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Study on the Computational Estimation Performance and Computational Estimation Attitude of Elementary School Fifth Graders in Taiwan

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Main purpose of this study is to investigate what level of computational estimation performance is possessed by fifth graders and explore computational estimation attitude towards fifth graders. Two hundred and thirty-five Grade-5 students from four elementary schools in Taipei City were selected for "Computational Estimation Test" and "Computational Estimation Attitude Survey". Based on 28 items of the Computational Estimation Test, average number of items correctly answered by students is 16.37, the percent of correct responses is 58.48%, and overall performance is moderate. The Computational Estimation Test includes items representing three number dimensions: whole numbers, decimals and fraction numbers. The data indicate that the number domain of fraction (46.63%) and decimal (54.30%) percent of correct response of the CET (Computational Estimation Test) were relatively low when compared with whole numbers (63.44%). Based on 35 items of the CEAS (Computational Estimation Attitude Survey), the mean scores of students' CEAS is 119.72, higher than average, indicating that attitude of elementary school fifth graders today to computational estimation is generally positive. As to subscales of elementary school fifth graders' attitude to computational estimation, "experience in computational estimation" component is near negative and passive, indicating that students experience in using computational estimation is somewhat not enough.

Keywords: estimation performance, estimation attitude, elementary student

Purpose of Research

In summary of mathematics curriculum standards in Taiwan and international, more and more countries concentrate on computational estimation teaching and stress its importance. "Number and Computation" from "Curriculum and Evaluation Standards for School Mathematics" published by National Council of Teachers of Mathematics (2000) suggested students to master computation and make reasonable estimation, besides, it went on to stress computational estimation importance, and it recommended to strengthen computational estimation teaching. Computational estimation was a neglected topic in past Taiwan mathematics teaching, while joint exam system governs teaching, manual computation skill, speed and sole answer were always emphasized to get higher mathematics point; stereotyped rule exercise and master of computation skill were often put on high priority, lacking cultivation of thinking and logic reasoning (YANG, 2000; 2001). Under educational reform,

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current curriculum standard pays more and more attention to computational estimation, insisting that computational estimation learning aids students' number sense and mathematical thinking.

But to most students, computational estimation was a kind of new skill, not yet encouraged in school to develop, so that students considered "mathematics" as being restricted to seek correct answer. They were usually devoted to finding "correct answer", and failed to tolerate error, without thorough understanding of "computational estimation" (Reys, 1988). Later, the research was found interesting when asked students to find which formula was wrong in three 2-digit integer multiplication without using paper and pen. Among 16 tested elementary school students, only eight students gave correct answer, where only four could determine answer by number size, the rest students got answer by manual computation CHI (1996). This phenomenon indicates that Taiwan students rely much on paper and pen to get a correct answer.

After education reform, Taiwan Grade 1-9 curriculum mathematics studying stresses on cultivation of take-away ability, insisting on vivid and meaningful learning (Ministry of Education, 2003). Computational estimation is widely applied in daily life, concepts, such as cash management, time and geometry concept, play a far more important role in life than computation ability, thus students are requested to match knowledge learnt with real life situation. Therefore, it is an important issue to develop computational estimation capability to mathematics education.

Now because computational estimation instruction has been put on priority by many advanced countries, its importance has been stressed. Mathematics curriculum of Taiwan has included computational estimation, but student computational estimation capability and attitude to computational estimation worth further study. Therefore, this study hopes to understand current performance of students' computational estimation capability and attitude in Taiwan and bring relevant information to mathematics education sector, so as to trigger emphasis on teaching of computational estimation.

Research Questions

(1) How is elementary school fifth graders computational estimation performance?

(2) What is the elementary school fifth graders' attitude toward computational estimation?

Literature Review

Understanding and Knowing Computational Estimation

Scholars proposed that computational estimation mixed multiple capability, skill and number concept operations, and combined with mental computation to calculate reasonable answer rapidly. Reys and Bestgen (1981) argued that computational estimation was the comprehensive application of mental computation, number concept and various computing skills, obtaining answer rapidly through mental computation, and answer obtained from such process had relative rationality. LIN (1995) also proposed that computational estimation was not formal computation, but integrated mental computation, number concept and some operation skills, such as approximation, place value concept, to get a reasonable rough answer rapidly approximated to precise computation result, this process was totally internal thinking without any external computation tool. Computational estimation was general personal understanding of number and operation, or a capability and propensity of making mathematical judgment through flexible application of mathematical knowledge understood, and developing useful strategy to deal with mathematical situation (YANG, 1997).

Computational estimation is internal thinking of getting rough answer in computing item, when precise

computation is unnecessary or impossible, such capability as computational estimation is needed to obtain a reasonable conjecture answer, which help to determine rationality of an answer resulted from computer (Siegel, Goldsmith, & Madson, 1982). CHI (1996) indicated that computational estimation could be called as a process of getting rough answer of a computation item, a skill of guessing reasonable approximate value. WANG (2004) stated that computational estimation referred to rough numerical computation in heart only by existed mathematical thinking strategy, without tools like paper, pen, abacus and electronic calculator.

Development of computational estimation capability can improve students' understanding of number meaning, and get rough answer in short time to determine whether or not electronic calculator answer is reasonable, then apply computational estimation process in realistic life. In American mathematics curriculum reform (NCTM (National Council of Teachers of Mathematics), 1989; 2000), computational estimation always occupies crucial stance. In fact, the use of manual computation or measuring tool is not permitted in a lot of actual situations, but computational estimation can provide a manner and test of obtaining reasonable answer. Therefore, in real life, computational estimation gets result more easily and efficiently than precise computation, so one can know how important the computational estimation capability is.

Computational estimation is incorporated into mathematics curriculum due to two reasons: One is to aid students in better understanding of mathematical concepts, or help develop number sense; the other is that computational estimation itself is an important learning objective and a skill worth to have (LIN, 2002). As to current Taiwan mathematics curriculum, computational estimation related courses occupy larger and larger ratio, indicating that Taiwan mathematics education gradually concentrates on computational estimation capability cultivation.

In summary of above researchers' definitions and views of computational estimation, we get to know that computational estimation is a complex skill, a kind of operation mixing multiple capabilities, skills and number concept, in which two aspects are involved, one is to simplify precise number into rough number, then treat these rounding numbers with mental computation to compute reasonable answer rapidly. Thus, researchers regarded computational estimation as rough operation absolutely in heart without any external computation tool to get reasonable answer.

Related Researches on Computational Estimation

Threadgill-Sowder (1984) posed 12 NAEP (National Assessment of Educational Progress) items to students of grades six through nine. This study found that "Students who gave acceptable responses consistently demonstrated this quantitative intuition, or number sense, whereas those who gave unacceptable responses seemed to have little feel for the numbers represented" (p. 335). The results of the study indicate that estimation skills are highly dependent upon a student's number sense. Threadgill-Sowder (1984) theorized that good estimators, which have a good understanding of basic facts, place value and arithmetic properties, are skilled at mental computation, demonstrate tolerance for error, and can flexibly use a variety of strategies as well as display self-confidence. Researchers have identified three general ways in which people estimate answers to computational problems: reformulation, translation and compensation (Reys, Bestgen, Rybolt, & Wyatt, 1982; Sowder & Wheeler, 1989; Sowder, 1994; Lefevre, Greenham, & Waheed, 1993).

More recently, the research have been done in Taiwan, CHI's (1993; 1996) computational estimation studied on elementary school students' computational estimation concept development in Taiwan and found that most students seldom found unreasonable phenomena during computation, and computational estimation

wish seemed to be related with habit. YANG (2000) also found that most students did not demonstrate computational estimation strategy capability, and solving mode was cling to manual computation rule. Most students thought that being able to obtain correct answer was better than computational estimation, even taking computational estimation for just a conjecture.

Computational Estimation Attitude

Bestgen, Reys, Rybolt and Wyatt (1980) discovered that good computational estimator had better attitude than worse computational estimator, and insisted that computational estimation error was acceptable. Reys et al. (1982) also found that in study of Grade 7-12 students and some adults, good computational estimators were very confident of their computational estimation capability, and confident students learned more than less confident students, and studied subsequent mathematical concepts better and became more interested. The study of emotion influence on computational estimation found that, characteristics of good computational estimators included error tolerance and situation factor like being confident with computational estimation. R. E. Reys, B. J. Reys, Nohda and Emori (1995) pointed out that, Japanese students failed to tolerate error, probably because repeat work was requested in school to verify answer, not using computational estimation to test answer rationality, and it was recommended to use mental computation and paper/pen to correct answer, incase it seemed for general Japan students to seek precise answer, though students were reluctant to permit error.

CHI (1993) made computational estimation study of 26 students of elementary school Grade 3-5 and four secondary school students in Taiwan. The results showed that students knew “roughly”, “about” concepts; but almost had no experience of using “rough number” in computational estimation. While a little computational estimation experience was on verification of exercise answer, no one used computational estimation to verify answer in exam, usually students compute again to verify answer correctness. The most frequently used method by students in testing calculator answer was to recalculate with electronic calculator, or by reverse operation, not knowing to verify by means of computational estimation. Later, CHI (1996) investigated computational estimation motive and situation. The situation includes internal mood and external ambience. To students, recognition maturity, general mathematical capability, mood and solving habit belong to internal situation; teacher requirement, class teaching, attitude of teachers and parent and pressure of group stayed are external situation. Such internal and external situations would affect computational estimation motive, and further affect students’ computational estimation capability performance.

Research Method

Research Design

The main purpose of this study is to investigate what level of computational estimation performance was possessed by fifth graders and explore computational estimation attitude towards fifth graders. In March 2007, instruments used to collect data were the components of the CET (Computational Estimation Test) and CEAS (Computational Estimation Attitude Survey). The population for the study consists of public elementary schools in Taipei City. The sample is composed of four public elementary schools in Taipei City, two classes of Grade-5 students in each school were randomly chosen to response CET and CEAS. There are 235 participants from these eight classes who completed data collection tasks during the Spring 2007 semester for the study.

Instruments

CET. The 28 item CET includes whole number, fraction and decimal items as well as the four basic

operations. CET was designed as multiple-choice items, and improper items were revised according to pilot study result. Table 1 provides the framework for CET items by number domain and the four basic operations.

Table 1

The Framework for CET Items by Number Domain and the Four Basic Operations

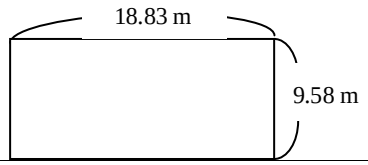
	Addition	Subtraction	Multiplication	Division
Whole number	14, 17, 23, 25	3, 4, 12, 16	19, 24	15, 7, 10, 18, 2
Decimals	1, 11	2	9, 15	7, 28
Fractions	8, 21	6	22	13, 20

Researcher adopted computer aided countdown Power Point display, let school students answer under time pressure without paper or pen, time limit of each item were defined according to item length, complexity and difficulty, and discussion and recommendation of experienced teachers. Finally, time limit was slightly adjusted according to students' answering speed. Result in polite study, the total answering time was about 20 minutes.

The Cronbach's alpha coefficient reliability for the CET is 0.76. The Cronbach's alpha coefficient reliability of the instrument has demonstrated consistent reliability for measures of internal reliability. In terms of content validity, related research literatures, elementary school curriculum data analysis and actual teacher recommendation are referenced in compiling test items, so that every item complies with research purpose. Comments of all parties are considered in compilation, and discussion and amendment are done not only with experts and professors, but also with active elementary school teachers, so these research tools have expert validity. The sample of CET items are shown in Table 2.

Table 2

Sample of CET Items

Which formula's result is greater than 1? (1) $\frac{7}{9}+\frac{4}{9}$ (2) $\frac{5}{7}+\frac{1}{7}$ (3) $\frac{1}{2}+\frac{1}{5}$ (4) $\frac{1}{3}+\frac{1}{8}$
Salt sells NT$19 per kg, mum buys $\frac{18}{35}$ kg, about how much shall be ready to afford? (1) 10 (2) 20 (3) 30 (4) 40
A farmer has a parcel of rectangular land as shown below, then about how many square meters does he have to plant vegetables? (1) 100 (2) 200 (3) 300 (4) 400 
When adding integers, $\begin{array}{r} \text{3-digit number} \\ +\ \text{3-digit number} \\ \hline \end{array}$ The answer may be (1) 1-digit or 2-digit number (2) 2-digit or 3-digit number (3) 3-digit or 4-digit number (4) 4-digit or 5-digit number
The school holds a field trip. Attendees will ride to the destination, each tourist bus can carry 40 passengers, totally 215 people attend it. Then how many tourist buses at minimum does the school have to rent? (1) 5 (2) 6 (3) 7 (4) 8

CEAS (Computational Estimation Attitude Survey). CEAS is used to evaluate student computational estimation attitudes. CEAS was adopted from Aiken's (1974) "mathematics study attitude scale". The researchers also discussed with mathematics educators and elementary school mathematics teachers to revise CEAS, and CEAS was revised again after pilot study was performed.

This survey includes 35 items in five subscales: "experience in computational estimation", "tolerance to

error", "confidence of computational estimation", "acceptability of computational estimation value" and "fun of studying computational estimation". Subject score acts as measurement of individual computational estimation attitude, and each component has positive and negative items, all in 5-point Likert scale. The CEAS uses a Likert scale wherein the subject responds, on a scale of 1-5, to their degree of agreement with a statement. The response choices range from "Strongly disagree" (1 point), "Disagree" (2 points), "Cannot decide" (3 points), "Agree" (4 points) and "Strongly agree" (5 points). Each domain scale consists of seven statements, six worded positively and six worded negatively. A score of 5 is given to the response that is hypothesized to have a more positive relation to learning mathematics. Scores of each domain scale and the cumulative score of all domains indicate students' attitudes toward computational estimation. A high score represents a positive attitude toward computational estimation.

The Cronbach's alpha coefficient reliability for the CEAS is 0.94. The Cronbach's alpha coefficient reliability of the instrument has demonstrated consistent reliability for measures of internal reliability. The reliability for the sub-scales in CEAS are: Experience in computational estimation (alpha = 0.81), Tolerance to error (alpha = 0.78), Confidence of computational estimation (alpha = 0.86), Acceptability of computational estimation value (alpha = 0.82) and Fun of studying computational estimation (alpha = 0.82). The four sub-scales in CEAS have demonstrated high reliability for measures of internal reliability as well. Sample of computational estimation attitude test items is shown in Table 3.

Table 3

Sample of Computational Estimation Attitude Items

Sub-scales	Statement
Experience in computational estimation	Before "computational estimation aptitude test", I often use computational estimation.
Tolerance to error	During computational estimation, I will think out some method or make some operation to let computational estimation result be more approximate to correct answer.
Confidence of computational estimation	I feel relaxed and happy in answering computational estimation items.
Acceptability of computational estimation value	Studying computational estimation makes my thinking more flexible.
Fun of studying computational estimation	Computational estimation items are challenging, and after solving correctly, I feel accomplished.

Research Results and Discussions

Computational Estimation Performance

This section analyzes answering of CET. Effective sample of this study has 235 students. Average correct percent of students' computational estimation test is shown in Table 4.

Table 4

Mean and Percent of Correct Responses of CET (N = 235)

	Number of items	Possible score	Mean	Percent (%)
Total number of items	28	28	16.37	58.48
Integer	17	17	10.78	63.44
Fraction	5	5	2.33	46.63
Decimal	6	6	3.26	54.30

As shown in Table 4, among all 28 items of CET, average number of items answered correctly by students is 16.37, the percent of correct responses is 58.48%, and overall performance was intermediate. The CET

included items representing three number dimensions: integral numbers, decimal numbers and fraction numbers. Table 5 displays the percents of correct responses and mean on the CET by number domains for the 235 participants. In Table 4, the data indicate that the number domain of fraction (46.63%) and decimal (54.30%) percent of correct response of the CET were relatively low when compared with integral numbers (63.44%).

The data show that the number domain of integers (63.44%) mean percent on the CET was relatively high as compared with the fractions (46.63%) and decimal (54.30%) mean percents. The longest and most familiar part of teaching content the students received in school was integer, hence, performance would be better. Items of integers with the percent of correct responses below 63.44% included items 4, 7, 10, 24 and 28; the percent of correct responses of items 24 and 28 were as low as 32.63% and 49.74% respectively. The data indicate that most students would determine appropriate numbers to facilitate computation, but did not reason answer rationality while obtaining result. According to the percent of correct responses of item 4 (51.05%), the data show that students performed worse in selecting numbers among excessive information for computational estimation test. The percent of correct responses of items 7 and 10 both are 54.74%. This indicates that students performed worse when they solved with division arithmetic items, using precise computation arithmetic in long division more often than estimation.

Decimal (54.30%) percent of correct response of the CET were relatively low when compared with integer (63.44%). Most students could round off decimals into integers without changing formula structure, followed by computational estimation, but extremely, a few students would be subjected to number type, saying that they did not touch similar decimal computational estimation items, and so failed to run computational estimation, less familiar decimal operation was weakly controlled. Items of decimal with the percent of correct responses below 54.30% included item 13 (41.58%) and item 21 (34.74%). The result of item 13 indicates that students were not good at decimal division. They do not understand number relation and unfamiliar items of integer divided by decimal, easily leading to the idea of long division. The result of item 21 indicated that students were confused about number of digit after decimal point, hence failed to estimate a proper number for computational estimation, resulted in wrong answer.

The number domain of fraction (46.63%) percent of correct response of the CET is relatively low when compared with integer (63.44%) and decimal (54.30%). The researchers regarded that Grade-5 students only touched fundamental fraction concept, and were not so familiar with fraction arithmetic. Items of fraction with the percent of correct responses below 46.63% included item 9 (24.74%) and item 15 (28.95%). Students were found unfamiliar with fraction multiplication, confined by teaching content, and they had to make precise computation with mathematic rules, failing to get estimate with computational estimation. During research, fraction addition and subtraction had been learned; meanwhile, operation rule of fraction multiplied by integer was also learned. Hence, quite a few students would be confined in methods taught by teacher, or once seeing fraction operation, one would immediately solve with arithmetic rule from intuition, that is, reduce to a common denominator and add, subtract or multiply by fraction. Therefore, it is indeed difficult to make flexible use of computational estimation capability to solve fraction arithmetic items.

In summary, fifth graders in elementary school performed moderately in CET. Precedence in order of test categorization were “integer”, “decimal” and “fraction”. In curriculum content nowadays, most computational estimation items are of integer type, as a result, students are most familiar with integer, so performance in this aspect will be better, while number expression transformation items appear difficult to students. Fraction arithmetic is often subjected to manual computation, and arithmetic rule has to be used to get answer. Maybe

contact with fraction and fraction arithmetic is not long, and there is no flexible thinking and no rough computation in heart.

Attitude Toward Computational Estimation

CEAS consists of five components: "Experience in computational estimation", "Tolerance to error", "Confidence of computational estimation", "Acceptability of computational estimation value" and "Fun of studying computational estimation". And subject score in scale acts as individual computational estimation attitude measurement, the higher the score, the more optimistic attitude to computational estimation. Score data were measured from scale, and provided to interpret subject attitude towards computational estimation. Statistic result of fifth graders in elementary school's computational estimation attitude is shown in Table 5. This scale adopts 5-point Likert scale, take 3 points as average of each item score and comparison benchmark, as known from Table 5, mean of students' computational estimation attitude total scale is 119.72, higher than average, indicating that now elementary school fifth graders' attitude to computational estimation is generally positive and active.

Table 5
Statistics of Component Means, Overall Mean and Standard Deviation of Students' Attitude to Computational Estimation (N = 235)

Sub-scales	Quantity	Average	Mean (M)	Standard deviation (SD)
Experience in computational estimation	7	21	20.71	5.62
Tolerance to error	7	21	24.30	3.60
Confidence of computational estimation	7	21	22.91	6.07
Acceptability of computational estimation value	7	21	27.34	5.28
Fun of studying computational estimation	7	21	24.46	5.62
Total scale	35	105	119.72	21.99

In case of components of elementary school fifth graders' attitude toward computational estimation, mean of "Experience in computational estimation" component is 20.71, less than average, indicating that students' experience in computational estimation appear insufficient, similar to CHI (1993)'s finding that Taiwan's elementary school students knew concepts of "about", "roughly", but rarely used computational estimation, a few cases of using computational estimation were to verify answers, and no one used computational estimation to verify answer in exam, usually students recalculated to verify answer correctness, besides, when testing electronic calculator answer, the most frequently used method was to count again with electronic calculator, or to calculate again in reverse operation, never using computational estimation to verify. Mean of "Tolerance to error" component is 24.30, higher than average, indicating that most students could tolerate error of computational estimation according to answer rationality, comparable to what Reys et al. (1995) pointed out that Japan students failed to tolerate error, probably because they were often asked to repeat to verify answer in school, instead of verification by means of computational estimation, furthermore, being encouraged to obtain right answer by means of mental computation and paper and pen to seek precise answer seemed to make general Japan students reluctant to permit error. Mean of "Confidence of computational estimation" component is 22.91, higher than average, indicating that students are a little confident of their own computational estimation capability. Reys et al. (1982) and Gliner (1991) found that good capability computational estimators felt very confident of their computational estimation capability, and confident students learned more than less

confident students, and studied subsequent mathematic concepts better with more fun. This study found that mean of students' confidence of computational estimation is 22.91, which is 1.91 more than 21 points, the average, while overall the percent of correct responses of computational estimation test is 58.48%, thus students' confidence influences computational estimation performance. Mean of "Acceptability of computational estimation value" component is 27.34, higher than average, indicating that students regard computational estimation as valuable and acknowledge computational estimation as important. CHI (1993) had similar research result, most teachers thought computational estimation very important in daily life, and computational estimation teaching should be added to elementary school curriculum. Therefore, both teachers and students have positive attitude toward computational estimation. Mean of "Fun of studying computational estimation" component is 24.46, higher than average, indicating that students like to study computational estimation and get ready to try solving computational estimation problems. Table 6 shows full scale mean analysis item by item (negative items have been scored reversely).

Table 6

Mean of Students' Attitude to Computational Estimation Sub-scale Item by Item (N = 235)

Experience in computational estimation	Item No.	11	17	19	27	8	25	31
	Mean	2.66	3.00	3.57	2.92	3.04	2.68	2.84
Tolerance to error	Item No.	2	7	9	18	10	24	28
	Mean	3.50	3.89	3.36	3.50	3.80	2.49	3.77
Confidence of computational estimation	Item No.	1	20	26	12	15	32	34
	Mean	2.68	3.15	3.20	3.69	3.26	3.30	3.62
Acceptability of computational estimation value	Item No.	4	13	23	29	3	21	33
	Mean	4.05	3.94	3.77	3.58	4.16	4.14	3.71
Fun of studying computational estimation	Item No.	5	14	22	35	6	16	30
	Mean	3.60	3.79	2.80	3.15	3.68	3.87	3.57

Note. Negatively items have been scored reversely.

In terms of "Experience in computational estimation", mean of item 11 is 2.66 (I often use computational estimation before CET), mean of item 25 is 2.68 (I seldom use computational estimation except in class and exam), mean of item 27 is 2.92 (I often apply computational estimation method in life), mean of item 31 is 2.84 (I rarely apply computational estimation in daily life), all means of these four items are below 3, indicating that students lack experience in using computational estimation in daily life except in school, thus teachers can make use of real life experience of students to enable more vivid and practical teaching, so that students can cultivate their experience in using computational estimation related knowledge and capability in real life. In terms of "Error tolerance", mean of item 24 is 2.49 (I feel that, to calculate answer precisely is better than with computational estimation at any time), lower than 3.00, so most students still concentrate on precise manual computation skill, speed and the only answer, but as time goes on, what is needed is to cultivate logic reasoning and thinking, not simply focusing on stereotyped arithmetic rule exercise and computation skill any longer. Therefore, students shall be cultivated to utilize computational estimation or reasonable judgment to solve the problem, no longer with only manual computation.

In terms of "Confidence of computational estimation", mean of item 1 is 2.68 (I think my computational estimation capability is very good), less than 3.00, indicating that students appear less confident of

computational estimation capability. In terms of "Fun of studying computational estimation", mean of item 22 is 2.80 (Computational estimation is pleasant and luring), lower than 3.00, indicating that students' love of studying computational estimation is moderate. Mean of item 3 is 4.16 (I feel that studying computational estimation helps me nothing), mean of item 4 is 4.05 (I feel computational estimation method is very useful in daily life), mean of item 21 is 4.14 (Computational estimation is absolutely not worth to study), these three items have highest means, and belong to "Acceptability of computational estimation value" component, hence most students can acknowledge computational estimation value and importance, and think studying computational estimation is worthy.

In perspective of total scale, subscale and mean per item, students' attitude to computational estimation is generally positive, from which teachers can begin to let students encounter more living computational estimation besides textbook, so that students can use computational estimation not only in school study but in actual living situation, not only to experience life but to accept various possible computational estimation answers and diversified computational estimation strategies, and to improve confidence inadvertently. Most students accept computational estimation value and importance, and think studying computational estimation is of fun, but experience in using computational estimation appears not enough, maybe because computational estimation is still ignored in current elementary school mathematics textbooks. Although computational estimation teaching gets more and more attention up to now, teachers and students still focus on manual computation skill, speed and only answer to get higher mathematics grade under system-guided teaching, so computational estimation concept is still poor and solitude in textbook, not yet merged to the whole mathematics concept. And computational estimation is easily confined to be a part of operation system. In fact, computational estimation is living mathematics, in most cases, computational estimation concept, which students study in class, uses round-off, unconditional entry method and unconditional reject method in computational estimation. Students' concept of computational estimation has been restricted to these three methods, and once seeing computational estimation items, one will use stubborn operation strategy, less likely to apply in other area flexibly, and use in less frequency certainly, not so familiar with computational estimation. Thus, confidence of computational estimation performance will naturally drop, and mathematics teaching content arrangement shall consider how to add computational estimation to curriculum, not to unit teaching. The key point is that students can realize that true meaning of computational estimation can simplify operation, so that one can get answer sooner, rather than using computational estimation just for exam.

Conclusion

In summary, elementary school fifth graders' performance in computational estimation test is moderate, precedence as per test categorization is "integer", "decimal" and "fraction". In fact, in Taiwan curriculum plan today, computational estimation items are primarily as integer type, as a result, what students are most familiar with is integer part, hence, performance will be better. Students are unfamiliar with fraction computational estimation items, and they have touched fraction arithmetic not for a long time. Hence, they will be influenced by manual computation, and have to use arithmetic rule to obtain answer, which is difficult in numeric expression transformation, as a result, they cannot think flexibly, and fail to make rough operation in heart.

Based on 35 items of the CEAS, the mean of computational estimation attitude scale is 119.72, higher than average, indicating that attitude of elementary school fifth graders today to computational estimation is generally positive. As to subscales of elementary school fifth graders' attitude to computational estimation,

"Experience in computational estimation" component is near negative and passive, indicating that students experience in using computational estimation is somewhat not enough; "Tolerance to error" component is near positive, indicating that most students can tolerate error of computational estimation according to answer rationality; "Confidence of computational estimation" component is near positive, indicating that students are confident of their own computational estimation capability; "Acceptability of computational estimation value" component is near positive, indicating that students think computational estimation is valuable, and acknowledge computational estimation importance; and "Fun of studying computational estimation" component is near positive, indicating that students like to study computational estimation knowledge, and are ready to try solving computational estimation problems.

Recommendation

Mathematics curriculum today still stresses acquisition of standard answers. So teachers are suggested to encourage students to make rough estimate of mathematical items before precise computation, judge reasonable range of answer ratio, and compute to test answer rationality. Teachers can encourage students to use computational estimation in daily life and mathematics solution, and apply computational estimation in multiple ways, so that students can have wider understanding of computational estimation, increasing tolerance to answer error.

Grade 1-9 mathematics curriculum clarifies requirement of computational estimation through recognizing computational estimation importance. It is observed that there is only one independent unit of rough computation in textbook. Computational estimation teaching shall be shown in course continuously, and if there is only some teaching events in one single unit, then the students will be confined to study of independent computational estimation unit. While mathematics curriculum textbooks today are dominated by round-off, unconditional entry and unconditional reject methods, as a result, students are inclined to solving by means of routine computational estimation strategy, restricting flexibility of students utilizing computational estimation strategy. Therefore, curriculum plan shall pay more attention to flexible application of diversified computational estimation strategies, allowing students to use non-routine method based on number intuition to check answer rationality while exploring freely computational estimation strategy. As matter of fact, "number and quantity" plays an important role in national mathematics curriculum, with extensive content and scope, integer, fraction and decimal covering a lot of units. Nonetheless, computational estimation items in textbooks are mainly of integer type, so that students feel higher difficulty in facing other types of computational estimation items, thus the curriculum plan is recommended to teach computational estimation concept in terms of all number types, and incorporate computational estimation element into related content of other units, e.g., letting students perform computational estimation of items before mathematics unit and allowing students to familiarize computational estimation and its application and have capability to judge its rationality, so as to further improve students' computational estimation performance.

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