The Learning Feature of Deep Knowledge and Its Relationship With Exercise

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Abstract
Nine Principles for Deep Knowledge of Habitual Domains (HDs) have been identified as an effective approach to expanding and enriching an individual’s HD, or in a broader sense, to improving learning. The purpose of this study was to examine the Principle for Deep Knowledge Survey (PDKS) and the correlations between the PDKS and other individual variables, such as gender, body mass index (BMI), and exercise routines. Seven hundred eighty-five industrial high school students completed the questionnaire. Overall, the results suggested that the psychometric properties of the PDKS were acceptable and also showed a significant relationship between gender and the Principles of Contrasting and Complementing and Cracking and Ripping. In addition, the Principles of Alternating, Changing and Transforming, and Void had a positive correlation with the variable of frequency of exercise. The results showed that exercise could be a mediator in expanding the competence of deep knowledge to improve learning.

Keywords
educational research, education, social sciences, education theory and practice, general education, educational measurement and assessment, students

Introduction
The Principles for Deep Knowledge have been identified by Habitual Domain (HD) as one of the three effective tool boxes for expanding an individual’s HD (P. L. Yu, 1995, 2002). The theory of HD was first introduced by Yu in 1977, was formulated in 1980 (P. L. Yu, 1980), and became a system of thought by 1985 (P. L. Yu, 1995). Since then, researchers in this field have disclosed a wealth of applications in mathematical (Chan & Yu, 1985; Chianglin, Lai, & Yu, 2007; Datta & Yu, 1991; P. L. Yu & Zhang, 1989a,1989b) and qualitative (Chen, Huang, & Yu, 2012; P. L. Yu, 2006; P. L. Yu & Chen, 2010; P. L. Yu & Chiang, 2002; P. L. Yu & Chianglin, 2006) approaches. The previous literature has demonstrated that many methods have contributed to the expansion of HD, including the nine Principles for Deep Knowledge. However, the literature lacked quantitative evidence, such as questionnaires.

HDs
The main concept of HD is that each human develops a set of tools for thinking, memory, judging, reacting, and handling situations or problems that gradually become stable within a certain domain over a period of time. The set is called the human’s HD; hence, HD is similar to the mental software that leads the human brain to think, memorize, judge, react, and handle situations (P. L. Yu, 1995, 2002). According to P. L. Yu (1995, 2002), there are four components of HD: the potential domain (PD), the actual domain (AD), the activation probability (AP), and the reachable domain (RD). PD is the collection of all thoughts, concepts, ideas, and actions that can potentially be activated. To improve our understanding of these four components, we can consider the act of taking a final exam. PD includes all of the contents studied during preparation. AD is the collection of all thoughts, concepts, ideas, and actions that are actually activated. During a final exam, AD represents the response to each particular question. AP is the probability that all thoughts, concepts, ideas, and actions in PD will actually be activated. AP illustrates the probability of giving a certain answer to a specific question, and RD is the collections of thoughts, concepts, ideas, and actions that can be generated from the initial AD. RD responds to reflections after the final exam, and the reflection may lead to a new approach to learning. Consequently, at any point, the HD is the collection of these four elements and is represented by the equation \( HD_t = (PD_t, AD_t, AP_t, RD_t) \) (Chen et al., 2012; P. L. Yu, 1995, 2002, 2006; P. L. Yu & Chen, 2010).

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**HDS and Learning**

P. L. Yu (2002) mentioned that “it always takes time to learn and acquire new ideas. Expansion of HD is actually a learning process” (p. 189). Furthermore, he used the four elements of HD as the foundation to explain working knowledge, which is known as AD (P. L. Yu, 2006). For example, when one reads a question during an exam, including confusing or challenging questions, the usual response utilizes a set of thoughts, concepts, ideas, and actions in PD. This particular set is, in fact, AD, which is also known as “working knowledge.” However, if AD is small and not flexible, one cannot give the most appropriate answers on the exam. Therefore, learning new knowledge allows one to avoid wrong answers, which expands the HD. “Working knowledge mining” is a way of “expanding and enriching the HD” (P. L. Yu, 2006).

For a better understanding of the learning process, P. L. Yu (2002) provided three factors: implanting, nurturing, and habituating. This concept supports the learning theory proposed by Vermunt and Vermetten (2004), who indicated that learning is viewed as the construction of knowledge and insights, taking in knowledge, and acquiring knowledge. For instance, new knowledge should be accepted to solve a particular question; hence, implanting is the practice of developing a good positive relationship between the new knowledge and the learner (constructing knowledge and insights). It is then necessary to improve the sense of this new knowledge in the mind (taking in knowledge through memorizing and reproducing), and this is the main purpose of nurturing. Finally, the new knowledge gradually becomes a habituating element of the HD (acquiring knowledge that can be applied to certain question or related challenges). Furthermore, P. L. Yu (1995, 2002, 2006) offered a clear description of how the nine Principles for Deep Knowledge have enriched our HD. In a broad sense, the nine principles have an influential impact on learning outcomes and academic achievement.

**Principles for Deep Knowledge**

The nine Principles for Deep Knowledge are Deep and Down Principle, Alternating Principle, Contrasting and Complementing Principle, Revolving and Cycling Principle, Inner Connection Principle, Changing and Transforming Principle, Contradiction Principle, Cracking and Ripping Principle, and Void Principle. The nine principles were identified and elaborated by P. L. Yu (1995, 2002, 2006) as follows:

1. There are two layers of meanings in the Deep and Down Principle. The first is emptying the desires in the mind to reduce pressure. By doing so, we can accept other useful knowledge. There are many ways to eliminate these desires on a daily basis and to develop deep and good thoughts, such as exercising. The other is called the humble position. An excellent explanation is provided by the great Chinese philosopher Lao Tzo, who aphorized “why is the ocean king of a hundred rivers? Because it lies below them. Therefore, it could allow the water to flow freely into it from hundreds of rivers” (P. L. Yu, 2002, p. 462). Consequently, asking for advice with an inferior attitude is one aspect of practicing humility.

2. The Alternating Principle involves the awareness to remove or add subsets of assumptions in the mind and alternating and combining these assumptions with each other. Alternating allows the creation of various values among the existing HDs.

3. There are many aspects of life concerned with Contrasting and Complementing Principles, such as positive and negative, good and bad, and so on. Considering the learning process, “teaching” and “learning” encompass the classic illustration.

4. All living things are involved in the natural cycle of birth, growth, and death, and so is learning. It is necessary to understand the Principle of Revolving and Cycling. Emotional ups and downs cannot be avoided and are influenced by academic achievement and the cycle of human physiology. A positive attitude toward learning is important for maintaining the motivation to achieve learning goals.

5. Stronger inner connections can reduce gaps and strengthen the connections between two parties. For example, to succeed, one needs to build a strong competence in connecting with the inner core of another successful person. Understanding the content and instructional materials presented by a teacher is an example of the Inner Connection Principle, which can help students learn new knowledge more effectively.

6. Currently, society is in an age of information overloading. World change is constant, and HDs should follow these changes and adjust to new environments. In a classroom, multimedia instruction and lively instructional approaches can increase the motivation for learning; hence, students must be willing to watch, imagine, and predict their own Principle of Changing and Transforming to expand their HD and improve learning.

7. It is necessary to learn to look at things from different points of view and to re-evaluate the results or conclusions. If any contradicted outcome is found, one must change the results or conclusions. The Contradiction Principle can train us to deeply observe and be more creative in learning. During the learning process, the Contradiction Principle allows students to realize that positive learning attitudes do not necessarily positively relate to the final grades.

8. HD consists of a series of sub-dimensions, and there are conflicts among these sub-systems. Unfortunately, most of these conflicts are inevitable and difficult to
recognize. Similarly, learning faces the same challenges. The function of the Cracking and Ripping Principle is to explore the cracking area in which the weakness is defined. A common strategy to improve learning focuses on an unfamiliar area or an area with lower scores to improve our knowledge weakness.

9. Because individuals tend to see, think, and judge based on his or her own HD, he or she cannot implement an effective action when an event occurs outside the HD. The Void Principle explains that others’ HDs can have a great impact on one’s own thinking. When actively applying the Void Principle, part of an existing HD should be emptied and then filled with others’ HDs. When faced with a challenging question, for instance, one can ask for assistance from other classmates.

Exercise or Physical Activity

Tomporowski, Davis, Miller, and Naglieri (2008) discussed issues regarding exercise and academic achievement by reviewing previous research and mentioned that most related studies have shown a statistically significant relationship between physical activity and academic achievement. This segment of physical activity is simply referred to as school-based physical education. For example, school-recorded data, including socio-demographics (gender, race, socio-economic status), fitness achievement, and body mass index (BMI) information, were used to determine the relationships between physical fitness and academic achievement in urban public schoolchildren (Chomitz et al., 2009), and the results showed statistically significant relationships between fitness and academic achievement. Another research study conducted by C. C. W. Yu, Chan, Cheng, Sung, and Hau in 2006 gave a Physical Activity Questionnaire to older children (PAQ-C) to assess habitual moderate to vigorous physical activity. Although these researchers did not find a direct connection between the level of physical activity and academic achievement, they concluded that physical activity may have a significant benefit in students’ self-esteem and that their enjoyment of a high level of physical activity did not cause them to suffer academically (C. C. W. Yu et al., 2006). The issue of the influence of physical activity on classroom behavior has been debated for decades (Grieco, Jowers, & Batholomew, 2009; Keays & Allison, 1995; Mahar et al., 2006). Thus, as Davis and Cooper (2011) mentioned, physical activity, obesity, and fitness may influence on-task classroom behavior, and BMI appears to be an effective measure of adiposity. More recently, Donnelly and Lambourne (2011) concluded that classroom-based physical activity provides a valuable approach to improving students’ fitness, BMI, learning cognition, and academic achievement.

The Present Study

The present study tested the measurement properties of the Chinese version of the Principle for Deep Knowledge Survey (PDKS). According to the theories of HD and learning, in this study, we used the PDKS to measure the features of the Principles for Deep Knowledge during the learning process. The original concept of PDKS was constructed and developed by Lin, Hsiung, and Huang (2011), who examined its face validity, content validity, concurrent validity, and internal consistency. The reliabilities, construct validity, convergent validity, and discriminant validity were examined in the present study. The literature (Donnelly & Lambourne, 2011; Tomporowski et al., 2008; C. C. W. Yu et al., 2006) concluded that there is a positive relationship between physical activity, cognition, and academic achievement. Some previous research studies (Chomitz et al., 2009; Davis & Cooper, 2011; Donnelly & Lambourne, 2011) showed statistically significant relationships between fitness (including BMI) and academic achievement. Moreover, this study investigated the correlations between PDKS and the variables of gender and physical activity and examined the differences between different gender and BMI groups with the expectation that relationships and differences would be detected.

Method

Participants and Procedure

A total of 785 ($M = 16.57 \pm 0.92$ years) high school students in Grades 10, 11, and 12 from an industrial high school in mid-West Taiwan participated in the study. The sample consisted of 668 males ($M = 16.54 \pm 0.92$ years) and 119 females ($M = 16.75 \pm 0.91$ years). The students were given a specific time to complete the survey during the 2012 spring semester. Testing was voluntary, and the test sessions lasted approximately 30 min.

Measures

BMI, frequency of exercise, length of exercise, and body shape maintenance. The BMI was calculated from the self-reported height (cm) and weight (kg; Venn et al., 2007). The students were divided into five groups based on their age in years (15 to 18 years) and national BMI norms (Sports Affairs Council, 2006), in which $g_1 =$ too light, $g_2 =$ light, $g_3 =$ moderate, $g_4 =$ overweight, and $g_5 =$ obese. According to the National Norms, each group has specific ranges of BMI values for these five groups within the ages of 15 to 18. The frequency of exercise per week was assessed by a signal question, which had an allowed response of one to seven times. The length of exercise was assessed by a question requesting the length of each exercise session, and one (less than 20 min), two (20 min), three (30 min), four (40 min), five (50 min), six (60 min), and seven (more than 60 min) were the allowed responses. The body shape maintenance was assessed by questioning the maintenance of body shape using exercise, and the allowed responses were yes and no.
**Principles for Deep Knowledge.** The key dependent variable was measured with the 45-item Chinese version of PDKS, which used a five-point scale ranging from 1 (**strongly disagree**) to 5 (**strongly agree**). The PDKS was initially developed by Lin et al. (2011), and the items were rephrased to reflect the general features of nine Principles for Deep Knowledge of HDs during the learning process. For a completed English version of PDKS, please see appendix. The scale was examined and found to exhibit good psychometric properties and was examined for face validity, content validity, concurrent validity, and internal consistency (α = .86; Lin et al., 2011). In the current study, an item analysis was conducted to test the effectiveness of the items before the validity test. Thirty-two items were found to be significant and were thus selected for the final questionnaire.

**Results**

**Reliability and Validity**

The reliability of the PDKS was determined by both Cronbach’s alpha value and composite reliability (CR). The alpha coefficient for the PDKS was .93 in this study, whereas a value of .86 was found in the previous study (Lin et al., 2011). It was found that the alpha values and CR values of all constructs in the current study were larger than .65, which suggests satisfactory reliability for all measurement scales (Table 1).

The current study used confirmatory factor analysis (CFA) using a maximum likelihood procedure to generate a proper fit. The CFA indicated a good fit for PDKS: χ²(428) = 112.384, p = .000, Comparative Fit Index (CFI) = 0.93, Tucker–Lewis Index (TLI) = 0.92, Root Mean Square Error of Approximation (RMSEA) = 0.05, and Standardized Root Mean Square Residual (SRMR) = 0.04.

According to the suggestion provided by Hair, Black, Babin, Anderson, and Tatham (2010), convergent validities can be examined by the corresponding standardized factor loading estimates, and a level of 0.50 is the recommended threshold. Table 2 shows that the overall factor loadings were all greater than 0.5 and statistically significant (α < .001). In addition, as shown in Table 1, CR levels greater than 0.6 illustrate positive convergent validities (Hair et al., 2010). The discriminant validity has been established as 0.8 or less (Kline, 2005). This study found that all of the correlations were smaller than .8 (Table 2). In addition, each of the nine factors displayed a satisfactory level of discriminant validity when measured by the average variance extracted (AVE; Fornell & Larcker, 1981).

**Descriptive Statistics and Correlations**

Among all of the principles, the Void Principle exhibited the highest mean, and the Alternating Principle had the lowest mean. Table 3 presents the means and SDs of the nine principles for each BMI group, and the ranks of the nine principles were found to be similar among all of the groups. The Pearson correlation analysis showed that gender was negatively correlated with the frequency and length of exercise and positively correlated with the Contrasting and Complementing Principle and the Cracking and Ripping Principle. The frequency of exercise was positively correlated with the Alternating Principle, Changing and Transforming Principle, and Void Principle and was negatively correlated with body shape maintenance. In addition, a statistically significant correlation between the PDKS and the frequency of exercise was found (r = .08, α < .05).

**Gender Differences and MANOVA**

An independent t test indicated significant gender differences between women (M = 4.10 ± 0.46) and men (M = 3.99 ± 0.99) for the Contrasting and Complementing Principle, t(783) = −2.20, p = .028. This study also found that women (M = 4.27 ± 0.46) exhibited a greater correlation with the Cracking and Ripping Principle, t(783) = −2.89, p = .004 than men. However, there was no significant difference in the PDKS among the BMI groups, as determined by MANOVA.

**Discussion**

This study has a number of findings. First, the objective of the present study was to make a contribution to the psychometric assessment of PDKS. Both the Cronbach’s alpha coefficients and the composite reliabilities found in this study showed acceptable reliabilities. A good fit of CFA and satisfactory levels of factor loading, AVE, CR, and correlation coefficients all demonstrated that the PDKS is a well-constructed scale. It is important to emphasize that the nine Principles for Deep Knowledge are alternative ways of learning, and the PDKS is a useful tool for the assessment of the features of the Principles for Deep Knowledge during the learning process.

When interpreting the results of this study, it is important to note that the sample of participants is representative of a population of teens (15-18 years of age) with the best enrollment scores and who maintain high academic performances nationally in the industrial high school system. The sample showed high levels of correlation on the PDKS, particularly for the features of the Principles of Void, Changing and Transforming, Cracking and Ripping, and Contradiction. The students tended to look for assistance from others for solving challenges that they could not overcome and
collaborated with other classmates to improve their leaning; this was the strongest feature of the Void Principle. Based on the definition provided by P. L. Yu (1995, 2002, 2006), individuals can empty and create free space in their mind when they are faced with challenges they cannot respond to effectively and subsequently have the ability to accept new HDs by asking for assistance or collaborating with others. Moreover, the sample illustrated that the use of multimedia technology and various other lively teaching approaches by teachers will improve the overall learning of students. The educational environment has been changing with the development of technology, and the result is a revolution in teaching and learning. Both teachers and learners should embrace these changes and transform themselves to increase the effectiveness of learning, which verifies the idea of the Changing and Transforming Principle (P. L. Yu, 1995, 2002, 2006). The sample also showed that better learning attitudes influence achievement in the future (the Cracking and

**Table 1. Results of Descriptive Statistics, Reliability, and Convergent Validity.**

| Nine principles items       | Composite reliability | Cronbach’s α | Factor loading | M   | SD  |
|-----------------------------|-----------------------|--------------|----------------|-----|-----|
| Deep and Down               | .75                   | .75          | .648           | 4.16| 0.675|
| A1                          | .654                  | .675         |                |     |     |
| A2                          | .620                  | .654         |                |     |     |
| A3                          | .711                  | .654         | .680           |     |     |
| Alternating                 | .75                   | .75          | .674           | 4.00| 0.656|
| B5                          | .678                  | .674         | .664           |     |     |
| B6                          | .650                  | .678         | .690           |     |     |
| B7                          | .627                  | .650         | .645           |     |     |
| B8                          |                       | .627         | .645           |     |     |
| Contrasting and Complementing| .65                   | .65          | .628           | 3.84| 0.635|
| C9                          | .646                  | .628         | .598           |     |     |
| C10                         | .583                  | .646         | .638           |     |     |
| Revolving and Cycling       | .76                   | .75          | .729           | 4.01| 0.666|
| D12                         | .671                  | .729         | .728           |     |     |
| D13                         | .743                  | .671         | .698           |     |     |
| D14                         |                       | .743         | .698           |     |     |
| Inner Connection            | .78                   | .78          | .624           | 3.87| 0.679|
| EP15                        | .701                  | .624         | .666           |     |     |
| EP16                        | .573                  | .701         | .644           |     |     |
| EP17                        | .669                  | .573         | .681           |     |     |
| EP18                        | .668                  | .669         | .636           |     |     |
| EP19                        |                       | .668         | .636           |     |     |
| Changing and Transforming   | .74                   | .73          | .656           | 4.08| 0.608|
| F20                         | .744                  | .656         | .592           |     |     |
| F21                         | .684                  | .744         | .579           |     |     |
| F22                         |                       | .684         | .579           |     |     |
| Contradiction               | .69                   | .68          | .663           | 4.07| 0.606|
| G23                         | .674                  | .663         | .528           |     |     |
| G24                         | .609                  | .674         | .626           |     |     |
| G25                         |                       | .609         | .626           |     |     |
| Cracking and Ripping        | .78                   | .77          | .727           | 4.17| 0.602|
| H26                         | .680                  | .727         | .586           |     |     |
| H27                         | .631                  | .680         | .674           |     |     |
| H28                         | .688                  | .631         | .626           |     |     |
| Void                        | .86                   | .85          | .675           | 4.08| 0.624|
| I30                         | .919                  | .675         | .547           |     |     |
| I31                         | .842                  | .919         | .565           |     |     |
| I32                         |                       | .842         | .565           |     |     |
Ripping Principle); however, the results do not show that academic achievement is positively correlated with learning attitudes (the Contradiction Principle), which suggested that higher academic scores are not correlated with positive attitudes of learning and that academic achievement and attitudes are two separate issues. This example applies the Contradiction Principle to students who think differently (P. L. Yu, 1995, 2002, 2006). In addition, the sample showed that an effective method of overcoming weaknesses could be studying harder in areas with lower scores and that are less familiar, which illustrates the Cracking and Ripping Principle. Although this study did not examine whether the nine principles influence academic performance directly, these nine principles could be features of the maintenance of motivation for studying. This study supported P. L. Yu’s (2006) theory that the nine Principles for Deep Knowledge are effective approaches to expanding and enriching working knowledge. During the process of learning, expanding, and enriching, working knowledge correlates with an improved academic performance; hence, the features of the nine Principles for Deep Knowledge can improve students’ attitudes during the learning process to increase academic achievement.

Significant correlations between gender and two principles were found. In this study, female students were more likely to implement the features of the Principle of Contrasting and Complementing and the Principle of Cracking and Ripping. Female students also maintained good connections with classmates to better their learning and paid attention to the development of their attitudes regarding future careers. However, according to the results, the male students were more likely to exercise. This study implied that 49.1% ($n = 327$) of the male students exercised more than three times per week, and 84.4% ($n = 562$) exercised more for than 30 min during each exercise session. In contrast, 23.5% ($n = 28$) of the female students exercised more than three times per week.

### Table 2. Results of Correlations and Discriminant Validity.

|     | M    | SD   | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  |
|-----|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1   | 4.09 | 0.49 | .43 | .22 | .26 | .24 | .26 | .21 | .13 | .17 | .17 |     |     |     |
| 2   | 3.89 | 0.50 | .48**| .43 | .22 | .21 | .29 | .22 | .14 | .19 | .18 |     |     |     |
| 3   | 4.01 | 0.48 | .51***| .47***| .38 | .28 | .39 | .20 | .18 | .23 | .18 |     |     |     |
| 4   | 3.96 | 0.57 | .49***| .46***| .53***| .51 | .33 | .24 | .17 | .22 | .19 |     |     |     |
| 5   | 4.06 | 0.47 | .51***| .53***| .63***| .57***| .42 | .30 | .22 | .32 | .24 |     |     |     |
| 6   | 4.17 | 0.48 | .45***| .47***| .45***| .49***| .55***| .48 | .28 | .24 | .23 |     |     |     |
| 7   | 4.14 | 0.46 | .36***| .38***| .42***| .41***| .47***| .53***| .42 | .26 | .22 |     |     |     |
| 8   | 4.15 | 0.48 | .41***| .43***| .48***| .47***| .57***| .49***| .51***| .47 | .32 |     |     |     |
| 9   | 4.24 | 0.51 | .41***| .42***| .43***| .43***| .49***| .48***| .47***| .57***| .67 |     |     |     |
| 10  | 1.15 | 0.36 | .02 | −.04 | .08* | .03 | .07 | −.04 | −.01 | .10** | −.04 |     |     |     |
| 11  | 2.66 | 1.53 | .02 | .10***| .03 | .06 | .05 | .07* | .04 | .05 | .11*** | −.17***|     |     |
| 12  | 4.19 | 1.74 | .04 | .03 | −.02 | −.04 | .00 | .07 | .02 | −.02 | .04 | −.24*** | −.03 |     |
| 13  | 1.78 | 0.42 | .01 | −.04 | .05 | −.01 | .01 | −.06 | −.02 | −.06 | −.07 | .01 | −.17*** | −.02 |

**Note**: Numbers displayed in bold are the values of AVE. 1. Deep and Down. 2. Alternating. 3. Contrasting and Complementing. 4. Revolving and Cycling. 5. Inner Connection. 6. Changing and Transforming. 7. Contradiction. 8. Cracking and Ripping. 9. Void. 10. Gender. 11. Frequency of Exercise. 12. Length of Exercise. BMI = body mass index. AVE = average variance extracted.

**p < .05 (two-tailed). **p < .01 (two-tailed).**

### Table 3. Descriptive Statistics of BMI Groups.

| BMI groups | 1 (n = 264) | 2 (n = 149) | 3 (n = 93) | 4 (n = 130) | 5 (n = 149) |
|------------|-------------|-------------|-------------|-------------|-------------|
| M          | 4.12        | 4.09        | 4.05        | 4.12        | 4.09        |
| SD         | 0.49        | 0.49        | 0.48        | 0.515       | 0.49        |
| BMI groups | 1 (n = 264) | 2 (n = 149) | 3 (n = 93) | 4 (n = 130) | 5 (n = 149) |
| M          | 3.87        | 3.90        | 3.93        | 3.86        | 3.89        |
| SD         | 0.51        | 0.47        | 0.48        | 0.50        | 0.49        |
| BMI groups | 1 (n = 264) | 2 (n = 149) | 3 (n = 93) | 4 (n = 130) | 5 (n = 149) |
| M          | 4.01        | 4.01        | 4.07        | 4.01        | 3.97        |
| SD         | 0.57        | 0.55        | 0.47        | 0.55        | 0.55        |
| BMI groups | 1 (n = 264) | 2 (n = 149) | 3 (n = 93) | 4 (n = 130) | 5 (n = 149) |
| M          | 4.07        | 4.08        | 4.09        | 4.03        | 4.04        |
| SD         | 0.47        | 0.49        | 0.46        | 0.48        | 0.48        |
| BMI groups | 1 (n = 264) | 2 (n = 149) | 3 (n = 93) | 4 (n = 130) | 5 (n = 149) |
| M          | 4.16        | 4.17        | 4.27        | 4.18        | 4.13        |
| SD         | 0.48        | 0.48        | 0.47        | 0.48        | 0.48        |
| BMI groups | 1 (n = 264) | 2 (n = 149) | 3 (n = 93) | 4 (n = 130) | 5 (n = 149) |
| M          | 4.11        | 4.13        | 4.21        | 4.14        | 4.14        |
| SD         | 0.47        | 0.44        | 0.48        | 0.44        | 0.47        |
| BMI groups | 1 (n = 264) | 2 (n = 149) | 3 (n = 93) | 4 (n = 130) | 5 (n = 149) |
| M          | 4.14        | 4.15        | 4.20        | 4.13        | 4.15        |
| SD         | 0.50        | 0.51        | 0.46        | 0.50        | 0.50        |

**Note**: BMI = body mass index.
week, and 64.7% \((n = 77)\) exercised more than 30 min at one time. The BMI results and the correlation between the frequency of exercise and body shape maintenance may explain this difference. This study showed that the interest in body shape maintenance increases with an increase in the exercise frequency. The percentage of males who were overweight or obese based on their BMI was 37 \((n = 250)\), but this percentage was only 24.4 \((n = 29)\) for females. In addition, only 11.1% \((n = 74)\) of the males had a normal BMI compared with 16% \((n = 19)\) of the females. Consequently, male students need to improve their BMI and body shape maintenance by increasing their exercise frequency.

Regarding the connections between the exercise variables and the features of the Principles for Deep Knowledge, this study detected a positive relationship between the frequency of exercise and three principles: Alternating, Changing and Transforming, and Void. The results clearly implied that individuals with Alternating, Changing and Transforming, and Void features will consistently exhibit motivation for both learning and exercising. As P. L. Yu (2006) mentioned, the use of the nine Principles of Deep Knowledge can be better observed when we are attempting to expand our knowledge. First, the Void Principle is applied to create and clear space in the mind, and the other principles will be used to fill it with newer and deeper knowledge. This study confirmed Yu’s hypothesis. The Void Principle was the strongest feature, as determined by the means of the results obtained from the students. Thus, exercising can be a great benefit to emptying the mind and allowing a student to acquire new and deeper knowledge during the learning process. Because the mind is open and ready to receive knowledge, it should have an impact on the effectiveness of learning. Therefore, by studying the extent of exercising and its influence on learning, a novel correlation between exercising and learning emerged. This study discovered that students who have either stronger features of the Void Principle, the Principle of Changing and Transforming, or the Alternating Principle appeared to show a higher frequency of exercise during the learning process. It may be possible that students are aware of the advantages of exercise because exercise has a great impact on the students’ acquisition of knowledge.

Because the sample exhibits strong academic achievement in both enrollment and graduation, was convenient, and was within a restricted age range, questions arise regarding the general applicability of these results. This sample may not represent the general population in terms of academic profile and implementation of the nine Principles for Deep Knowledge. In addition, context variables that may have a potential impact on the relationship between the PDKS and academic achievement were not investigated in the current study. In future studies, causal relationships should be designed through a longitudinal and mixed method to create assumptions of causality for path analysis. Each of the demographic variables, such as the frequency of exercise, length of exercise, and body shape maintenance, consisted of only one item on the questionnaire and was lacking in both reliability and validity, which may cause a few significant relationships between the PDKS and exercise. Future research studies should utilize a well-designed psychometric exercise scale. Remarkably, the current study found no statistically significant relationship between the PDKS and body status, including the BMI. Of course, many future studies should be performed to discover the impact of exercise on PDKS and academic achievement.

**Conclusion**

In conclusion, the current results demonstrate the acceptable psychometric properties of the PDKS, provide support for the previous study (Lin et al., 2011), and indicate that the PDKS is a useful tool for measuring individual differences in the features of deep knowledge during the learning process. In addition, gender differences in two of the nine subdimensions of the PDKS were found, and exercise was a factor. Developing an awareness of one’s own features may provide insights into one’s weaknesses and the strength of the features of deep knowledge to improve learning effectiveness. Furthermore, for the purpose of extending the sparse related literature, further research is needed to examine whether the frequency of exercise would mediate the association between the competence of deep knowledge and academic achievement during the learning process.

**Appendix**

**Nine Principles of Deep Knowledge Survey**

The Nine Principles for Deep Knowledge was a strategy, proposed by Dr. Po-Lung Yu in expanding the knowledge of Habitual Domain (HD) including Deep and Down Principle, Alternating Principle, Contrasting and Complementing Principle, Revolving and Cycling Principle, Inner Connection Principle, Changing and Transforming Principle, Contradiction Principle, Cracking and Ripping Principle, and Void Principle. Please fill out the following questions based on personal experience, there is no “correct” or “wrong” answer.

- 1 = Strongly Disagree; 2 = Disagree; 3 = No Comment; 4 = Agree; 5 = Strongly Agree

**Questions**

1. Condescending to ask for advice links me with weakness.
2. Meditation helps me calm down to better my learning.
3. Asking questions actively helps me learn efficiently.
4. Being over-concerned regarding scores helps me learn efficiently.
5. Releasing pressure properly, for example, exercise/meditation/serenity helps my learning.
6. Utilizing knowledge in diverse fields improves my learning.
7. Thinking from varied perspectives will confuse me.
8. A teacher’s diversified teaching strategies can help me learn.
9. Constant challenges will facilitate my learning.
10. A teacher’s admonishment is an encouragement, not censure.
11. A teacher’s advice does not influence or help my learning.
12. I learn from others’ attitude and strategies to improve my learning.
13. The difficult level of a course influences my learning effect.
14. My learning attitude is influenced by others’ performance.
15. Keeping interaction with others in class cannot help my learning.
16. Feeling low emotionally leads to my lower achievement in learning.
17. I am not arrogant when I have better performance.
18. I still keep on learning even when I fail to achieve the expected goal.
19. Setting a personal goal does not help my learning.
20. Regardless of score, I believe constant effort leads to self-set learning goal.
21. Understanding the content of a lesson thoroughly cannot improve my learning outcome.
22. Key concepts illustrated in class promote better learning.
23. More teacher–student interaction does not facilitate my learning.
24. Others’ better performance will push me to learn more actively.
25. Utilizing examples from surroundings in class prompts my understanding in learning.
26. I am sensitive to changes in the surroundings for better learning.
27. My learning attitude is not changed by the surrounding changes.
28. Diversity in teaching strategies influences my attitude toward class.
29. Versatile teaching style will enhance my learning effect.
30. Teaching with multimedia in class can improve my learning effect.
31. I like using contrary thinking to improve my learning.
32. Knowing my problem in ineffective learning cannot help my learning.
33. Opinions from others in class cannot improve my learning.
34. The academic grades cannot represent learning attitudes.
35. Searching for information from reliable extracurricular sources does not help my learning.
36. I put in more effort in studying the less familiar topics to enhance my learning.
37. For better efficiency, I do not spend time reviewing the more familiar topics to me.
38. Studying the topics of lower grades harder improves my performance.
39. I can still achieve my academic goal even with a passive learning attitude.
40. I believe one’s learning attitude will reflect one’s future job performance.
41. Abandoning my outdated ideas will not help my learning.
42. I discuss with classmates to improve my learning performance.
43. Without focusing on scores, I can learn more actively.
44. Discarding censure from the teacher does not help me focus on learning.
45. Facing insuperable difficulties and looking for assistance from others can help me learn.

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