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Construction of Diagnostic Test in Mathematics on Addition and Subtraction Basic for Primary Students

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Abstract

The objectives of this research were to construct and verify a mathematics diagnostic assessment on addition and subtraction basis for grade 4 students in Buriram Primary Educational Service Area Office 3. The research samples consisted of 440 Prathomsuksa 4 students selected by adapting the multi-stage random sampling method. The research instruments employed in this research comprised of two types of examinations constructed according to strand 1: number and algebra in Mathematics 1.1. The tests were to examine test and diagnostic test. The examining test was a subjective test, consisted of 80 items which divided into addition part for 40 items and subtraction part for 40 items. The diagnostic test was a multiple-choice with 4 choices tests, consisted of 48 items which divided into addition part for 24 items and subtraction part for 24 items. The diagnostic test. The results showed that the content validity, determined by the expert, had the IOC score at 0.60−1.00. The addition part in the 1st test had a difficulty score of 0.21–0.79, the discrimination score at 0.23–0.89, and the reliability score at 0.89. The subtraction part in the 2nd test had the difficulty score at 0.31–0.72, the discrimination score at 0.32–0.72 and the reliability scores at 0.32–0.81.

Keywords: basic of addition and subtraction, diagnostic test, mathematics

1. Introduction

Mathematics has always played an important role in the 21st century successful learning. Since mathematics helps human think creatively, logically, and systematically. Through mathematics learning, we are able to analyze problems or situations delicately. This quips human to predict, plan, and decide on doing something precisely and it can be adapted in real life situation effectively (Ministry of Education, 2017, p. 1; Edame, 2014; Santrock, 2011). However, according to the Ordinary National Educational Test from the National Institute of Educational Testing Service (Public Organization), since 2017–2019 the national scores of shows that students' studying achievement in mathematics was quite low (National Institute of Educational Testing Service, 2019, Online). Elementary school exams are not popular with national and international exams. However, there is evidence to support that the math performance of students at this level is unsatisfactory (Clarke & Shinn, 2004; Clements et al., 2008; Denton & West, 2002). Although Thailand places importance on teaching and learning in mathematics, in the past Thai children haven't been successful in learning mathematics. As a result of the PISA 2018 assessment, it appears that mathematics in Thailand has an International Average Score (OECD) of 419, from an International Average Score (OECD) of 489. This reveals that the average score is lower than the International Average (OECD) (The Institute for the Promotion of Teaching Science and Technology (IPST), 2019). After considering the results from the National Educational test of grade 6 students in Buriram Primary Educational Service Area (PESA) Office 3 from 2016 to 2018, it discovered that grade 6 students had a low level of studying achievement. However, one of the major problems in the education system is the preparation of students to cope with rapidly changing environments (Oyedeji, 2014).

Classroom assessment is aimed to diagnose the learning defect and its cause, also to discover knowledge adequacy, and students' capacity, according to the learning standards and indicators in the curriculum leading to the solutions of the problems in order to enable students to learn. Therefore, teachers are required to give precedence to assessment in order to diagnose students. It provides a chance to design learning activities that appropriate to students' ability and enable individual's learning capacity, including the examining of learners' capacity after finishing subunits. Teachers are required to conduct a test after finishing each subunit to diagnose

which subunit students are unsuccessful and the reasons. Hence, teachers can definitely solve the problems. They might conduct a remedial teaching to develop learners' knowledge and enable them to have adequate foundation to learn the next chapter. Therefore, to diagnose learners in subunits beforehand allows teachers to discover learners' deficiency and reinforce their capacity as being scaffolded for studying further level learning in the next subunits. Diagnostic assessment for discovering learners' deficiency is extremely important to teachers and learners (Ministry of Education, 2010).

Diagnostic assessment is a measurement that aims at discovering deficient students' defects in which aspects they have limited learning in order to facilitate them to achieve the prescribed target and assist teachers to initiate remedial class precisely (Pattiyatanee, 2019; Smith, 2006). Diagnostic assessment can be employed to analyze students' defects more effectively than other types of measurement. Due to its importance and qualification mentioned above, it is necessary to use diagnostic assessment in mathematics. In learning process of mathematics, teachers always confront a situation that students have defects or struggle with studying. Unless the problems have been solved, it will affect students' learning ability in that chapter (Yeo, 2009). Since mathematics is an abstract science that is characterized as an instrument for solving problems, it is the foundation of scientific and technological education and can provide guidelines for its application in everyday life (Chambers, 2008).

In consonance with the previous mention, the researcher is interested in constructing a diagnostic assessment in mathematics on the topic of addition and subtraction for grade 4 students expecting it to be a model to develop teaching strategies. Teachers can employ it to examine students' knowledge or diagnose students' defects at the end of each chapter aiming to develop more effective teaching in mathematics and reinforce students' foundation for further studying.

2. Research Objectives

1) To construct mathematics diagnostic test on the topic of addition and subtraction for grade 4 students in Buriram Educational Service Area Office 3.

2) To verify the quality of the mathematics diagnostic test on the topic of addition and subtraction for grade 4 students in Buriram Educational Service Area Office.

3. Research Methodology

3.1 Population and Samples

1) The population in this research consisted of 4,594 students from grade 4 in Buriram Educational Service Area Office 3, semester 2 of academic year 2019.

2) The samples in this research consisted of 440 students from grade 4 in Buriram Educational Service Area Office 3, semester 2 of academic year 2019 by adapting multi-stage sampling method.

3.2 Scope of Work

The content selected to construct the diagnostic test was from Primary 4 strand 1: number and algebra in Mathematics 1.1. Students understand diversity of number display, number operation, operation product, operation qualification, implementation, and the core value of addition, subtraction, multiplication, and division the number more than 100,000 and 0 (Ministry of Education, 2017).

3.3 Research Instrument

The research instruments employed in this research were diagnostic assessment in grade 4 mathematics on the topic of addition and subtraction basis. The assessment consisted of 2 tests accordingly.

1) The examining test was a subjective test divided into addition part for 40 items and subtraction part for 40 items, totaling 80 items.

2) The diagnostic test was a multiple-choice test divided into addition part for 24 items and subtraction part for 24 items, totaling 48 items.

3.4 Construction of Diagnostic Test

1) Constructed a diagnostic table as being the framework to construct the diagnostic test constructed according to strand 1: number and algebra in Mathematics 1.1, the core value of addition, subtraction, multiplication and division of number more than 100,000 and 0.

2) Constructed a subjective test to examine defects, according to the prescribed framework and conducted a trial with 70 grade 4 students from 5 schools to collect the deficiency from students' answers to design options.

3) Constructed a diagnostic test with 4 options for 80 items, the options on each item were collected from the students' answers in the trial in an effort to generate deceive options.

4) Validated the content validity of the diagnostic test with the indicators by 5 experts in order to consider whether each test measures the indicators to be tested and covers the content.

5) Conducted the 1st time trial with grade 4 students to find difficulty and discrimination and to study the clarity of the language use during the process of select and develop the test. The trial was conducted with 120 students from 10 schools by finding basic statistics: difficulty values and discrimination values using Brennan's formula.

6) Revised diagnostic test and conducted the 2nd time trial to analyze the difficulty and discrimination with 120 students from 10 schools in order to select and develop the test.

7) Conducted the 3rd time to analyze the difficulty, the discrimination and reliability of the entire test using Lovett's method in order to study the deficiencies and causes of defects in the test. The experiment was conducted with 130 students from 15 schools.

3.5 Data Analysis

1) The verification of the test was masterminded as follow.

Content validity of the diagnostic test was examined by Rovinelli and Hambleton's formula: Index of Item Objective Congruence (IOC).

Difficulty (p) was examined for each item.

Discrimination was examined for each item by Brennan's formula which was called B-Index.

Reliability was examined by Lovett's method.

2) Statistics consisted of percentage, average and standard deviation.

4. Results

4.1 The Results of Construction of Diagnostic Test in Mathematics on Addition and Subtraction for Grade 4 Students

1) Construction of the test to explore the defect of short-answer test.

To construct the diagnostic assessment, the researcher had examined students' foundation by constructing an examining test consisted of 80 items to conduct a trial with 70 students. Then, the researcher analyzed the outcome from the examining test to obtain incorrect answers and discover defects in order to design deceive options in diagnostic test. The students' defects have been displayed in Table 1.

Table 1. The outcome of deficiency diagnosis from students' answers.

No. of Issue	Defects
Issue No. 1 Addition	Uncomprehend estimation, miscalculation, place wrong value, forget commute, uncomprehend addition operation, show method of finding answers less than 2 process, uncomprehend fraction addition, uncomprehend fraction and mix number changing, uncomprehend mix number addition, uncomprehend mix number and improper fraction changing, uncomprehend addition problem solving operation, malfunction of value of cardinal number, uncomprehend cardinal number addition
Issue No. 2 Subtraction	Uncomprehend estimation, miscalculation, place wrong value, forget commute, uncomprehend subtraction operation, show method of finding answers less than 2 process, uncomprehend fraction subtraction, uncomprehend fraction and mix number changing, uncomprehend mix number subtraction, uncomprehend mix number and improper fraction changing, uncomprehend subtraction problem solving operation, malfunction of value of cardinal number, uncomprehend cardinal number subtraction

The outcome of the analysis of grade 4 students' defects could be diagnosed as follows.

From issue no.1, the diagnostic outcome of grade 4 students' learning deficiency on the topic of addition found that the highest amount of the deficiency was uncomprehending addition problem solving operation totaling 61.43%. The second highest amount was uncomprehending fraction subtraction totaling 57.14%. The third highest amount was showing method of finding answers less than 2 processes totaling 52.85% accordingly.

Issue No. 2 the diagnosis outcome of grade 4 students' learning deficiency on the topic of subtraction found that the highest amount of deficiency was uncomprehending subtraction problem solving operation totaling 68.75%. The second highest amount was uncomprehending mix number subtraction totaling 64.29% and

uncomprehending cardinal number subtraction totaling 58.57%.

2) Construction of a four-choice diagnostic test, comprising on the topic of additions for 40 items and subtraction for 40 items, a total of 80 items. The choices in each item were selected from the wrong answers from the survey test to create a distractor.

4.2 The Inspection of Construction of Diagnostic Test in Mathematics on Addition and Subtraction for Grade 4 Students

1) The consistent index value between the assessment and indicators was at 0.60 – 1.00. This means that the constructed assessment is consistent with the prescribed indicators. The experts suggested that the difficulty of the test should be appropriate with students' ability and the items should be decreased.

2) To test the quality of each item in term of difficulty, discrimination and reliability of the entire assessment, the researcher conducted 3 trials with 120, 120, and 130 students accordingly. The results were displayed in the Table 2.

Table 2. The 1st, 2nd, and 3rd trial of finding difficulty, discrimination and reliability of the test.

No. of issue	First trial			Second trial			3rd trial			Reliability
	Items	p	B	Items	p	B	items	P	B	
1. Addition	40	0.23-0.82	0.13-0.77	32	0.23-0.78	0.10-0.88	24	0.21-0.79	0.23-0.89	0.89
2. Subtraction	40	0.28-0.81	0.10-0.69	30	0.22-0.70	0.14-0.73	24	0.31-0.72	0.32-0.81	0.88

From Table 2, the outcome of the analysis of difficulty, discrimination and reliability of diagnostic test on addition and subtraction foundation for grade 4 students were as follows.

From issue no. 1 of addition, in the 1st quality testing with totally 40 items, the difficulty was at 0.23–0.82, discrimination was at 0.13–0.77. In the 2nd quality testing with totally 32 items, the difficulty was at 0.23–0.78, discrimination was at 0.10–0.88. In the 3rd quality testing with totally 24 items, the difficulty was at 0.21–0.79, discrimination was at 0.23–0.89. The reliability of the first assessment was at 0.89.

From issue no. 2 of subtraction, in the 1st quality testing with totally 40 items, the difficulty was at 0.28–0.81, discrimination was at 0.10–0.69. In the 2nd quality testing with totally 30 items, the difficulty was at 0.22–0.70, discrimination was at 0.14–0.73. In the 3rd quality testing with totally 24 items, the difficulty was at 0.31–0.72, discrimination was at 0.32–0.81. The reliability of the first assessment was at 0.88.

5. Discussion and Conclusion

5.1 Construction of a Diagnostic Test

Each diagnostic test has a distractor that could point out any defects in a student's answer because the researcher first took the survey test with a baseline survey with 70 students in order to collect the student's wrong answers to create the distractor. Students wrote their answers or the solutions. And the researcher took the students' answers to record the frequency and the percentage to analyze the reasons for the wrong answers in each answer by considering the process of the solutions and selecting the answers most of the students gave wrong answers. The selected answers could point out the cause of the students' defects, so these were created as a choice of a four-choice diagnostic test based on the learning indicators, which exams could be clearly measured according to the indicators. Questions, choices, and distractors were systematically written, especially the distractors created could diagnose student deficiencies. The diagnostic test had a mean content validity of 1.00, which was determined by the criteria (Kanchanawasi, 2009). The IOC value should be greater than or equal to 0.50, indicating that the exam satisfied the objective indicators, able to point out student defects, which were useful for students and teachers.

5.2 The Inspection of Construction of Diagnostic Test

1) The Validity of the diagnostic test Grade 4 was considered by 5 experts in the congruence between each test item and the indicators. The results of the experts were taken to calculate the item-objective congruence index between the test and the indicators. These found that all 80 multiple choice diagnostic tests had IOC values ranging from 0.60–1.00, which showed that all of the exams were accurate in content (Content Validity). In other words, every exam was measured according to the indicators and covered the content of the exam curriculum with accuracy. This was because the researcher had clearly defined the scope of the content in which the exam would be issued, as well as had studied the indicators and learning areas of Mathematics (Revised

Edition B.E. 2560) according to the Basic Education Core Curriculum B.E. 2551 (A.D. 2008), resulting in the exam with the congruence index within the specified criteria. This has been consistent with Cohen, Manion and Morrison (2017) that content validity is an instrument that can measure, according to the content, has been in line with Panya (2015) who said that content validity is a method for measuring and evaluating learning outcomes consistent with knowledge and skills as specified in the curriculum or in accordance with the stated learning objectives, and has been in line with Phatthiyathanee (2019) who said that in order to determine the validity of the test by having each expert examine it. If the average is from 0.50–1.00 the test is valid.

2) To examine the quality of the diagnostic test, the researcher authentically used the test in the 3rd time. It was revealed that the difficulty of the issue no. 1, addition, was at 0.21–0.79 and issue no. 2, subtraction, was at 0.31–0.72 which were the appropriate range reaching the criteria. Since the test constructed by the researcher consisted of many low-quality items according to the criteria. The researcher adjusted the test, for example, simplified complicated questions, amended both correct and deceive options to be more appropriate. This attributed to the 3 quality tests which consistent to Pattiyanee (2019) stated that the test with difficult index level at 0.20–0.80 is a quality test in accordance with the criteria. Considering the criteria, the difficulty index value at 0.20–0.39 is quite difficult, at 0.40–0.60 is medium and 0.61–0.80 is quite simple. As well as Taireaukam (2009) stated that the ratio should have displayed that number of correct and incorrect answers. The test is simple on condition that the number of correct answers is higher, and vice versa, on higher number of incorrect answers. The appropriate test to take should be at medium level around 0.50. However, the frequently used level has been between 0.20–0.80. Furthermore, Jompook (2017) has studied the construction of diagnostic test to determine defects in mathematics on the topic of algebra with grade 6 students under Lopburi Primary Educational Service Area Office 2. The outcome revealed that issue no.1 had difficulty index level at 0.67–0.80. The issue no. 2 had difficulty index value at 0.69–0.80 and issue no. 3 was at 0.65–0.80. The difficulty index levels of 3 issues were in between medium to simply. As well as, Puttima (2013) has studied the development of diagnostic assessment in mathematics on the topic of multiplication and division by using a computer program. The study was conducted with grade 4 students under Chiang Rai Primary Educational Service Area Office 2 and the outcome showed that the difficulty index level of the test was at 0.24–0.69.

3) Discrimination index of diagnostic test, the researcher authentically used the test in the 3rd time. Discrimination index level of issue no. 1, addition, was at 0.23–0.89 and discrimination index level of issue no. 2, subtraction, was at 0.32–0.81. The standard criteria are at 0.20–1.00. This means that the proportion of a group students passing the criteria could answer correctly more than a group of students failing the criteria that has been consistent with Chen and Lin (2003) studied the developing a Two-Tier diagnostic instrument to assess high school students' understanding—the formation of images by a plane mirror found that the discrimination value was between 0.30–0.80. As Kachornsil (2000) said, a quality exam should have a discrimination rating of 0.20 or higher. And according to Gamgade (2008) stated that the discrimination index of the test showed the efficiency of the questions in the test to categorize learners in high ability group and low ability group. Furthermore, Pattiyanee (2019) addressed discrimination index level helps classify learners' ability. Furthermore, Jompook (2017) studied the construction of diagnostic test to determine defects in mathematics on the topic of algebra with grade 6 students under Lopburi Primary Educational Service Area Office 2. Discrimination index level was at 0.20–0.80. Also, Ladda (2015) studied the construction of diagnostic test to examine defects in mathematics on the topic of addition and subtraction with grade 4 students. The outcome revealed that discrimination index level of issue no.1 was at 0.58–0.84, discrimination index level of issue no.2 was at 0.44–0.77, and discrimination index level of issue no. 3 was at 0.42–0.71.

5.3 Reliability Index of the Diagnostic Test

The researcher authentically used the test in the 3rd time. Reliability index level of issue no. 1, addition, was at 0.89 and reliability index level of issue no. 2, subtraction, was at 0.88. This attributed to the researcher's effort to convince students to realize the importance of mathematics learning and evaluation process. Hence, students attempted to take the examination, which results in a high level of reliability index. Therefore, the diagnostic test constructed by the researcher, for 2 issues, could be reliable, that after multiple times of taking the examination, same students would receive similar scores to the scores of the previous times. Furthermore, Kerliger (1986) stated that on condition that the tools used in data collecting had a coefficient of reliability (r_{tt}) at 0.90, this meant that the common-cause variation would be at 81% after using this tool in the previous time and the later time. In the other words, when the test was repeatedly used, the values would be at 81%. And Saiyos and Saiyos (2000) said the reliability of the test should be above 0.70. As well as Grasaesome (2018) stated that reliability meant a stable result from the measurement or the reliable stability of the outcome of the assessment aiming to measure the points to which it expected. Kornchom (2018) studied the construction of diagnostic test in mathematics on

the topic of application with grade 6 students. The results showed that all 4 issues had the reliability index between 0.82–0.88.

6. Suggestion

Recommendation for the use of this research.

1) The criteria of pass and fail, teachers are able to prescribe the point on their own views to be appropriate to students' ability.

2) Aftermath, students should be informed their results immediately and provide a remedial class to solve defects before continuing to the next chapter.

3) Using this diagnostic test, teachers can recognize students' learning defects in both addition and subtraction. Therefore, in order for the learning in this subject matter to be effective, one should examine the deficiencies and plan for improvements in parallel with the teaching.

Suggestion for further research.

1) The outcome from this study should be adapted to develop a diagnostic test with the other year levels.

2) There should be a computer program that informs the results of the diagnosis immediately after taking the test.

3) Teachers should have substituted guidelines for deficient students, for instance, activities or innovation in order to reinforce students' ability.

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