Wright maps are a qualitative evaluation of the match between the distribution of item difficulties and the performance abilities of the respondents. In reviewing a Wright map, the ranking of items (i.e., questions) can be seen on the right side of the map, with the uppermost items the most difficult and the lower the easier. The left side of the Wright map ranks the person with the highest ability scores on the uppermost section and lowest ability score at the lowest section.

3. Results

3.1. Unidimensionality

Table 2 illustrates the standardized residual variance in eigenvalue units. The result of the unexplained variance in first contrast was 2.37, which was close to the criterion of unidimensionality, 2.00. The results of de-attenuated correlation in the approximate relationships between the person measures indicated that the value was in the range of .52 to 1.00 (see Table 3). If the value is close to 1.00, it indicates the test is each category measures the same construct. The lowest value was .52, which is rather high and can be treated as a sub-dimension of the test (Brentani and Golia, 2007). As such, the unidimensionality of the test was ensured through this analysis.

3.2. Model data fit

The results of the item fit analysis illustrated that one item was out of the range 0.5-1.5, to be considered as a good fit of the model (Liu, 2010). The outfit of item 19, the question about the use of the hand for spiking, was 1.66, so the item was eliminated. After the deletion of item 19, the second round of the item fit analysis was conducted. All items were classified within the range (see Table 2).
3.3. Separation and reliability index

The person separation index was 2.04 which was classified as a good level of separation, and an item separation index was 4.33 which was judged as an excellent level of separation (Bond and Fox, 2007). The reliability index was close to 1.0 for both person and item aspects (person Cronbach’s $\alpha = .81$; item Cronbach’s $\alpha = .95$; see Table 3) indicating a high degree of confidence in having various levels of question difficulties in the test (Bond and Fox, 2007).

3.4. Wright map

The Wright map (i.e., person-item) reported in Figure 1 shows that for the group of 126 students, the 29 items were very good items targeting the students’ ability. Items are distributed well for distinguishing students who have low to moderate knowledge levels, while there was a small gap between item 18 and 20.

4. Discussion

The purpose of this study was to evaluate the validity and reliability of the test of volleyball CCK among Japanese physical education preservice teachers using Rasch modeling. A key assumption of the Rasch modeling is that the construct is unidimensional. The analysis of unidimensionality was 2.37, which is close to the criterion of 2.00 (Brentani and Golia 2007). This confirms that the test is unidimensional. The analysis also requires that data fit the Rasch model. The model data fit indicated that 29 of 30 questions met the criteria of a good fit of the model (0.5-1.5; Liu, 2010). One item was 1.6 which was outside of the criteria of a good fit of the model; thus, one item was eliminated. The person and the item separation indexes were 2.04
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(a good level of separation) and 4.33 (an excellent level of separation), respectively. The reliability index was close to 1.0 for both person and item aspects. These results provide good evidence that the test items included different levels of the questions to differentiate various knowledge levels of preservice teachers. The wright map showed that the 29 items were a good fit in targeting the different ability students. However, there is a small gap between items 18-20 which could potentially limit differentiating high knowledge groups of preservice teachers.

Overall, the results of Rasch analyses showed that the CCK test of 29 items is a valid and reliable measure to assess Japanese preservice teachers’ knowledge of volleyball that is taught in Japanese secondary schools.

The limitation of this study is that although the total sample size was appropriate for Rasch assessment, collecting a larger sample size to confirm the representativeness of these findings as well as to monitor the consistency of the test over time across programs is needed. Future research should focus on establishing CCK tests for a variety of content areas in secondary physical education. Developing CCK tests can provide essential expectations and scope for teacher preparation programs to teach to produce quality teachers.

5. **Conclusion**

This was the first study to develop a valid and reliable assessment to measure teachers’ CCK in volleyball in secondary physical education in Japan. It is important to emphasize that the test is specific to Japanese secondary physical education context and should not be translated and used in other languages and contexts without first validation in that language and setting. The results of the study show that the test is reliable and valid to assess the knowledge of preservice teachers. The test can be used to determine what preservice teachers know about volleyball before and after receiving instruction. Developing CCK tests in different content areas would
assist the field of physical education teacher education in Japan to better prepare physical
education teachers leading to improvement in teaching and student learning.

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9 **Main Works:**

10 • Tsuda, E., Wyant, J., Bulger, S. M., Elliott, E., Taliaferro, A. R., Burgeson, C., & Wechsler, H. (in press). Recommendations for Developing and Implementing State-Level Physical Education Accountability Systems in Student Learning. *Journal of Physical Education, Recreation and Dance.*

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Membership in Learned Societies:

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### Table 1

The Percentage of participants’ volleyball learning and teaching histories (n = 126)

| Experiences                              | No  | Yes | 1-5 yrs | 6-10 yrs | 10 yrs < |
|------------------------------------------|-----|-----|---------|----------|----------|
| Playing outside of physical education    | 84.9| 15.1| 26.3    | 36.8     | 36.8     |
| Teaching                                 | 84.9| 15.1| < 1yr   | 2-3 yrs  | 4 yrs <  |
| Course taking in college                | 38.9| 61.1|         |          |          |
### Table 2
*Item fit of the Rasch analysis for volleyball CCK test*

| Item | Difficulty | S.E. | Infit MNSQ | ZSTD | Outfit MNSQ | ZSTD | PT-measure Corr. |
|------|------------|------|------------|------|-------------|------|------------------|
| 7    | 2.97       | .26  | .95        | -.27 | 1.45        | 1.21 | .29              |
| 5    | 2.25       | .22  | 1.12       | 1.24 | 1.51        | 1.91 | .23              |
| 18   | 1.71       | .21  | 1.04       | .50  | 1.25        | 1.35 | .36              |
| 20   | 1.10       | .20  | 1.29       | 3.54 | 1.49        | 3.22 | .21              |
| 22   | .86        | .20  | 1.08       | 1.04 | 1.33        | 2.38 | .38              |
| 15   | .74        | .20  | 1.14       | 1.59 | 1.17        | 1.29 | .37              |
| 3    | .57        | .21  | .96        | -1.43| .87         | -1.27| .23              |
| 30   | .49        | .21  | .92        | -.90 | .90         | -.76 | .54              |
| 26   | .40        | .21  | .85        | -1.60| .80         | -1.53| .59              |
| 29   | .35        | .21  | 1.18       | 1.80 | 1.38        | 2.51 | .32              |
| 14   | .31        | .21  | 1.18       | 1.74 | 1.23        | 1.56 | .35              |
| 17   | .31        | .21  | 1.14       | 1.34 | 1.15        | 1.08 | .38              |
| 11   | .18        | .21  | .91        | -1.81| .89         | -1.72| .54              |
| 21   | .18        | .21  | 1.25       | 2.24 | 1.40        | 2.41 | .29              |
| 23   | -.21       | .23  | 1.00       | .08  | .95         | -.19 | .48              |
| 24   | -.26       | .23  | .89        | -.85 | .80         | -1.06| .56              |
| 28   | -.26       | .23  | .69        | -2.76| .62         | -2.31| .69              |
| 10   | -.32       | .23  | .99        | -.06 | .85         | -.73 | .51              |
| 13   | -.54       | .24  | .92        | -.56 | 1.00        | .06  | .51              |
| 25   | -.65       | .24  | .71        | -2.23| .51         | -2.46| .68              |
| 27   | -.65       | .24  | .87        | -.93 | .74         | -1.12| .57              |
| 12   | -.84       | .25  | .73        | -1.94| .62         | -1.62| .64              |
| 8    | -.84       | .25  | .88        | -.76 | .91         | -.25 | .52              |
| 6    | -1.19      | .27  | .95        | -.24 | .95         | -.05 | .46              |
| 9    | -1.19      | .27  | .94        | -.29 | .79         | -.59 | .49              |
| 16   | -1.26      | .28  | 1.09       | .54  | .83         | -.44 | .41              |
| 2    | -1.26      | .28  | .89        | -.58 | .67         | -1.02| .52              |
| 1    | -1.34      | .29  | .94        | -.27 | .76         | -.65 | .47              |
| 4    | -1.61      | .31  | 1.02       | .18  | 1.21        | .63  | .36              |
| Mean |            |      |            |      |             |      |                  |
| P.SD | 1.08       | .24  | .98        | .0   | 1.00        | .28  | 1.5              |

Note. MNSQ = Mean square residual; ZSTD: Standardized mean square residual.
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Table 3
*Summary statistics of the Rasch analysis for volleyball CCK test*

| Item                  | Item | Person |
|-----------------------|------|--------|
| Number measured       | 29   | 126    |
| Location mean (SD)    | 83.5(22.2) | 9.8 (5.8) |
| Infit MNSQ mean (SD)  | .98 (.15) | .99 (.22) |
| Outfit MNSQ mean (SD) | 1.00 (.28) | 1.00 (.46) |
| Reliability           | .95  | .81    |
| Separation            | 4.33 | 2.04   |
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Figure 1. Wright map of the Rasch analysis for volleyball